EFFECTS OF AEROBIC TRAINING ON KIDNEY FUNCTION AMONG TYPE II DIABETES MELLITUS PATIENTS IN KANO METROPOLIS, NIGERIA

BY

Yakubu Muhammad ANAS
PhD/EDUC/9696/2011-2012
P15EDPE9009

July, 2017

EFFECTS OF AEROBIC TRAINING ON KIDNEY FUNCTION AMONG TYPE II DIABETES MELLITUS PATIENTS IN KANO METROPOLIS NIGERIA

BY

Yakubu Muhammad ANAS
BSc Ed, PGDE, PGDRTM, MSc PHE (BUK)
PhD EDUC/9696/2011-2012
P15EDPE9009

A Thesis Submitted to the Department of Physical and Health Education Ahmadu Bello University, Zaria, Nigeria, In Partial Fulfillment of the Requirements for the Award of Doctor of Philosophy Degree in Exercise and Sport Science

Department of Physical and Health Education,
Ahmadu Bello University, Zaria

JULY, 2017

DECLARATION

I declare that the work in this Thesis titled “Effects of aerobic training on kidney function among Patients with type II diabetes mellitus in Kano metropolis, Nigeria has been carried out by me in the Department of Physical and Health Education Ahmadu Bello University Zaria under the supervision of Prof J. A. Gwani, Prof C. E. Dikki and Prof J. O. Ayo.

The information derived from the literature has been duly acknowledged in the text and a list of references have been provided. No part of this thesis was previously presented for another degree, diploma to any other institution or university.

_____ _____

Yakubu Muhammad ANAS Date

CERTIFICATION

This Thesis titled “Effects of Aerobic Training on Kidney Function of Type ii Diabetes Mellitus Patients in Kano Metropolis Nigeria” by Yakubu Muhammad ANAS meets the regulations governing the award of the Doctor of Philosophy Degree of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Prof C. E. Dikki Chairman Supervisory Committee	Date
Prof J. A. Gwani Member, Supervisory Committee	Date
Prof J. O. Ayo Member, Supervisory Committee	Date
Prof Mrs M A Sulaiman Head of Department	Date
Prof S.Z. Abubakar Dean, Postgraduate School	Date

DEDICATION

This work is dedicated to all diabetics who struggle with kidney complications and to all those who contributed through research and literature in the cause of easing the problems of diabetics in Nigeria.

ACKNOWLEDGEMENT

The researcher is grateful to Allah subhanahuwataala for enriching him with the life, health and composure to carry out this study despite all the challenges of life.

The researcher expresses profound gratitude to the members of supervisory committee in persons of Prof J. A. Gwani, Prof C. E. Dikki and Prof J. O. Ayo for their invaluable support and contributions that make this work a success. It is a mark of their patience and commitment to making the research worthy of the award.

The researcher also expresses sincere gratitude to Prof (Mrs) M. A. Sulaiman, Prof (Mrs) T. N. Ogwu, Prof E A Gunen and Prof (Mrs) V. Dashe. all of the Department of Physical and Health Education who helped in one way or the other to see the researcher through this onerous task.

The researcher also wish to appreciate his dear wife Rabia and wonderful children Saudat, Ibrahim Khalil, Abddulhaq (my regular escort), Asiya, Abdusshakur, Rabiah, Abdulwahab and Abdullahi for their patience and cooperation during the period of this study specifically for bearing his absence in presence. May Allah bless all abundantly and extend the mutual benefits.

The researcher expresses profound gratitude to Professor M G Yakasai and Dr Musa Sa’ad of Kano University of Science and Technology for their continued inspiration and support. The researcher is also grateful to his research assistants Aminu Muhammad, Muhammad Tijjani Badamasi, and Mardhiyya Shatima

The researcher further wishes to acknowledge his course mates Jamilu Ajiya, Debora Koni, Abdullahi Sule Dambatta, his friends and colleagues Yusuf Muhammad Director at Senior Secondary Schools Management Board Kano, Abba T Sharif the Director PRS Private and Voluntary Agency Institutions Board, Kano for their continued inspiration throughout the study period.

The researcher also appreciate the Executive Secretary Hospitals Management Board Kano state, the Chairman ethical committee Dr M. Abdullahi, the Zonal Chief Medical Director Murtala Mohammed Specialist Hospital Kano, the HOD Diabetes Clinic Dr Idris I. B. N. Garba, the matron of the diabetes clinic and all staff of the unit for their cooperation and support and all the staff of the Murtala Muhammad Specialist Hospital Diabetes Clinic.

Abstract

Type 2 Diabetes is one of the most common physiological disorders worldwide. Kidney's role in and associated problems linked to T2DM has long been acknowledged as an important factor in the long term effects of the disease. Aerobic exercises has proved beneficial to blood pressure and glucose control in patients with diabetes, however, the potentials of aerobic exercise as a tool to support exercise-based prevention activities for kidney degeneration among diabetics is uncommon. The purpose of this study was to investigate the effect of bench-step aerobics (BSA) on Blood pressure, blood sugar, albumin and creatinine among type 2 diabetes mellitus patients in Kano, Nigeria. Thirty male T2DM patients were randomly assigned to one of two groups that performed 30 min of BSA or served as a control group that did not perform the bench step aerobics but continue with drugs and activities of daily living. The training was performed at 55% maximal heart rate (HR max), which was also in line with the ACSM recommendation of 50-60% of HR max (ACSM, 2000). Direct assessments for the four variable (blood sugar, blood pressure, albumin and creatinine) were performed on both groups (experimental and control) before the commencement of the training, at week four, week eight and after week twelve of the training. Statistical procedures selected for the analysis included means and standard deviations. The hypotheses were tested with inferential statistics of two-way repeated measure ANOVA. The result showed significant difference in the mean level of Creatinine $P< 0.003$, and in systolic and diastolic blood pressure $P < 0.025$. No significant difference was observed in the blood sugar $P > 0.684$ and albumin $P > 0.487$. BSA is recommended as an exercise modality effective for improving the selected body parameters of diabetic patients, especially their blood pressure and creatinine levels. Therefore, the inclusion of BSA as an exercise adjunct for managing T2DM and kidney function was recommended but for relatively longer number of weeks since most observed significance was made between the baseline and the twelfth week of exercise.

Table of Contents

Contents	Page
Cover Page	i
Title page	ii
Declaration	iii
Certification	iv
Dedication	v
Acknowledgement	vi
Abstract	vii
Table of contents	x
List of tables	xiv
Operation definition of terms	xv
CHAPTER ONE INTRODUCTION	
1.1 Background of the Study	1
1.2 Statement of the Problem	3
1.3 Research questions	9
1.4 Purpose of the study	9
1.5 Basic assumption	10
1.6 Hypotheses	10
1.7 Significance of the study	11
1.8 Delimitations of the Study	12
1.9 Limitation of the study	12
CHAPTER TWO: REVIEW OF RELATED LITERATURE	
2.1 Introduction	13
2.2 Nature of Type 2 Diabetes Mellitus	14

22.1 Symptoms of Type 2 Diabetes Mellitus 15

2.2.2 Pathophysiology of Type 2 Diabetes and kidney function 17

2.2.3 Complications of Type 2 Diabetes Mellitus 22

2.3.0 Risk factors of Kidney Disease in Type 2 Diabetic Mellitus 24

2.3.1 Kidney Disease in Nigeria 25

2.3.2 Kidney and Cardiovascular Health 26

2.3.3 Aetiology of Kidney Problem in Type 2 Diabetes Mellitus 34

2.3.4 Oxidative Stress in Type 2 Diabetics Kidney Function 35

2.4.0 Effects of Aerobic Exercise in Type 2 Diabetes Mellitus 38

2.4.1 Effects of Bench Step Aerobics (BSA) 45

2.4.2 Effects of Aerobic Exercise on Renal Function of T2DM
with Kidney Disease 47

2.4.3 Effects of Exercise on Blood Pressure and Blood Glucose in T2DM 50

2.4.4 Effects of Aerobic Exercise on Kidney Function of T2DM patients 53

2.4.5 Physical Activities and the Regulation of Blood Glucose in T2DM 54

2.5.0 Exercise Prescription for T2DM Patients 55

2.6.0 Summary 61

CHAPTER THREE METHODOLOGY

3.1 Introduction 63

3.2 Research Design 63

3.3 Population of the Study 63

3.4 Sample and Sampling Technique 64

3.5 Instrumentation 64

3.6 Research Assistants 65

3.7 Data collection 65

3.8 Training protocol 67

3.9 Training Procedures 68

3.9.1 Training Intensity and Duration 70

3.9.2 Monitoring Training Intensity 70

3.10 Procedure for Data Analysis 71

CHAPTER FOUR DATA ANALYSIS

4.1 Introduction 72

4.2 Results 72

4.3 Discussion 92

CHAPTER FIVE SUMMARY CONCLUSION AND RECOMMENDATIONS

5.1 Introduction 98

5.2. Summary of Findings 98

5.3 Conclusions 100

5.4 Recommendations 101

5.5 Recommendations for further studies 101

References 103

Appendix 1 Minimum Exercise Prescription Recommendations for T2DM 115

Appendix 2Maximum Heart Rate Training Table 116

Appendix 3 Chart to Estimate Heart Rate in BPM for each intensity Zone 117

Appendix 4 Borg's Rate of Perceived Exertion (RPE) Scale 118

Appendix 5 Interpretation of RPE Scale 119

Appendix 6: Ahmadu Bello University Request for permission to Collect Data 110

Appendix 7: Hospitals Management Board Approval 111

Appendix 8: Physical Activity Readiness Questionnaire (PAR-Q) 112

List of tables

Tables	Page
Table 2.5.1 Exercise Intensity	58
Table 2.1 Mode of Exercise	60
Table 4.2.1: Effects of aerobic exercise on blood sugar, blood pressure albumin, and creatinine of diabetic patients in the control and experimental groups	73
Table 4.2.2 Mean and SD of blood sugar levels for the experimental and control groups	74
Table 4.2.3 Mean and SD of Albumin levels over for the Experimental and Control groups	75
Table 4.2.4 Mean levels of Creatinine observed over the study period for the two groups (Control and Experimental)	76
Table 4.2.5 Mean levels of Systolic blood pressure levels observed over the study period for the Control and Experimental groups	77
Table 4.2.6 Mean levels of Diastolic blood levels observed over the study period for the Control and Experimental	78
Table 4.3.2: Summary of two-way repeated measure ANOVA on the effects of aerobic exercise on blood sugar of T2DM patients in Kano Metropolis	80
Table 4.3.3: Pairwise comparison of levels of blood sugar measured (mmol) at the different period of the training	81
Table 4.3.4: Summary of the two-way repeated measure ANOVA on effects of aerobic exercise on the kidney function albumin (mmol/l) of diabetic patients	83
Table 4.3.5: Summary of the two-way repeated measure ANOVA on effects of aerobic exercise on creatinine (mmol) of diabetic patients	85
Table 4.3.6: Summary of the two-way repeated measure ANOVA on effect of aerobic exercise on systolic blood pressure (mm Hg) levels of diabetic patients	87
Table 4.3.7: Pairwise comparison of mean levels of systolic blood pressure of diabetic patients	88
Table 4.3.8: Summary of the two-way repeated measure ANOVA on effect of aerobic exercise on diastolic blood levels of diabetic patients in Kano metropolis	89
Table 4.3.9: Pairwise comparison of mean levels of diastolic blood pressure of diabetic patients	90

Operational Definition of Terms

Aerobic Training: This refers to the modified Step Aerobic Training engaged in by the diabetics for the purpose of this study

Bench Step Aerobics: The aerobic training mode that the diabetic patients used in the experimental group. This was performed three times each week to obtain the anticipated changes in the participants diabetes and kidney function.

Control group: Type 2 diabetic patients that fall in the even numbers through the random selection that did not engage in the aerobic training and were tested alongside the experimental group. And have their results compare to that of the experimental group

Experimental group: Patients that fall in odd numbers through random selection and have participated in the bench step aerobic training

Kidney Function: Test results of urine creatinine and albumin that was collected from both the experimental and control groups of diabetic patients used for this study.

Type 2 Diabetics: refer to subjects of the study who were diagnosed with non-insulin resistant diabetes for three years or more and were between the ages of 40 and 60 years

CHAPTER ONE
INTRODUCTION

1.10 Background of the Study

Type 2 Diabetes Mellitus (T2DM) is a disease that is characterized by an abnormal accumulation of sugar in the blood affecting almost all functions of the body and it is the most common and fastest growing form of diabetes globally attracting considerable medical attention (Anas, 2011), it has some specific long-term complication affecting the retina, kidney, and nervous system (International Diabetes Federation, (IDF), 2014). An increasing number of people presenting Type 2 diabetes mellitus very late in Kano state is raising concern because sometimes the patients are faced with further complications. The consistent recommendations for patients on lifestyle adjustment with emphasis on physical activity made it further necessary that the physical activities should be cost effective and practically possible. One other factor is the large patients turn out in major hospitals within Kano metropolis that implied a significant health challenge that requires serious attention and actions to alleviate the disease and prevent complications. Also the number of T2DM patients presenting kidney disease and other cardio-metabolic complications on several visits to hospitals has made it imperative to professionals in the field of exercise and sports science to participate in intervening to reduce the number of T2DM patients deteriorating to kidney disease. Diabetics are subject to different types of complications based on duration, age at onset, lifestyle and compliance to medical advice and prescribed drugs. It is expected that exercise in general and aerobic exercise in particular has significant benefit in the prevention and management of diabetes. The choice of physical activity remained a challenge to many individuals both healthy and those facing challenges of debilitating ailments such as obesity, diabetes, hypertension and other cardiovascular diseases that may subject patients to higher risks such as kidney disease and end stage renal disease.

Kidney disease takes time to develop manifesting in different presentations that if effectively monitored the progression to end stage renal disease could be prevented or delayed. Having T2DM and high blood pressure increases the chances of developing other diabetes-related diseases, such as kidney disease and retinopathy. A high level of sugar in blood can cause problems in many parts of the body, including the heart, kidneys, eyes, and brain. Over time, this can lead to kidney disease and kidney failure. The combination of hypertension and T2DM is particularly lethal and can significantly raise the risk of having a heart attack or stroke. Most people with early kidney damage do not have symptoms and the best way to determine early kidney damage is through a urine test to check for protein in the urine called albumin and Creatinine that are measured to determine whether a diabetic patient has incipient nephropathy. Urinary albumin and urinary creatinine are measured in a random urine collected and are used in the diagnosis and treatment of diseases involving the liver and/or kidneys. Increased microalbuminuria is a sign of renal disease and may be predictive of nephropathy risk in patients with TDM and it is also associated with hypertension and cardiac disease. Creatinine is produced by creatine and creatinine phosphate as a result of muscle metabolic processes. It is then excreted by glomerular filtration during normal renal function (Martin, 2011). Creatinine may be measured in both serum and urine. Creatinine measurement is useful in the diagnosis and treatment of renal diseases, in monitoring renal dialysis, and as a calculation basis for other urinary analytes (e.g., total protein and microalbumin). Over time, the high blood glucose levels associated with uncontrolled diabetes can cause a number of complications, including blindness, heart disease, kidney disease, nerve damage and erectile dysfunction (Wolf & Ritz,2003). Proper T2DM care and management can prevent or delay the onset of these complications, (Ontario Local Health Integration Network LHIN, 2013). Diabetic complications are mainly a consequence of macrovascular and microvascular damages of the target organs, (Shravya, Sharanm, Bandi, Suresh, Preetham & Mallikarjuna, 2012). Managing and or avoiding possible short term as well as long term problems and

complications of diabetes is most important and these includes patient education, dietary support, prescribed exercise and self glucose monitoring with the goal of maintaining blood glucose levels and preventing complications (Anas, 2011). To achieve a proper management of diabetes may require a combination of diet, exercise and weight loss, in addition, given the associated higher risks of cardiovascular disease, lifestyle modifications should be undertaken to control blood pressure and cholesterol by exercising more and consuming balanced diet

With the progression of T2DM, the small blood vessels in the kidneys are injured and therefore the kidneys cannot clean the blood properly. The body will then retain more water and salt than it should, protein may then be presented in the patient's urine and often waste materials will build up in the blood. The earliest sign of diabetic kidney disease is an increased excretion of albumin in the urine which is present long before the usual tests are done to show evidence of kidney disease. As the kidneys fail, blood urea nitrogen (BUN) levels will rise as well as the level of creatinine in your blood. Measuring the levels of creatinine in the bloodstream and in the urine can be helpful for tracking the progression of diabetic kidney disease. The determination of creatinine clearance can reflect the status of renal plasma flow or renal microvascular disease as well as the status of chronic kidney disease in T2DM, since creatinine clearance or glomerular filtration rate correlates directly with renal plasma flow (Futrakul and Futrakul, 2011). The variables in this study are blood sugar, urine albumin, urine creatinine and blood pressure of the T2DM patients

1.11 Statement of the Problem

As at 2013, there were more than 382 million people living with T2DM worldwide that has implication for significant impact on the health, quality of life and life expectancy of patients as well as on the health care system (Pandey, Tripathy,

Pandey, Srivatava & Goswani, 2011). T2DM is a leading public health problem with increasing incidence and long term complications such as diabetic nephropathy, diabetic neuropathy and diabetic retinopathy, and according to the World Health Organisation (WHO, 2016), the prevalence of diabetes mellitus has reached epidemic proportions. T2DM often goes undiagnosed for many years because early symptoms are not severe, and it is estimated that by the time someone is diagnosed with Type 2 diabetes, the disease has been present for four to seven years. Since diabetes may have been present for some time, the chances for kidney damage increase and that 8% of new patients diagnosed with T2DM have nephropathy, or kidney damage (Bakris, Sharma, and Ecelbarger, 2011). Given the enormous public health and economic burden posed by the global epidemic of T2DM, intervention in the stages of the disease process to prevent progression to kidney disease and its vascular complications would be a most sensible approach (Rosentock, 2007). It is expected that diabetics can live for more than 20 years with compliance to proper treatment and lifestyle adjustment (Ulasi and Ijoma, 2010), while being a complex disease Type 2 Diabetes Mellitus (T2DM) involves multiple organs and tissues with its progression and the onset of secondary complications (Dabla, 2010). The alarming increase in the number of patients diagnosed with most particularly T2DM increased from 6% as at 1999 to 10% in 2006, particularly in Kano, Kaduna, Borno, and Sokoto States, and it was ranked third in prevalence in Kano State among the most frequently nominated rural health priorities (Dutse, 2006).

The rising prevalence of kidney disease among T2DM patients and the increasing risk of degeneration to chronic kidney disease remains a global public health challenge particularly in developing countries, including our local environments where patients present late and may already be in need of renal replacement or at best require hemodialysis. Increased urinary albumin excretion is a strong predictor for the development of overt diabetic nephropathy and overall cardiovascular morbidity and

mortality in patients with T2DM (Lazarevic, Antic, Vlahovic, Djordjevic, Zvezdanovic, & Stefanovic, 2007). It has been recorded recently that about 15,000 new cases of kidney failure occur every year in Nigeria and that 30 million Nigerians are suffering from Kidney disease most of whom had suffered diabetes and specifically T2DM. Patients are paying high charges for dialysis every week while costs of transplant varies from hospitals, patients also need so much money to get immunosuppressive drugs monthly after a successful transplant (Obinna, 2013). Kidney disease has remained at the background, while patients continue to die without any form of assistance (Usman, Umar, Shehu, Wali, and Nasir (2012); Obinna, 2013). The magnitude of the existing burden of illness caused by renal failure, the projections for increasing incidence of ESRD, and the limitations of the existing treatments for renal insufficiency in Nigeria all point to the need for interventions aimed at prevention of ESRD (Alebiosu *et al,* 2006). Early detection of modifiable risk factors and other preventive or management strategies may reduce this prevalence and burden among which physical activity may be beneficial. Kidney function and associated problems linked to T2DM is a very important issue in long term effects of the disease (Christian & John, 2002). Currently available therapies for diabetes management do not address the various components of the disease that have to be treated, to prevent progression and to improve overall mortality and morbidity (Family Doctor, 2014). People living with T2DM are more vulnerable to various forms of both short- and long-term complications, which often lead to premature death, the tendency of increased morbidity and mortality because of the commonness of its insidious onset and late recognition, especially in low resource developing countries (Olokoba, Obateru, & Olokoba, 2012). It has been observed that no fewer than six million Nigerians are living with T2DM and that it has accounted to several deaths (Adebayo, 2013). Renal function complications are the leading cause of death in T2DM patients and the resulting cardiovascular complications are responsible for more than

seventy percent (70%) of deaths and it is also responsible for the increase in the number of patients going blind and suffering from stroke and kidney diseases (Adler, Stevens, Manley, Bilous, Cull & Holman, 2003; Dutse, 2006).

Hawkins, Richardson, Fried, Arena and Kriska, (2011) observed that kidney disease is a condition characterized by the deterioration of the kidney's ability to remove waste products from the body, although treatments to slow the progression of the disease are available chronic kidney disease may eventually lead to a complete loss of kidney function. Studies have shown that physical activities of moderate intensity may have renal benefits while few studies have examined the effects of total movement on kidney function (Hawkins, 2010). Han, Bai, Lin, Sun, and Chen, (2010) explained that decline in kidney function is an independent predictor for cardiovascular events and death among type 2 diabetics. Moreover, the majority of currently available diabetes drugs are plagued with serious and life-threatening side effects that limits their long term usage, which is a major disadvantage because of the life-long nature of the disease. (Padmalayam, 2014)

A number of lifestyle factors and genetics are known to be important to its development, these includes insufficient physical activity, sedentary lifestyle, cigarette smoking and generous consumption of alcohol (Olokoba, Obateru, and Olokoba, 2012)**.** Prudent life style changes have been shown to significantly reduce the risk of progression in individuals with T2DM, although lifestyle modifications are difficult to maintain, there is evidence that intensive intervention results in continued preventive benefit after the stopping of structured counseling (Dutse, 2006). A number of drug therapies, have also been proven effective in preventing progression, but unresolved issues still remain. Specifically, whether large numbers of individuals with T2DM who may not necessarily progress to kidney disease should be exposed to the risk of pharmacological adverse effects remains a topic of discussion and debate (Rosentock, 2007). Studies have shown

that there is significant reduction in the incidence of T2DM with a combination of regular exercise, maintenance of body mass index of 25 kg/m^2, eating high fibre food and unsaturated fat and diet low in saturated and trans-fats, abstinence from smoking and less or non consumption of alcohol (Olokoba, Obateru, and Olokoba, 2012). Low awareness, lack of physical exercise and increased consumption of foods high in fats and sugars were identified as reasons why Nigeria has a high population of people suffering from diabetes than those living with HIV/AIDS, which affects just 3.5 million Nigerians (Adebayo, 2013; Obinna, 2013). However, patients with diabetic complications remain at high risk of complications as available therapies may not successfully enable all patients to reach glycaemic goals and the drugs with new mechanisms of action are not available (Deshpande, Harris-Hayes and Schootman, 2008). Patients may face spikes in blood glucose, weight gain, hypoglycaemia, and a loss of effectiveness of their treatments and often they have to struggle to make the necessary life style changes to control blood sugar levels, while medications have limitations and can have adverse gastrointestinal side effects (Genc, Karadurmus, Kisa, Tapan, Naharci, Sonmez and Dogru, 2010).

Population based studies of the United States population have shown that individuals with diabetic kidney disease are less active than the general population, an examined cross-sectional data showed that physically inactive individuals had over twice the prevalence of diabetic kidney disease compared to very active individuals (Toyama. Sugiyama, Oka, Sumida, & Ogawa, 2010). Therefore, there is an urgent need for approaches which are effective in all-around diabetes management and are at the same time safe enough for long time use.Exercise is recommended for the management of T2DM and in addition to being effective in improving glycaemic control it may exert beneficial effects in preserving beta-cell function (Rosentock, 2007), but its effect on diabetic nephropathy are not clear, it may be assumed that appropriate exercise improves early attenuation of inflammation and oxidative damage in diabetic nephropathy.

Exercise is perhaps the most under utilised way to help prevent onset and or control diabetes and delay further, which except contrary to medical advice may be an effective non therapeutic measure in the management of diabetes. Plowman and Smith (2003), opined that exercise is directly related to the body's demands and functions and it affects psychological, nutritional, behavioural, and physiological aspects in humans. Therefore, exercise effects the development of the body and serves as a means of managing health problems. The prohibitive costs of diabetic complication therapies predispose many patients to complications including kidney disease and this underscores the need for preventive measures to reduce the impact of diabetes and consequent risks of kidney disease. This forms the basis for this research and aerobic exercise interventions may prove effective in preventing and controlling these complications. The chance of developing T2DM as well as its complications may be cut by between 30 and 40 per cent with just three and a half hours of exercise a week, half an hour's exercise a day and that at least 150 minutes of aerobic activity in a week, and at least an hour of muscle-strengthening had the best results (Leehey, Moinuddin, Bast, Qureshi, Jelinek, Cooper, Edwarsd, Smith & Collins, 2009). Awareness of the potential benefits of increased physical activity for improved kidney function as just an hour's work-out every seven days can reduce the risk of kidney disease by 13 per cent (Medical Express, 2014; Snowling & Hopkins, 2006)..

Jogging, running, cycling and recreational sports are effective forms of physical activities that may improve general body conditions and enhance kidney function but they have not always been attractive modes of exercise to adult diabetics in Kano and the constraint of decision on the right choice of exercise and making it a daily routine in their lives is a challenge. Making aerobic exercise affordable and accessible to diabetics may ensure their regular participation, especially when it can be performed indoors and at home such as the bench step aerobic which can be performed on the local women's stool,

bench and door steps. Physical activity and known regular exercise can prevent diabetes and effectively manage risk factors, but most diabetics in Kano do not exercise enough to beneficially manage the risk. Tailored aerobic exercise has shown promise as a means to increase fitness and reduce risk, but optimal implementation practices remain unknown especially in communities with reduced access to exercise and or fitness facilities. Moderate aerobic exercises have proved to be beneficial tools to achieve stable blood pressure and glucose control in patients with diabetes. However, the potentials of bench step aerobic exercise as a tool to support exercise-based prevention activities for kidney degeneration among diabetics is uncommon. Therefore, there was the need to investigate the effects of bench step aerobic training on kidney function among T2DM. patients.

1.3 Research questions

i. What are the effects of bench step aerobic exercise on blood glucose levels of T2DM patients?
ii. What are the effects of bench step aerobic exercise on albumin levels of T2DM patients?
iii. What are the effects of bench step aerobic exercise on creatinie levels of T2DM patients?
iv. What are effects of bench step aerobic exercise on systolic blood pressure of T2DM patients?
v. What are effects of bench step aerobic exercise on diastolic blood pressure of T2DM patients?

1.4 Purpose of the study

This study was designed to determine the effects of bench step aerobic training on:

i. Blood glucose levels of T2DM patients

ii. Albumin of T2DM patients

iii. Creatinine of T2DM patients

iv. Systolic blood pressure of T2DM patients.

v. Diastolic blood pressure of T2DM patients.

1.5 Basic assumption

1. It was assumed that T2DM patients have problems blood glucose
2. It was assumed that improper blood glucose control may lead to T2DM complications such as hypertension and kidney disease.
3. It was assumed that aerobic exercise would help to control and/or improve the conditions of T2DM patients

1.6 Hypotheses

One major and three sub-hypothesis were formulated for this study:

Major hypothesis:

There is no significant effect of bench step aerobics training on glycaemic status, kidney function and blood pressure of the of T2DM patients.

Sub-hypotheses:

i. There is no significant effect of 12week bench step aerobic exercise on blood glucose status of T2DM patients.

ii. There is no significant effect of 12week bench step aerobic exercise on the albumin of T2DM patients

iii. There is no significant effect of 12week bench step aerobic exercise on the creatinine of T2DM patients

iv. There is no significant effect of 12week bench step aerobic exercise on systolic blood pressure of T2DM patients.

v. There is no significant effect of 12week bench step aerobic exercise on diastolic blood pressure of T2DM patients.

1.7 Significance of the study

The evidence of the effects of aerobic exercise on kidney function among Type 2 diabetics is very scanty. Few studies have suggested non-exhaustive evidence relating to variable effects of aerobic exercise on Albumin and creatinine which are markers of kidney function among type 2 diabetics. The findings of this study would be beneficial in guiding patient and clinicians on the roles of exercise in the prevention of T2DM complications, and consequent morbidity and mortality rates.

The findings of the study would be a useful tool in planning treatment for type 2 diabetics and other people at risk of kidney diseases and, therefore, possibly bring hope to T2DM patients, their families and other people at risk of kidney problem, who may not afford the high cost of chemotherapy or even attend fitness centres. It is also expected to add to the body of knowledge in the field of exercise and sport science, physical education, sports and exercise medicine, family medicine, community medicine, health educations and preventive medicine. It should also support gymnasium managers and students interested in preventive and management approach to renal complications of T2DM and related cases.

1.8 Delimitations of the Study

The study is delimited to the following:

1. Male adults diagnosed with T2DM three years or more and do not have any clinical condition that is contraindicated to exercise

2. Patients who were attending diabetic clinics in Kano City

1.9 Limitations of the Study

The patients of both exercise and control groups were instructed to continue with their medications as prescribed by their physicians, comply by dietary advice and not to participate in any structured physical activity during the study period. Patients in the control group were asked to attend health education sessions weekly where they were lectured on the importance of complying to drug therapy, dietary control, while their blood sugar, blood pressure, albumin and creatinine were assessed. Other medications outside the diabetic drugs being administered to patients were not considered for possible influence in this study other than contraindications to exercise or diabetes.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1. Introduction

This chapter reviewed related literature on type 2 diabetes mellitus and the effects of aerobic training on blood pressure, blood glucose, kidney function The chapters reviewed were as follows:

2.2.0 Nature of Type 2 Diabetes Mellitus

2.2.1 Symptoms of Type 2 Diabetes Mellitus

2.2.2. Pathophysiology of Type 2 Diabetes and Kidney Function

2.2.3. Complications of Type 2 Diabetes Mellitus

2.3.0. Risk factors of Kidney Disease in Type 2 Diabetic Mellitus

2.3.1. Kidney Disease in Nigeria

2.3.2. Kidney and Cardiovascular Health

2.3.5 Aetiology of Kidney Problem in Type 2 Diabetes Mellitus

2.3.6 Oxidative Stress in Type 2 Diabetics Kidney Function

2.4.0 Effects of Exercise Training in Type 2 Diabetes Mellitus

2.4.1 Effects of Exercise on Renal Function of Diabetics with Kidney Disease

2.4.2 Effects of Exercise on Blood Pressure, Insulin and blood glucose

2.4.3 Effects of Exercise on T2DM patients Kidney Function

2.4.4 Physical Activities and Regulation of Blood Glucose

2.5.0 Exercise Prescription for T2DM Patients

2.6.0 Summary

2.2.0 Nature of Type 2 Diabetes Mellitus

Diabetes mellitus has been one of the risk factors for the development of kidney disease and death of retina in human eyes. The complications exemplified by renal vascular and cardiovascular disease cause the most morbidity and mortality in type 2 diabetes group of patients (Jisieike-Onuigbo Unuigbe, Oguejiofor, 2011). Kidney disease is a serious public health concern because of the large physical and economic burden on society. This large burden made it important to determine what factors are associated with the development and progression of the disease, especially in early stages. Physical activity has been shown to be related to many risk factors for kidney disease; however, few studies have assessed its direct relationship with kidney function. Diabetic retinopathy is the leading cause of new blindness in persons aged 25-74 years, but the exact mechanism by which diabetes causes retinopathy remains unclear, though several theories have been postulated to explain the typical course and history of the disease. Diabetic nephropathy, a leading course of kidney failure and one of the key complications of diabetics, is defined by either microalbuminuria that is a urinary albumin excretion greater that 300 mg in a 24-hour collection or by abnormal renal function as present by an abnormality in serum creatinine, calculated creatinine clearances or glomerular filtration rate (GFR) in diabetic patients (Usman, Umar, Shehu, Wali, and Nasir, 2012). Type 2 diabetes mellitus, also known as non-insulin-dependent diabetes is a multi-causal disease that develops slowly and in a stepwise order. Initially, it commences with insulin resistance (Al-Rawi, 2011). It is a complex metabolic and cardiovascular disorder with multiple pathophysiologic abnormalities with the core defects represented by insulin resistance in muscle and liver, and a beta cell (β-cell) failure that occurs much earlier in the natural history of the disease (DeFronzo, Eldor and Abdul-Ghani, 2007).

Although Nigeria lacks an aggregate data, physicians stated that no fewer than six million Nigerians are living with diabetes mellitus. Diabetes accounts for deaths in Nigeria and other parts of the world, and that it is fast becoming the most dreaded disease (Enengedi, 2013; Ulasi and Ijioma, 2010). The International Diabetes Federation also predicts that developing countries such as Nigeria, where there is an acute shortage of health facilities and medical personnel, would record higher statistics of people living with this disease in the nearest future (Adebayo, 2013). Today end-stage renal disease (ESRD) is a major health concern. It is a deterioration stage resulting in the dysfunction of the kidneys for a long period, which requires either dialysis treatment or transplantation in advance cases. The ESRD results in a negative clinical status, which in turn results in both structural and functional changes in the musculoskeletal system. Consequently, the patient is faced with a sedentary life, making the patient even further dependent. Low functional capacity, exhaustion/fatigue and under nutrition was found to be prevalent among incident dialysis patients (Yurdalak, 2013).

2.2.1 Symptoms of Type 2 Diabetes Mellitus

Type 2 diabetes mellitus is characterized by insulin insensitivity as a result of insulin resistance, declining insulin production, and eventual pancreatic beta-cell failure, that leads to a decrease in glucose transport into the liver, muscle cells, and fat cells with an increase in the breakdown of fat with hyperglycaemia (Olokoba, Obateru, and Olokoba, 2012), and inadequate pancreatic compensation consequent to impaired β-cel function (Lam, 2005). Most people with T2DM are still able to produce insulin; however, the insulin they produce is unable to perform its primary job, which is helping the body's cells to use glucose for energy which is usually due to a problem with the body's insulin receptors, the location on cells where insulin binds so that glucose can enter (Anas, 2011). This condition is called insulin resistance and it accounts for ninety percent (90%) of all diabetes problems [American Diabetes Association (ADA), 2016]. In its early diagnosis, the disease is characterized with reduced insulin sensitivity and

elevated levels of insulin in the blood. At this stage, hyperglycaemia can be reversed by a variety of measures and medications that improve insulin sensitivity (George, Thomas, Timothy and Kenneth, 2000). Approximately 55% of type 2 diabetics are found to be obese. The combined effect of the disease is found in greater number among elderly women than men in most populations, (Amoah, Owusu, & Adjei, 2002). Sixty to ninety percent (60%-90%) of type 2 diabetics are obese when first diagnosed and symptoms are usually associated due to high blood glucose, although in many milder cases there may not be any symptoms, (Ibrahim, 2008). Type 1 and type 2 diabetes have several serious short term and long term complications, so it is important to be aware of the common signs indicating the need for further diagnosis. Hyperglycaemia is the primary physiological complication in diabetes mellitus which is the leading cause of all physical symptoms. Depending on the type of diabetes, hyperglycaemia is caused by either a lack of insulin or an inability to use insulin effectively. In either case, the lack of insulin prevents the body from using the glucose in the blood and thus the glucose levels rise to dangerous levels. According to Anas, (2011), Obinna (2013) and Penny (2007), the classic symptoms of hyperglycaemia are:

i. **Excessive thirst** (polydipsia): the body tries to compensate for the excess sugar in the blood stream via a homeostatic mechanism in which the body tries to dilute the excess sugar in the blood by adding water. A signal is sent to the brain to encourage consumption of water. This signal is the sensation of excessive thirst.
ii. **Excessive eating or hunger** (polyphagia): the body tries to secrete more and more insulin to convert excessive sugar levels. Insulin can stimulate hunger.
iii. **Excessive urination** (polysuria): the body tries to rid the excess sugar in the body through urination. The excessive urination often leads to severe dehydration.

iv. **Unexpected weight loss:** weight loss is often seen due to inadequate processing of meals. This occurs even though there is a feeling of hunger and eating normally. The loss of sugar, water and electrolytes in the urine also contribute to unexplained weight loss.

v. **Fatigue:** the inefficient use of glucose for fuel often triggers feelings of fatigue. Without sufficient energy from proper glucose metabolism, the body starts to use other sources such as fat. This requires a further expenditure of energy to allow the body to fully function.

vi. **Mental Abnormalities**: mental status abnormalities include irritability, agitation, lethargy and confusion. These changes need immediate medical attention.

vii. **Infections**: a combination of immune system suppression and the love of certain bacteria for glucose can trigger increased infection. Common places of infections include the skin, the urinary tract and the genitals. Also associated with immune suppression is poor wound healing

viii. **Other Symptoms**: other common symptoms of diabetes include blurred vision, headaches, loss of consciousness (this is very infrequent), numbness and/or tingling of the extremities, and impotency (Sims, 2008).

2.2.2. Pathophysiology of Type 2 Diabetes and Kidney Function

Diabetic kidney disease takes many years to develop and in some people, the filtering function of the kidneys is actually higher than normal in the first few years of their diabetes [National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), 2013]. Insulin resistance and poor beta cell function manifests into diabetic kidney disease, because the kidney also contribute to glucose homeostasis by filtering and reabsorbing or excreting glucose thereby protecting the body against wide variations in glucose demand and glucose supply, a process that is essential for life. Overproduction

of glucose is the major factor responsible for fasting hyperglycemia in T2DM considered to be solely due to excessive hepatic glucose production because the human kidney was not regarded as an important source of glucose except during acidosis and after prolonged fasting, however, data accumulated over the last 60 years in animal and in vitro studies have provided considerable evidence that the kidney plays an important role in glucose homeostasis in conditions other than acidosis and prolonged fasting (Tan, Li &Wang, 2012). Diabetic kidney disease is a progressive condition in which damage occurs over time in a slow process that the patient may not even realize anything wrong in the body until it is late. In fact, most people do not show any symptoms or discomfort from kidney damage until the kidneys can no longer work well enough to support their vital life functions. With an early diagnosis of diabetes, steps can be taken to help prevent kidney damage and even if tests indicate a person has slight kidney damage, there are treatments options that may help prevent further damage and preserve remaining kidney functions.

The pathophysiology of T2DM involves both insulin resistance and poor beta cell function which manifests into diabetic kidney disease (Young, Chinenye, Unachukwu, 2012). At present, diabetic kidney disease affects type 1 and type 2 diabetic patients and several decades of extensive research elucidated various pathways to be implicated in the development of diabetic kidney disease. The metabolic factors beyond blood glucose that are involved in the pathogenesis of diabetic kidney disease include advanced glycation end-products and the aldose reductase system. Haemodynamic factors, renin-angiotensin system, endothelial system, and nitric oxide system, the intracellular signaling molecule protein kinase C are also related to diabetic kidney disease. Other factors are the respective roles of transforming growth factor beta (TGF-β), which has been recognized as a central player in the diabetic nephropathy being involved in the development of glomerulo-sclerosis and interstitial fibrosis, as observed in the course of end-stage renal

disease (Gomes, Rodrigues, and Fernandes, 2014). Other factors includes a type of protein consists of a variety of cytokines expressed in many different cell types that controls proliferation (Burks and Cohn, 2011), and also a cellular differentiation and other function in most cells which plays a role in immunity, diabetes and heart disease (Burks and Cohn, 2011). Serum transforming growth factor beta (TGF-β) level is increased in T2DM and certain diabetic complications are mediated by this cytokine (Genc, Karadurmus, Kisa, Tapan, Naharci, Sonmez and Dogru, 2010), and vascular endothelial growth factor, and platelet-derived growth factors (Schrijvers, DeVriese and Flyvbjerg, 2004). In people with T2DM that do not show sym23ptoms of overt nephropathy, but are at high risk for cardiovascular disease, progression of renal insufficiency is slow based on changes in creatinine levels. On the basis of reaching threshold levels of renal function, progression rates are clinically meaningful, especially considering population life expectancy.

The pancreatic beta-cells secrete insulin in response to fluctuations in circulating glucose concentrations to stimulate glucose uptake into peripheral organs. β-cell failure represented by insufficient insulin secretion and impaired action of insulin to stimulate glucose uptake known as insulin resistance that both contribute to hyperglycemia, precede the development of T2DM (Cerf, Chapman, and Louw, 2012). β-cell dysfunction and insulin resistance are inherently complex with their interrelation for triggering the pathogenesis of diabetes that induce hyperglycemia and therefore increase insulin demand (Cerf, 2013).

These complications progress gradually with time until the body fails to maintain glucose haemostasis resulting in glucose intolerance, this is because the insulin is either not sufficient to convert the blood sugar or the insulin cannot support the process (Al-Rawi, 2011). This elevation in glucose level is as a result of impaired response to insulin or insulin resistance and may lead to detrimental effects through several pathways

(Pedersen and Saltin, 2006). β-cell dysfunction results from inadequate glucose sensing to stimulate insulin secretion, therefore, elevated glucose concentrations prevail. If glucose concentration is persistently elevated above the physiological range, it may result in the manifestation of hyperglycaemia (Cerf, 2013). Insulin resistance causes impaired glucose tolerance and 40% of persons with impaired glucose tolerance develop T2DM within 5–10 years, while some will remain insulin resistant and others will regain normal glucose tolerance (Gao, Ferguson, Connell, Walshe, O'Brien, Redmond, and Cahill, 2014). β-cells are dynamic and altered in response to fluctuating metabolic demand for insulin. β-cells hypertrophy and hyperplasia occur during β-cell compensation to increase beta cell mass in response to hyperglycaemia in diabetogenic states (Cerf, Chapman, and Louw, 2012). Insulin resistance could lead to an increase in fasting plasma glucose (FPG) that secondarily causes a defect in β-cell function. Alternatively, a primary decrease in β-cell function which may be due to a functional defector to a loss in β-cell mass, could result in an increase in FPG, and the resultant increase in FPG could feed back to further impair β-cell function (Abdul-Ghani, Matsuda, Jani, Jenkinson, Colettea, Kaku, and DeFronzo, 2008).

Subjects that have lost >80% of their β-cell function in the upper tertile of impaired glucose tolerance (IGT) are maximally or near-maximally insulin resistant and in addition to muscle, liver, and β-cells, accelerated lipolysis in adipocytes, incretin deficiency or resistance in the gastro-intestinal tract, hyperglucagonemia, increased glucose reabsorption in the kidneys, and insulin resistance and neurotransmitter dysregulation in the brain, play important roles in development of glucose intolerance in T2DM individuals (DeFronzo et al, 2013). The frequency of other risk factors, for example, overweight, hypertension and dyslipidaemia, is high in patients with impaired glucose tolerance (Pedersen and Saltin, 2006). Dyslipidaemia is an independent risk factor for kidney disease because dyslipidaemia accelerates the risk for chronic kidney

disease (Toyama, Sugiyama, Oka, Sumida, Ogawa, 2010). The combination of multiple risk factors is likely to create a particularly unstable environment to the patient (Katz, Leiter, Mellbin, and Rydén, 2014). Both hyperglycaemia and hypoxia play essential pathophysiological roles in diabetes (Gao, *et al*, 2014). Although type 2 diabetes mellitus is defined based on hyperglycemia, its underlying pathophysiology is that of a pro-thrombotic milieu in which a raft of risk factors, including insulin resistance, high triglycerides, low high-density lipoprotein cholesterol, increased visceral fat and a pro-inflammatory environment, exacerbates the deleterious effects of hyperglycaemia on the entire vascular system (Katz *et al*, 2014). Systemically these perturbations are accompanied with changes in a variety of biochemical processes such as obesity, an altered lipid profile and lipid perioxidation (Al-Rawi, 2014), with acute coronary syndromes associated with increased risk in this population that represents potential targets for treatment against cardio-metabolic risk factors, including hyperglycaemia, insulin resistance, atherogenic dyslipidaemia, increased visceral fat and inflammation (Katz et al, 2014).

Abnormally increased levels of lipids, lipoproteins and lipid peroxides in plasma may be due to the abnormal lipid metabolism, and the patients frequently have an abnormal blood lipid profile consisting of moderately elevated low density lipoprotein cholesterol, moderately decreased high density lipoprotein cholesterol, and triglycerides (Al-Rawi, 2011: Gao *et al*, 2014). Inadequate levels of high density lipoprotein cholesterol, in conjunction with more atherogenic forms of low density lipoprotein cholesterol may contribute to atherogenesis (Wright Scism-Bacon, and Glass, 2006) Studies in experimental animals conducted by Abdul-Ghani (2) *et al*, (2008), demonstrated that the FPG begins to rise only when >80% of β-cell mass is lost. Based upon recent studies in humans that demonstrated that individuals with impaired fasting glucose (IFG) have no more than a 50% reduction in β-cell volume, it seems unlikely

that decreased β-cell mass alone, in the absence of a concomitant reduction in β-cell function, could explain the rise in FPG observed in the present study in individuals with IFG (Cerf, Chapman, and Louw, 2012) With systemic insulin resistance, insulin signalling within glucose recipient tissues is defective therefore hyperglycaemia perseveres and beta cell dysfunction supersedes insulin resistance in inducing diabetes. Both pathological states influence each other and presumably synergistically exacerbate diabetes (Al-Rawi, 2011: Gao *et al*, 2014; Katz *et al*, 2014). An increase in abdominal fat accumulation and loss of muscle mass are highly associated with the development of insulin resistance (Ivy, 1997) Hypertension often occurs together with insulin resistance and hyperinsulinemia (Maeda, Inoguchi, Takei, Sawada, Sasaki, Fujii, Kobayashi, Urata, Nishiyama, and Takayanagi, 2010).

Preserving β-cell function and insulin signaling in beta cells and insulin signalling in the glucose recipient tissues will maintain glucose homeostasis this is because alpha cells secrete glucagon which is antagonistic to insulin and help to regulate glucose homeostasis (Cerf, Chapman, and Louw, 2012) β-cell compensation occurs to restore beta cell physiology but optimal control of blood glucose concentrations depends on subtle changes in insulin synthesis and secretion by β-cells and on their capacity for large increases in secretion after meals, requiring large stores of insulin (Cerf, *et al*, 2011; Gao *et al*, 2014; Katz *et al*, 2014)

2.2.3. Complications of Type 2 Diabetes Mellitus

Hyperglycemia is the most common characteristic of type 2 diabetes mellitus which is resulting from defects in insulin secretion, insulin action, or both. The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction and failure of various organs, especially the eyes, kidneys, nerves, heart and blood vessels. The rapidly increasing population growth, aging, urbanization and increasing prevalence of

obesity and physical inactivity has made Type 2 diabetes mellitus a global health problem (Dabla, 2010).

T2DM complications can be classified broadly as microvascular or macrovascular disease. Microvascular complications include neuropathy (nerve damage), nephropathy (kidney disease) and vision disorders, for example, retinopathy, glaucoma, cataract and corneal disease) (Liu, Fu, Wang, and Xu, 2010; Anas, 2011). Macrovascular complications include heart disease, stroke and peripheral vascular disease, which can lead to ulcers, gangrene, and amputation. The complications include infections, metabolic difficulties, impotence, autonomic neuropathy and pregnancy problems (Anas, 2011; Futrakul and Futrakul, 2011). Common complications of type 2 diabetes mellitus are; cataract formation, glaucoma, blindness, dental caries, still-birth/miscarriage, neonatal death, congenital defects, cardiovascular disease, kidney disease, gangrene, and impotence (Sims, 2007). Over time, high blood glucose levels can cause damage to virtually every organ system of the body, including central nervous system, vision, cardiovascular, kidney, skin, sexual, teeth and gums, and musculo-skeletal system (Anas, 2011; Futrakul and Futrakul, 2011; Kartz, *et al*, 2014).

Chronic complications are the major outcome of T2DM progress, which reduce the quality of life of patients, incur heavy burdens to the health care system, and increase diabetic mortality (Liu *et al*, 2010). Complications of T2DM are of two major types; short term complications; and long term complications. Short term complications includes; diabetic ketoacidosis, hyperosmolar non ketotic coma and hypoglycemia and the long term complications are; arteriosclerosis, diabetic nephropathy, diabetic retinopathy, micro-angiopathy, diabetic neuropathy, infections, heart disease and stroke. In a study conducted by Liu *et al,* (2010) it was conclude that chronic complications are highly prevalent among type 2 diabetic outpatients, the glycemic control of diabetic patients with chronic complications was poor, and future efforts should be directed at

intensive blood glucose control, strengthening early diagnosis and improving case management to prevent and minimize the occurrence of complications (Usman *et al*, 2010; Anas, 2011; Liu *et al*, 2010; Futrakul and Futrakul, 2014).

2.3.0. Risk factors of Kidney Disease in Type 2 Diabetic Mellitus

The kidneys play several vital roles in maintaining health. One of their most important jobs is to filter waste materials from the blood and expel them from the body as urine. The kidneys also help control the levels of water and various minerals in the body (Hawkins, Richardson, Fried, Arena and Kriska, 2011). T2DM is characterized by insulin resistance, which is the failure to respond to normal concentrations of insulin, and this is accompanied by compensatory hyperinsulinaemia, although the kinetics of insulin secretion gets abnormal very early. In later stages, β-cell secretion fails to overcome insulin resistance, and an increased lipolysis with fatty acid release and accumulation of fat in parenchymal organs further aggravate the metabolic disturbance (Wolf and Ritz, 2003). Older patients with T2DM may also have vascular and tubule-interstitial changes due to the presence of comorbid conditions, including long-standing hypertension and renal vascular disease and potential senescence of glomeruli due to ageing itself (Kramer and Molitch, 2005). The incidence of chronic complications in T2DM patients is significantly associated with the degree of hyperglycaemia, as measured by the plasma glucose level, and according to a cohort study, a one percent (1%) reduction in average blood plasma glucose was associated with reductions of fourteen percent (14%) for myocardial infarction and thirty seven percent (37%) for microvascular complications (Liu *et al*, 2010)

Studies have found decreased glomerular filtration rate (GFR) in the absence of increased urine albumin excretion in a substantial percentage of adults with type 2 diabetes mellitus, but without kidney biopsies, investigators can only speculate on the

etiology of decreased GFR in the absence of increased urine albumin excretion. Pathologic evidence of diabetic nephropathy has been documented in adults with diabetes even in the absence of increased urine albumin excretion (Atkins, *et al*, 2003; Wolf and Ritz, 2003; Stevens *et al*, 2006; Futrakul and Furakul, 2011). Renal microvascular disease is a progressive entity in Type 2 diabetes that usually remains asymptomatic, and is recognized only when the disease is associated with advanced renal insufficiency. Accumulating evidence supports the correlation between renal microvascular rarefaction and the progression of tubulointerstitial disease (Futrakul and Futrakul, 2011).

2.3.1. Kidney Disease in Nigeria

Most forms of progressive renal disease lead to a common end point: the end stage kidney renal failure, which is usually characterized with fibrotic and reduced mass, this is an important cause of morbidity and mortality in Nigeria (Alebiosu *et al*, 2006). Kidney damage is a major determinant for the development of progression of accelerated atheroscelerosis, ischaemic vascular disease and death from cardiovascular effects on the essential kidney functions. Individuals with even the earliest signs of CKD are the inreased risks of cardiovascular disease and may die long before they reach ESRD (Ulasi and Ijioma, 2010). Some 15,000 new cases of kidney failure occur every year in Nigeria, the statistics have further showed that 30 million Nigerians are suffering from Kidney disease and currently, patients pay high charges for sessions of dialysis every week; costs of transplant varies from hospitals and a patient needs so much money monthly to get immunosuppressive drugs after a successful transplant (Obinna, 2013). However, health watchers have expressed worry that a country still battling with a myriad of health issues, kidney disease has remained at the background, while patients continue to die without any form of assistance (Usman *et al*, 2012; Obinna, 2013). The magnitude of the existing

burden of illness caused by renal failure, the projections for increasing incidence of ESRD, and the limitations of the existing treatments for renal insufficiency in Nigeria all point to the need for clinical and population-based interventions aimed at prevention of ESRD (Alebiosu *et al*, 2006).

Chronic kidney disease (CKD) is one of the most common complications of diabetes mellitus and screening for CKD is not routinely performed in many diabetic clinics in sub-Saharan Africa due to limited diagnostic resources, in particular, microalbumin testing is available in very few centers. (Janmohamed, Kalluyya, Mueller, Kabangila, Smart, Downs, and Peck, 2013)). Renal failure ranks high among killer illnesses in Nigeria, but unlike malaria and HIV/AIDS, it is often ignored. In the past, kidney issues were considered as exclusive disease of the aged, particularly in Nigeria. Today, more Nigerians, children inclusive, are coming down with the ailment (Enengedi, 2013). Most patients in Nigeria were able to afford only three sessions of haemodialysis because the total cost of dialysis is borne by the patients is on the high side. In one Nigerian study according to Alebiosu *et al*, (2006), 70.8% of patients were able to remain on dialysis for less than 1 month, 12.7% for between 3 and 6 months, 5.1% for between 7 and 12 months and only 1.9% remained on dialysis for over 12 months.

2.3.2. Kidney and Cardiovascular Health

The kidneys are highly vascular organs receiving 20% of resting blood volume. Often people who have diabetic nephropathy also have high blood pressure. As plasma flows through and is filtered by the kidney, the rate of plasma clearance over a unit of time glomerular filtration rate or GFR) can be used to assess kidney function. In normal kidneys, the GFR is between 90-130 mL/min/1.73m^2. After the age of 40, GFR decreases by approximately 8 mL/min/1.73 m^2 a decade (Stevens *et al.*, 2006; Liu *et al*., 2010).

There are also other factors such as diabetes and hypertension which can hasten this decline in GFR that will be discussed in more detail later (Lui *et al*., 2010).

The functional units of the kidneys where filtration actually occurs are called nephrons. Each kidney has about one million nephrons, more than what the body needs to sustain normal filtration. The overall GFR is the sum of all of the single nephron GFR's. The nephrons consist of a glomerulus, where filtration occurs, and tubules, which play a role in secretion and re-absorption of molecules. The size or structure and ionic charge of the glomerular basement membrane is important in controlling the filtration of water and smaller molecules, providing a barrier against filtration of larger molecules (Atkins *et al*., 2003). However, when larger molecule such as albumin is able to pass through this barrier, this may indicate a loss in the charge and/or size selectivity barrier (Futrakul and Futrakul, 2011). Changes in filtration result from changes in membrane permeability and can also be the result of changes in pressure in the glomerulus. The pressure is controlled by constriction or dilation of the afferent and efferent arterioles (Delanaye and Ebert, 2012). The inability of the kidneys to concentrate the urine in response to restricted fluid intake, or to dilute the urine in response to increased fluid intake during osmolarity testing, may indicate decreased kidney function. Anderson (2012), explained that, the kidneys normally excrete almost no protein in the urine therefore its persistent presence in amounts that exceed the normal 24-hour urine value, usually indicates some type of kidney disease. As nephrons become non-functional by disease, the response will increase the pressure in the remaining nephrons (Andersen, 2012; Bevc *et al.,* 2012). In the long-term the increase in pressure may lead to damage of the remaining nephrons and thus contributes to progression of kidney disease (Prigent, 2008). Diabetic nephropathy is the kidney disease that occurs as a result of type 2 diabetes mellitus. Cardiovascular and renal complications share common risk factors such as blood pressure, blood lipids, and glycemic control. The markers of diabetics

nephropathy in diabetic patients are serum glucose, creatinine clearance, urinary albumin and blood pressure (Usman *et al.,* 2012), The human body carries out an important process of breaking down material to be utilized for energy, maintaining cell structure, as well as other important functions, in this process of metabolism, waste products are generated that need to be removed from the body and the kidneys major function is to remove these wastes from the body. The kidney has other important functions which help to maintain chemical balance in the body through the secretion and degradation of enzymes and hormones, as well as regulating the body's fluid volume and electrolyte balance. The kidneys are involved with the secretion of erythropoietin and calcitriol, which has important functions in red blood cell formation and bone health. Diabetic nephropathy usually causes no symptoms, and people who have the condition often produce normal amounts of urine (Bakris, 2014), but their filtering system breaks down. To detect diabetic nephropathy, healthcare providers rely on tests that measure protein levels in the urine and blood tests to evaluate the level of kidney function. (Usman *et al.*, 2010). When the kidneys are functioning normally, they prevent protein from leaking into the urine, so detecting protein in the urine is a sign that the function of the kidneys is impaired (Andersen, 2012; Bevc *et al*., 2012)

Kidney function test is a collective term for a variety of individual tests and procedures that can be done to evaluate how well the kidneys are functioning (Prigent, 2008). The kidneys are the body's natural filtration system that perform many vital functions, including removing metabolic waste products from the blood stream, regulating the body's water balance, and maintaining the pH (acidity/alkalinity) of the body's fluids (Ulasi and Ijioma, 2010). Approximately one and a half quarts of blood per minute are circulated through the kidneys, where waste chemicals are filtered out and eliminated from the body (along with excess water) in the form of urine (Stevens, Coresh, Greene and Levey, 2006). Many conditions can affect the ability of the kidneys

to carry out their vital functions, some conditions can lead to a rapid (acute) decline in kidney function; others lead to a gradual (chronic) decline in function, however, both can result in a build -up of toxic waste substances in the blood (stevens, et al, 2006; Howkins, 2010). The kidneys have an important function for regulating blood pressure by secreting renin which activates the renin-angiotensin system (RAS), while the body's fluid volume is regulated by controlling the amount of water and sodium that are excreted in the urine (Soares, Eyff, Campani, Ritter, Camargo and Silveiro, 2009). The regulation of fluid volume and electrolyte balance, for example potassium and magnesium levels, have important implications for a number of the body's functions including, blood pressure, cardiac output, and cell membrane potentials and excitability (Stevens, *et al.*, 2006; Soares *et al.*, 2009; Howkins, 2010).

The main problem of type 2 diabetes mellitus management is its serious micro-and-macrovascular complications, which include, among others, diabetic nephropathy (Mega, Teixeira de Lemos, Vala, Fernandes, Oliveira, Mascarenhas-Melo, Teixeira, and Reis, 2011) Diabetic nephropathy affects 40 % of type 1 or type 2 diabetic patients, and is the leading cause of end-stage renal disease (Afsar, 2013). T2DM nephropathy is one of the major long-term micro-vascular complications occurring in nearly 40% of diabetic patients and also a major cause of end-stage kidney disease (ESKD) throughout the world. It is assumed that the number of T2DM and diabetic nephropathy patients is increasing and that more and more patients will experience progressive renal disease due to lack of effective treatments (Tomino, Cooper, Kurtz, and Shimizu, 2012). It increases the risk of death mainly from cardiovascular causes (ADA and ACSM, 2010). Although the aetiology of this insidious disorder is not well understood, hyperglycemia and hypertension may play pivotal roles in the pathogenesis of diabetic nephropathy, while increasing evidence indicates that inflammatory and immune response mechanisms may

contribute significantly to the development and progression of diabetic nephropathy (Murakoshi, Gohda, Tanimoto, Funabiki, Horikoshi, and Tomino, 2011).

The earliest clinical evidence of nephropathy is micro-albuminuria (ADA and ACSM, 2010). Deregulation of protein synthesis, processing, and degradation underlie the development of renal matrix changes induced by hyperglycaemia in T2DM. (Mariappan, 2012). Without specific interventions, micro-albuminuria may progress to overt nephropathy in years (ADA and ACSM, 2010). A higher proportion of individuals with T2DM are found to have microalbuminuria and overt nephropathy shortly after the diagnosis of their diabetes, because diabetes is actually present for many years before the diagnosis (Mariappan, 2012). The pathogenesis of type 2 diabetic nephropathy includes genetic, metabolic (hyperglycaemic), and/or haemodynamic factors such as glomerular hypertension and associated renal hypertrophy (Tomino, Cooper, Kurtz, and Shimizu, 2012). High blood glucose level can start series of complicated pathophysiological processes (Mariappan, 2012). Hyperglycaemia, increased blood pressure levels, and genetic predisposition are the main risk factors for the development of diabetic nephropathy. Accumulation of advanced glycosylation end-products and changes in glomerular mesangium structure may contribute to renal damage (ADA and ACSM, 2010). Therefore, regulation of blood glucose may ameliorate the progression of diabetic nephropathy (Andersen, Jodal, Erlandsen, Morsing, Frokier, and Brochner, 2013). The importance of hyperglycaemia in renal injury was confirmed by the Diabetes Control and Complications Trial and the United Kingdom Prospective Diabetes Study, which demonstrated that diabetic kidney disease can be prevented by keeping blood sugar in target range; however, this is difficult to achieve (Mariappan, 2012).

Diabetes can affect many parts of the body, including the kidneys, in healthy kidneys, many tiny blood vessels that filter waste products from the body, the blood vessels have holes that are big enough to allow tiny waste products to pass through into

the urine but are still small enough to keep useful products (such as protein and red blood cells) in the blood (ADA, 2013). High levels of sugar in the blood can damage blood vessels if diabetes is not controlled, and can cause kidney disease, which is also called nephropathy. If the damage is severe enough, the functions of the kidneys may be arrested (Alebiosu, et al, 2006: Christian and John, 2002). High blood sugar can overwork the kidneys, which over time damage them and after many years, they start to leak small amounts of protein (albumin) into the urine, which indicates that the kidneys are damaged, but not everyone with diabetes develops kidney disease (Deshpande, Harris-Hayes, and Schootman, 2008). Factors that can influence kidney disease development include genetics, blood sugar control, and blood pressure, and the better a person keeps diabetes and blood pressure under control, the lower the chance of getting kidney disease (Andersen, et al 2013). Up to 35% of new patients beginning dialysis therapy have T2DM (Deshpande, Harris-Hayes, and Schootman, 2008), the impact of diabetes on renal impairment changes with increasing age, serum markers of glomerular filtration rate and micro-albuminuria identify renal impairment in different segments of the diabetic population, indicating that serum markers as well as micro-albuminuria tests should be used in screening for nephropathy in diabetic older people (Dabla, 2010).

Diabetic kidney disease takes many years to develop in some people due to the filtering function of the kidneys which is actually higher than normal in the first few years of their diabetes. According to the National Kidney and Urologic Disease Information Clearinghouse (NKUDIC, 2006), this process has been called hyper filtration, a complication that occurs in some people with diabetes and can progress to kidney failure in some cases, treatment of which mostly aims to prevent or delay the progression of the disease and to reduce the risk of developing cardiovascular diseases such as heart attack and stroke which are much more common than average in people with this disease (ADA, 2013). In a study conducted, Adler, Stevens, Manley, Bilous,

Cull and Holman, (2003), reported that the proportion of patients with T2DM mellitus who develop micro-albuminuria was substantial with one quarter affected by 10 years from diagnosis and relatively fewer patients develop macro-albuminuria, but in those who do, the death rate exceeds the rate of progression to worse nephropathy. Chronic glomerulonephritis, hypertensive nephron-sclerosis (hardening of the walls of the small arteries that convey blood from arteries to the even smaller capillaries of the kidneys caused by hypertension), and diabetes mellitus are the commonest causes of chronic renal failure in Nigeria. Most patients are presented late. Cardiovascular complications and infections were mostly responsible for a greater morbidity among the patients (Bevc, Hojs, Ekart, Gorenjak, and Puklavec, 2012). The main functions of the kidneys are to remove waste products and excess water from the body and to produce important hormones such as erythropoietin (which helps form red blood cells), a loss of these functions causes kidney disease; with many factors contributing such as diabetes, high blood pressure, blood vessel disease, and inflammation of the blood vessels in the kidney (Bakris, Sharma, and Ecelbarger, 2011; Delanaye, 2012). Diabetic nephropathy is a leading cause of kidney failure and one of the key complications of diabetics, defined by either micro-albuminuria that is a urinary albumin excretion greater than 300 mg in a 24 hour collection or by abnormal renal function as presented by an abnormality in serum creatinine, calculated creatinine clearances or glomerular filtration rate in diabetic patients (Usman *et al*., 2012). Patients with history of diabetes mellitus, proteinuria, diabetic retinopathy and normal or increased renal sizes on ultrasound were classified as having diabetic nephropathy (Alebiosu, Ayodele, Abbas, and Olutoyin, 2006). Multiple connections and interactions between diabetes and the kidney function includes:

i. The kidney accounts for one-third to one-half of the metabolic clearance of insulin and glucagon;

ii. Glycosuria is a defence mechanism against hyperglycaemia controlled by an intricate glucose sensing and glucose transport system;

iii. The kidney is affected by insulin resistance; and on the other hand poor kidney function affects insulin regulation;

iv. The kidney is capable of gluconeogenesis and, in certain conditions, contributes substantially to total-body glucose release, (Usman, *et al*., 2012; Adebayo, 2013).

The main protein that leaks out from the damaged kidneys is called albumin, which in a normal healthy kidneys only a tiny amount of albumin is found in the urine. A raised level of albumin in the urine is the typical first sign that the kidneys have become damaged by diabetes. Diabetic kidney disease is divided into two main categories, depending on how much albumin is lost through the kidneys:

i. Micro-albuminuria; when the amount of albumin that leaks into the urine is between 30 and 300 mg per day. It is sometimes called incipient nephropathy.

ii. Proteinuria; when the amount of albumin that leaks into the urine is more than 300 mg per day. It is sometimes called macro-albuminuria or overt nephropathy.

Urine test for protein is conducted and if there is protein in the urine, this could mean that the diabetes has damaged the holes in the blood vessels of the kidneys. This makes the holes big enough for protein and other nutrients needed by the body to leak into urine. blood test may also be taken to see how much damage has been done to the kidneys (Family Doctor, 2014). Kidney function tests help to determine if the kidneys are performing their tasks adequately, a number of clinical laboratory tests that measure the levels of substances normally regulated by the kidneys can help to determine the cause and extent of kidney dysfunction, and commonly urine and blood samples are used for these tests. Serum glucose level, creatinine clearance, and microalbuminuria and other clinical data including the age of the patients, with history of diabetes are important

markers in assessing kidney function of diabetics (Han, Bai, Lin, Sun, and Chen, 2010). In people with T2DM, but without overt nephropathy, who are at high risk for cardiovascular disease, progression of renal insufficiency is slow on the basis of changes in creatinine levels. On the basis of reaching threshold levels of renal function, progression rates are clinically meaningful, especially considering population life expectancy (Mann, Gerstein, Franke, Lonn, Hoogwerf, Rashkow and Yusuf, 2003).

2.3.3 Aetiology of Kidney Problem in Type 2 Diabetes Mellitus

Diabetes, particularly T2DM, is the most common cause of ESRD requiring chronic renal replacement therapy and that it has generally been accepted by the medical community that kidney disease among adults with T2DM follows the some clinical course and that increased urine albumin excretion is the earliest clinical evidence of kidney disease in this population (Stevens, Coresh, Greene, and Levey, 2006). While albuminuria may be a suitable test for general population screening for renal and cardiovascular disease, it should not replace testing for proteinuria in those with known or suspected renal disease (Atkins, Briganti, Zimmet, and Chadban, 2003). Persistently increased levels of urine albumin excretion 30 –299 mg/24 h or spot urine albumin-to-creatinine ratios 30–299 mg/g indicate the presence of microalbuminuria while urine albumin excretion levels higher than this (300 mg/24 h or albumin-to creatinine ratio 300 mg/g in a spot urine sample) denote macroalbuminuria (also called clinical albuminuria or clinical proteinuria) (Stevens, Coresh, Greene, and Levey, 2006). Information on presence of urine albumin excretion in addition to level of glomerular filtration rate (GFR) may be used to stage CKD according to the National Kidney Foundation (NKF), and it is worthwhile to review how this staging system applies to people with diabetes (Mann, *et al*, 2003; Liu, *et al*,2010: Andersen *et al*, 2013).

Proteinuria is a condition that is often associated with diabetes, especially those who have been living with diabetes for several years. It is one of the complications that can result from diabetes and is an indicator that patient's kidneys are not properly filtering blood. Protein is necessary for the body to function properly: It is used to help protect the body from infection, help blood to clot, build muscle and bones, and keep the appropriate amounts of fluid circulating in the body, among other functions. One of the kidney's main tasks is to filter out waste products while at the same time leaving the proteins in the blood so they can be used for all of the above functions. When the kidney's filtering system (called glomeruli) begins to break down, small (micro) amounts of protein (also called albumin) get passed into the urine and this is a sign of chronic kidney disease which intensive diabetes therapy can significantly reduce the risk of its development (Adler, *et al,* 2003: Alebiosu, *et al,* 2006: Afsar, 2013)

2.3.4 Oxidative Stress in Type 2 Diabetics Kidney Function

Diabetic kidney problem is the leading cause of renal failure worldwide and is associated with an increased risk of cardiovascular events. Mast cells are present in human kidneys, and it is reported that their number increases in a variety of renal diseases, including diabetic nephropathy (Maeda *et al*., 2010). Oxidative stress is acknowledged as an important pathogenic factor in the development of diabetic vascular complications, including nephropathy. (Wright *et al.*, 2006). The production of angiotensin may play important role in the enhancement of oxidative stress in diabetic kidney, thus contributing to the development of diabetic nephropathy (Maeda *et al.*, 2010). The overproduction of intracellular oxidative stress in response to hyperglycaemia can occur in mitochondria if the intake of metabolic substrate from glucose overwhelms the mitochondrial electron transport system (Taneda, Honda, Tomidokoro, Uto, Nitta, and Oda, 2010). Oxidase, a major source of reactive oxygen species (ROS), is stimulated

by high glucose and its expression in the kidney was associated with the hyperglycemic state while its inhibition may prevent renal injury (Maeda *et al*., 2010). The occurrence of ROS-induced lipid peroxidation causes considerable changes in the cell membrane. In T2DM antioxidant levels may be assessed through measuring the salivary and serum concentration of uric acid, superoxide dismutase and reduced glutathione (Al-Rawi, 2011).

Accumulating evidence suggests that the intra-renal renin-angiotensin system may be involved in the progression o.f diabetic nephropathy (Maeda *et al*., 2010). Endothelial cells support a putative role for glucose in modulating vascular cell growth under hypoxic conditions mechanism a response that may have important implications for the tissue's capacity to adapt to low oxygen tensions under hyperglycaemic conditions (Gao *et al,* 2014). The causative factors of diabetic retinopathy, neuropathy and arteriosclerosis include hyperglycaemia and hypoxia which is primarily because blood glucose is strongly associated with morbidity after an acute hypoxic challenge, that is, acute myocardial infarction, suggesting a potential deleterious influence of hyperglycaemia on the tissue's capacity to adapt to low oxygen tensions (Gao *et al.*, 2014). Evidence suggests that oxidative stress is increased in diabetes because hyperglycaemia is reported to augment oxidative stress due to excessive production of reactive oxygen species and an impaired antioxidant defence mechanism (Al-Rawi, 2011: *Gao et al.*, 2014). Peroxidation of the lipid membrane has been related to the pathogenesis of many degenerative diseases, such as diabetes mellitus (Wright *et al.*, 2006). The lipid peroxide in the blood provides useful information for the prognosis of diabetes in which secondary disorders are often fatal (Katz *et al.*, 2014).

The significant decrease in serum and salivary superoxide dismutase and reduced glutathione (GSH) as well as increase or decrease of other antioxidants reflects the overwhelming adaptive response to the challenge of oxidative stress in the diabetic state

with or without complication. Diabetic humans have shown increased lipid peroxidation (Maeda *et al.*, 2010). Levels of antioxidants among diabetics may be explained on the basis that the existence or increased free radicals production may enhance the antioxidant defence system which counter-balances the pro-oxidant environment (Al-Rawi, 2011). Oxidative stress exists in diabetic patients as evidenced by the increased total antioxidant capacity in the saliva and blood of patients. Indeed, there is evidence that suggests that endogenous antioxidant capacity is eroded in diabetes, due to several factors, including the impact of non-enzymatic glycation on key enzymes, the polyol pathway and its consumption of reducing power, as well as the constant demands of oxidative stress (Wright *et al.*, 2006; Maeda *et a*.l, 2010). The assay of salivary oxidative stress parameters has brought substantial insight into the pathogenesis and evolution of diabetes (Maeda *et a*.l, 2010).

Lipid peroxidation and antioxidant parameters assessed in saliva of diabetic patients may be of great importance in evaluating the disease activity and severity (Wright *et al.*, 2006). The increase in lipid peroxidation and the tendency of antioxidants to rise in diabetes is probably due to an adaptive response to the pro-oxidant status of diabetes (Maeda *et al.*, 2010). Hypoxia is a reduction in oxygen delivery below tissue demand and can be either acute or chronic and effects on the stress activator response can cause a reduction in the expression of the anti-apoptotic protein (Gao *et al*., 2014). Accumulation of advanced glycosylation end products and changes in glomerular mesangium structure may contribute to renal damage (Kurdak, Sandikci, Ergen, Dogan and Kurdak, 2010).

2.4.0 Effects of Aerobic Exercise in T2DM

Aerobic training in patients with type 2 diabetes mellitus is feasible, well tolerated, and beneficial and individualized exercise prescription offers an ideal opportunity to account for both cardiac and non cardiac considerations in T2DM (Marwick, Hordern, Miller, Chyun, Bertoni, Blumenthal, Philippides, and Rocchini, 2009). Aerobic training has the ability to impact beneficially on the comorbidities associated with diabetes mellitus and chronic kidney disease and is accepted as an important intervention in the treatment, prevention and rehabilitation of other chronic diseases, however, the role of exercise in kidney function is overlooked (Gould, Graham-Brown, Watson, Viana, and Smith, 2014). In T2DM, exercise training may also improve control over hepatic glucose production (Ivy, 1997), and enhance β-cell function (Barcellos, *et al,* 2012*;* Adams, 2013*;* Ann, 2013). Physical activity exerts pronounced effects on substrate utilisation and insulin sensitivity, which in turn potentially lowers blood glucose and lipid levels, and improves many other physiological and metabolic abnormalities associated with T2DM such as lowering body fat, reducing blood pressure and normalising dyslipoproteinaemia (Ivy, 1997; Barcellos, *et al,* 2012*;* Adams, 2013). Moderate-intensity exercise has shown effects on the improvement of insulin sensitivity (Pedersen and Saltin, 2006).

Optimal control of hyperglycaemia is a highly-desirable approach in the treatment of diabetic complications, including nephropathy. The difficulty in achieving this goal due to inability to adhere to therapeutic regimens and adverse effects of intensive glucose control regimens require us to find additional therapeutic avenues (Mariappan, 2012). A number of large-scale studies have demonstrated the beneficial effect of strict glycaemic control, by implementing intensive treatment with the aim to maintain blood glucose concentrations close to normal range, on slowing the development of nephropathy in type I and II diabetes (Vos, Schollum and Walker, 2011).

It has demonstrated that adding a structured exercise intervention to already physically active type 2 diabetics improved glucose control over 12 weeks and in addition, improvement in resting blood pressure and exercise capacity were also observed in the exercise group and these improvements occurred without weight loss (Yan, Prista, Ranadive, Damasceno, Caupers, Kanaley and Fernhall, 2014). T2DM results in the diminished capacity of the pancreas to secret insulin in response to a given glucose stimulus, and/or the decreased capacity of the cells to respond to insulin and increase glucose uptake (Robergs and Ketiyian, 2003). The net result of either condition is the same; that of an increased blood glucose concentration, a decreased ability to use glucose as a fuel, and subsequent alteration in the metabolism of carbohydrate, fat and protein. The reduced ability to use blood glucose causes large increases in blood triglycerides, and therefore increases risk for coronary heart disease. However, the connection between T2DM and being over fat indicates the main aspect of treatment- diet and exercise, to lower blood lipids, decrease body fat, improve cardiovascular function, and increase the ability of skeletal muscles to use glucose without the need of insulin. Marwick et al (2009) explained that the key elements of the type of exercise training to be performed by individuals with T2DM are those specific to combating diabetes risk factors. The unique benefits of exercise training to individuals with type-2 diabetes mellitus, is its ability to allow skeletal muscles to take up glucose without the need for insulin (Barcellos, *et al,* 2012*;* Adams, 2013). The response to exercise training is localized to the muscles that are exercised (Yan, *et al.*, 2014), during a given bout of exercise the effects can be retained for extended periods of time if exercise training duration and frequency is repeated within 72 hours (Robergs and Ketiyian, 2003; Marwick, *et al.*, 2009).

In T2DM with low insulin secretion, an increased insulin secretion may result from physical training, perhaps due to accompanying sensitization of the autonomic nervous system (Krotkiewski, *et al*., 1985). Regular aerobic training enhances insulin

sensitivity in the exercised muscle and enhances muscle contraction induced glucose uptake (Gould *et a.l,* 2014), through mechanisms that include increased post receptor insulin signaling and protein, increased glycogen synthase activity, increased hexokinase activity, decreased release and enhanced clearance of free fatty acids, and enhanced influx of glucose to the muscles due to enhanced muscle capillarisation and blood flow (Yokohama *et al*., 2004: Pedersen and Saltin, 2006). Physical activity has beneficial effects on the endothelial dysfunction seen in patients with insulin resistance by increasing blood flow stress on the blood vessel wall, thereby stimulating endothelium derived nitric oxide, which induces smooth muscle relaxation and vasodilatation (Adams, 2013). Physical activity induces a decrease in blood pressure that typically lasts 4–10 h after cessation of exercise, but that may last 22 h. The blood pressure decrease averages 15 mm Hg systolic and 4 mm Hg diastolic (Painter, 2005). Peripheral insulin concentrations may not alter which suggests that the extra insulin produced is captured by the liver, this mechanism, and the improved peripheral insulin responsiveness seen in the whole body will also be at the cellular level, and both probably contribute to an improvement in glucose tolerance (Krotkiewski, *et al*., 1985) Aerobic exercise is a generally accepted therapeutic strategy for type 2 diabetes because it has beneficial effects not only on glycaemic profile, but also on reducing metabolic risk factors for cardiovascular diseases including insulin resistance (Yokohama *et al.*, 2004; Pedersen and Saltin, 2006; Anas, 2011).

In a 12-week exercise training differences were not significant in age, height, and baseline weight between the exercise and control groups. Systolic and diastolic blood pressures at the end of the intervention were significantly lower in the exercise group than control group after co-varying for the baseline values. Glycated haemoglobin (HbA1c) was significantly reduced in both groups combined, but there was no significant interaction effect. In response to the

glucose load, the exercise group had a significantly lower plasma glucose level than control group following the exercise training (Yan *et al.*, 2014). Regular exercise is especially important for a person with T2DM because it helps blood sugar control, weight loss, and high blood pressure. People with T2DM who exercise are less likely to experience a heart attack or stroke than diabetics who do not exercise regularly. Exercise, generally helps control blood glucose levels because exercising muscle cells use more sugar and oxygen than those at rest. Utilization of excess blood sugar, make exercise one of the easiest things to control the disease, other benefits that may accrue includes improved cardiovascular function, strength and better glucose control. Regular exercise is especially important for a person with diabetes because it helps in controlling blood sugar, weight loss, and high blood pressure. Type 2 diabetics who exercise are less likely to experience heart attack or stroke. This is relevant in both T1DM and T2DM, because it can increase insulin sensitivity, lower blood glucose, and have positive psychological effects. More markedly in type 2 than type 1, regular physical activity improves glycaemic control, reduces hypertension, and normalizes lipids (Taylor, Fletcher, and Tiarks, 2009). Study by Toyama, Sugiyama, Oka, Sumida and Ogawa, (2010) demonstrated that there are beneficial effects of exercise training, especially on renal function they added a structured exercise intervention to already physically active males with type 2 diabetes and this improved glucose control over 12 weeks. In addition, improvement in resting BP and exercise capacity were also observed in the exercise group and these improvements occurred without weight loss. In the study, the intensity and duration of the exercise training program met the recommendations made by public health guidelines for type 2 diabetes. Despite unchanged VO2 peak of exercise over the 12wks, aerobic exercise time during a VO2 max test was increased after training, indicating improvement in work capacity (Yan, Prista, Ranadive, Damasceno, Caupers, Kanalley. And FernHall (2014)

The general role of exercise particularly aerobic exercise, may include, extra spending of calories, which would be funded by carbohydrates and fats stored in the body. This indicates that excess glucose and fats will be utilized, (Anas, 2011). Subsequent generations of diabetes practitioners have established exercise as one of the four cornerstones of care (along with diet, medication and monitoring), and have come to learn a great deal more about the mechanisms by which exercise is able to provide such profound benefits for physical health, (Sims, 2008). Exercise lowers blood sugar by decreasing insulin resistance, a common problem in type 2 diabetes, in which cells do not respond properly to insulin. Insulin resistance reduces the amount of glucose that cells can absorb from the blood stream for energy, even when plenty of insulin is available. An exercise session lowers insulin resistance for about a day, so it is important to be active every day to maintain this benefit (Anas, 2011).

There are two main types or groups of exercise; aerobic and anaerobic. While Aerobic exercise implies a steady activity carried out over a long period of time and causes the body to utilize oxygen and makes the heart and lungs stronger, lowers blood lipids, lowers blood pressure, and use up blood sugar, examples are brisk walking, cycling, dancing, swimming, jogging, cross-country skiing, some team sports, etc. Anaerobic exercise on the other hand implies short burst of energy that strengthens one part of the body at a time, such as weight lifting. It builds muscles but does not strengthen the heart and lungs. It uses small amount of sugar that is insufficient to have substantial effect on blood glucose levels. Exercise can possibly reduce the amount of medication needed to treat diabetes or even eliminate the need for medication". It also provides relief from stress, which is the major contributing factor for raising blood sugar levels. Working up to 1,000 steps on cycle ergometer may be as effective as 10 minute walk. Three sessions a week, for 20-30 minutes per session, and gradually building up to 60 minutes may be beneficial to lose weight. 90 minutes of daily exercise is

recommended by the US Food and Drug Administration, considered a cornerstone for the management of diabetes, along with diet and medication. However, high quality evidence on the importance of exercise and fitness in diabetes was lacking until recent years, (Taylor, Fletcher, and Tiarks, 2009).

Today there is no longer any doubt that tight glycemic control prevents the onset or progression of diabetic nephropathy in type 2 diabetic patients (Wolf and Ritz, 2003). Aerobic exercise and training lead to numerous changes and/or adaptations in the normal physiological functioning of the body (Campbell and Anderson, 1987). For healthy living, a diabetic patient should measure his/her blood glucose level continuously, having appropriate nutrition and regular exercise. As exercise cause fitness, body flexibility, increase muscle tone, improving heart and lung function; also help keeping body weight which can relate to beneficial changes in insulin sensitiveness (Hejazi, Soltani, Zare, Nornematolahi, and Aminian, 2012) Several factors influence exercise fuel use, but the most important are the intensity and duration of physical activity which causes a shift from predominant reliance on free fatty acids (FFA) at rest to a blend of fat, glucose, and muscle glycogen, with a small contribution from amino acids (Adams, 2013). And with an increase in exercise intensity, a greater reliance on carbohydrate will increase as long as sufficient amounts are available in muscle or blood early in exercise (Barcellos, *et al*, 2012). Glycogen provides the bulk of the fuel for working muscles at the early stage of exercise and as glycogen stores become depleted, muscles increase their uptake and use of circulating blood glucose, along with FFA released from adipose tissue, depending on intensity and duration of the exercise (Ivy, 1997; Pizaaz, 2010; Anas, 2011; Ibrahim, 2012). Intramuscular lipid stores are more readily used during longer-duration activities and recovery, glucose production also shifts from hepatic glycogenolysis to enhanced gluconeogenesis as duration increases (Phillipides and Rocchini, 2009; Barcellos, *et al,* 2012*;* Adams, 2013).

Efficient respiratory and circulatory systems (including the heart) are essential for maintaining our quality life, and they are also essential to enable us to participate in sporting and recreational activities (Ibrahim, 2012). Different intensities of aerobic exercise training with different metabolic pathway cascades show different effects on the body (Kali, 2012). Furthermore, a weak heart and inefficient respiratory and circulatory systems are more susceptible to diseases that cause premature death (Ibrahim, 2012). Moderate and high intensity aerobic running are effective in controlling the resting state plasma fibrinogen whereas high intensity aerobic running is effective in decreasing the resting LDL cholesterol in individuals (Kali, 2012). In a study conducted by Parameswari and Gopinath (2012), it was concluded that 12 weeks of aerobic exercise reduced the percentage of body fat and increased lean body mass of the subjects but no further remarkable changes found in body mass index. The positive effects on cardio-respiratory capacity with the frequency of 3-5 days per week will conclude energy expenditure around 1500 kcal for one week regardless of the variety of participants and the apparent effects (Strejcová, Konopková, Řehořková, and Bunc, 2013). Spending about 140 minutes in a supervised exercise per week, including time spent warming-up and cooling-down in aerobic exercise that involved walking fast enough to burn 12 kcal/kg per hour could result in absolute change in HbA1c (Padmalayam, 2014) It was estimated that individuals get at least 30 minutes of moderate exercise five days a week to improve total body function and achieve reduction in weight, lipids and blood pressure (Marwick, *et al*, 2009; Parameswari and Gopinath, 2013). Aerobic exercise has been the mode traditionally prescribed for diabetes prevention and management (Hatice, Sunay, Nilay, Ayse, Kurdak and Sadi, 2010). A minimum of one week of aerobic exercise can improve whole-body insulin sensitivity in individuals with T2DM while moderate and vigorous aerobic training improve insulin sensitivity although for only a period of hours to days (ADA, 2016). A lesser intensity of aerobic exercise in some cases may also

improve insulin action to some degree (Abdul-Ghani, *et al*, 2007). In a study by Ezema, Ezema, Onwunali, Laminam, Ezugwu, Amaeze, Nwankwo, and Amaeze, (2013), it was revealed a significant decrease in systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting blood sugar (FBS) and increase in VO_2max in the exercise group over control group and also indicated a significant negative correlation between changes in VO_2max and changes in FBS, with the favourable changes resulting from aerobic training in both SBP and DBP demonstrated. Studies (Hansen, *et al*., 2013) indicated that blood HbA_{1c} content decreases or insulin sensitivity increases with significantly greater magnitude when increasing exercise frequency, adding resistance exercises to endurance exercises, or prolonging exercise intervention.

2.4.1 The effectiveness of Bench Step Aerobics (BSA)

Bench Step Aerobics (BSA) exercise has been promoted as a low impact physical activity recommended for the improvement of cardiorespiratory and muscular fitness (Kraemer, Keuning, Ratamess, Volek, McCornick, Bush, Nindl, Gordon, Mazzetti, Newton, Gomez, Wickham, Rubin, and Hakkinen, 2001). The main goals of performing step-on (forward-ascending) and step-off (backward-descending) movements combined with marching, dancing, jogging, and jumping exercises, as part of choreographed sequences using a step bench 10–25 cm high, are to obtain metabolic and mechanical benefits for health and fitness (Santos-Rocha, Oliveira and Veloso, 2008). The history of aerobics goes back quite a few years as people have been dong aerobic workouts or forms of aerobic workouts since the 1950s, but step aerobics was created 1989, when competitive gymnast Gin Miller injured her knee by overworking it in high-impact aerobic workouts and as part of her physical therapy, an orthopedic doctor told her to step up and down on a milk crate as rehabilitation for a knee injury, and she was inspired to turn the idea into step training, which quickly became one of the biggest phenomena in

the fitness industry and is still a mainstay for group exercise around the world. She had to make this stepping up and down a part of her daily routine and decided to use her front porch steps and some music to make the workout more interesting thereby step aerobics was officially born (Monroe, 2008). Step aerobics offers many health and economic benefits and the routine can be easily adapted to fit individual needs providing a high-intensity, low-impact workout that will give the desired results with little effort. Step aerobics, also known as step exercises, is one type of cardiovascular workout in which specific aerobics benches or simple steps are used to work on the muscles of the heart, lungs and legs (Stanforh, Stanforth and Velasquez, 1993). The best thing about this exercise is that it does not need too many equipment and accessories other than a step bench and a pair of gym shoes and for the practice, it is basically an inexpensive platform, which is used as a multi-functional equipment for working out (Scharf-Olson, Williford, Blessing and Brown, 1996). Usually, the height of a step bench ranges between 4 inches (10.16cm) and 12 inches (30.48cm), which can be varied or adjusted with the help of integral block risers in order to suit the requirements of a variety of exercises (Stanforh, Stanforth and Velasquez, 1993).

The entire workout revolves around ‘stepping’ which, being a low-impact movement can be done either in the gym or even at the home and it includes a wide variety of exercises from low-impact ones intended for beginners to fast-paced ones aimed at advanced exercisers mostly known to target lower body muscle groups, thereby offering excellent elevation to regular workout practices in a hassle-free workout routine that can be modified as per the requirements and fitness levels of the practitioners that helps in toning up the lower section of the body at a rapid pace (Scharf-Olson, *et al* 1996 ; Stanforh, Stanforth and Velasquez, 1993).. BSA can effectively burn calories by practicing step aerobics for 30 minutes a day, for example, can help you burn as much as 300 calories for a person with a body weight of 150 lbs. Bench step aerobics includes

lifting the entire body from one foot to another while taking steps on and off the bench rhythmically (Stanforh, Stanforth and Velasquez, 1993). The results of a study by Scharf-Olson, and Williford, (1996) demonstrated that aerobic bench stepping is an exercise modality that provides sufficient cardiorespiratory demand for enhancing aerobic fitness and promoting weight loss as an endurance exercise that uses large muscle groups and can be performed continuously, and is rhythmic. In order to develop and maintain cardiovascular fitness, this exercise should be performed at a frequency of 3 to 5 days per week, an intensity of 60% to 90% HRmax or 50% to 85% HRmax reserve, and a duration of 20 to 60 minutes (Scharf-Olson, Williford, Blessing, and Greathouse, 1991; Stanforh, Stanforth and Velasquez, 1993). Considering the fact that instructors often conduct up to 20 hours of step aerobics classes a week the number of steps performed during a weekly workout ranges from 3500 to 6000 complete stepping rounds that is 12 to 20 rounds per minute (Kucharska, Wysocka, Winiarski, Szpala, and Sobera, 2017)

2.4.2 Effects of Exercise on Renal Function of Diabetics with Kidney Disease

Exercise in type 2 diabetes patients receiving regular treatment for kidney disease was first introduced 3 decades ago, but is still only offered in a minority of renal units around the world, despite a significant body of evidence to support its use. (Kosmadakis, Bevington, Smith, Clapp, Viana, Bishop, and Feehally, 2010). Population based studies of the United States population have shown that individuals with diabetic kidney disease are less active than the general population, an examined cross-sectional data showed that physically inactive individuals had over twice the prevalence of diabetic kidney disease compared to very active individuals. Internationally, studies have also found similar results, identifying low levels of physical activity among individuals with decreased renal function, physical activity levels may also be low due to the fact that their capacity for exercise may be reduced (Hawkins, 2010). Patients with chronic kidney disease

(CKD) often have decreased physical fitness and activity, the main causes of which are muscle atrophy, myopathy, inactivity, malnutrition, and lower albumin levels, besides, anaemia, inflammation, and uremic acidosis that also play a role (Afsar, 2013) According to the American Heart Association (2014), one of the more common long-term complications of diabetes is diabetic renal disease also known as diabetic nephropathy, a condition which is a result of direct vascular abnormalities that accompany diabetes. Furthermore, diabetes mellitus is the main cause of ESRD, the most advanced stage of kidney disease. Several studies have shown that regular physical activity and acceptable levels of physical fitness are associated with reduced risks of elevated blood lipids, high blood pressure, obesity, coronary heart disease (CHD), and other health related problems (Yan, *et al*, 2014; Youngren, 2016). In a study conducted, Hawkins, (2010), confirmed that light intensity physical activity made the largest contribution to total movement, and that objectively assessed light intensity physical activity was independently associated with kidney function while objectively and subjectively assessed moderate to vigorous physical activity was not. Patients with diabetes, and chronic kidney disease are generally physically inactive, have a high mortality rate, and may benefit from an exercise program because exercise training in diabetic patients with kidney disease is feasible and may have clinical benefits (Leehey *et al*., 2009). A link between physical inactivity and kidney function decline has been demonstrated among older adults in the general population, and thereby emphasized that increased physical activity may slow kidney function decline in patients with kidney disease and also suggested that exercise could have a powerful effect on maintaining patients' health (Hawkins, 2010).

Exercise training increases aerobic fitness, improves muscle strength and function, and decreases blood pressure in people with chronic kidney disease. Individuals with T2DM can improve their kidney deterioration and reduce mortality if they improve their physical fitness. Adults with T2DM who improve their physical fitness lower their

chances of getting CKD, and if they already have kidney damage, they can improve their kidney function (Medial Express, 2014). Emerging data suggest that greater physical activity may be associated with less albuminuria and physical activity could protect against albuminuria, however, the relationship between physical activity and albuminuria is not uniform. For example, in diabetic patients, physical activity is associated with lower albumin excretion, and physical activity has led to regression of albuminuria in interventional studies, however, in non diabetics these associations were not observed while the relationship between physical activity and albumin/protein excretion become more complex by the phenomenon of postexercise proteinuria (Afsar, 2013). A team studied 256 participants of the Seattle Kidney Study, an ongoing study that is collecting information on patients with CKD, for an average of 3.7 years and discovered that physical activity was inversely related to kidney function decline in a graded fashion and to a degree that was stronger than previously reported in the general population with each 60-minute increment in weekly physical activity linked to a 0.5% slower decline per year in kidney function.After a large-scale randomized controlled trial the effects of exercise on renal functions, cardiovascular fitness, inflammation, and oxidative stress in diabetic patients with kidney disease exercise training resulted in an increase in exercise duration during testing, which was accompanied by slight but insignificant decreases in resting systolic blood pressure and 24-hour proteinuria. Exercise did not alter GFR, haemoglobin, glycated hemoglobin, serum lipids, or C-reactive protein. Caloric intake and body weight and composition also did not change with exercise training. With so much research effort directed towards better glycaemic control and aldose reductase inhibitors, it may eventually be possible to reverse or prevent this potentially disabling and lethal complication of diabetes (Ewing and Clarke, 1986). Individuals with diabetes mellitus may have some impaired fitness-related components and alterations in their cardioresp iratory responses to exercise (Komatsu *et al.*, 2010). Therapeutic effects of

exercise training in patients with type 2 diabetes include improvements in glycemic control, cardio-respiratory function, body composition, lipid profiles, and skeletal muscle function. Aerobic training also improves maximal oxygen uptake (Tan, Li and Wang, 2012).

2.4.3 Effects of Aerobic Exercise on Blood Pressure and blood glucose

It is a common finding that physical training has lowering effect o blood pressure of the patients. From a sixteen trials encompassing persons with hypertension (SBP >140 mm Hg; DBP > 90 mm Hg), physical training has reduced SBP by 7.4 mm Hg and DBP by 5.8 mm Hg (Painter, 2005). In another study, Yokoyama *et al*., (2004) concluded that aerobic exercise for 40 minutes per day, for 5 days a week, at a mean intensity of 50.6±8.6% of maximal heart rate was beneficial even though, there were no significant differences in age, duration of diabetes, body mass index (BMI), percentage of body fat, and systolic blood pressure between the control and experimental groups before the intervention. Glucose metabolic profiles, including insulin sensitivity were also similar in both groups. Fasting plasma glucose significantly decreased after intervention in both groups, whereas HbA1c significantly decreased only in the experimental group.

In a study (Pedersen and Saltin, 2006), persons with impaired glucose tolerance were subdivided into four groups: diet alone, physical exercise, diet1physical exercise and control, and followed them for 6 years. The risk of diabetes was reduced by 31% in the diet group, by 46% in the exercise group and by 42% in the diet1exercise group. Oral glucose tolerance improves in patients with diabetes mellitus (Gould *et al*., 2014). In both diabetic and control subjects initially elevated C-peptide concentrations decreased, while low C-peptide values increased and which was particularly pronounced in diabetic subjects with subnormal values. Peripheral insulin values did not change. Glucose disposal rate measured with the glucose clamp technique was similar in diabetic patients and control subjects. An improvement was seen at both submaximal and maximal insulin

levels in both groups, correlating with improvement in glucose tolerance in the diabetic subjects (Krotkiewski, *et al.*, 1985). More prolonged and vigorous exercise-training protocols have produced more favourable results (Wellberg-Henriksson *et al*., 1998). Several important adaptations to exercise training have proved to be beneficial in the prevention and treatment of insulin resistance, impaired glucose tolerance and T2DM. (Wellberg-Henriksson *et al*., 1998; Cerf, Chapman, and Louw, 2012; Gould *et al*., 2014). Consistent findings from various studies show that lower levels of physical activity increase a person's risk for diabetes, a recent review of 10 prospective cohort studies investigating moderate-intensity physical activity and diabetes provides evidence that people who achieve recommended levels of even moderate activity are about 30% less likely to develop diabetes than their inactive counterparts (Deshpande, et al, 2008). When the goal of aerobic training is to improve exercise capacity, muscle strength or physical function, similar outcomes from either moderate or high intensity exercise training program can be expected with similar time course changes in muscle strength compared to participants in a high intensity exercise training program (Ann, 2013). Therefore individuals with T2DM who have lower baseline exercise capacity and lower baseline physical function are likely to have larger improvements in in response to exercise training.

Physical activity or structured exercise training used alone or in combination with diet, insulin injections, or oral hypoglycaemic drugs are the foundations of therapy for T2DM, and evidence for the benefit of physical activity comes from studies showing that individuals who maintain a physically active lifestyle are less likely to develop insulin resistance, impaired glucose tolerance, or T2DM (Snowling and Hopkins, 2006). Studies have found that exercise training induces improvements in physical fitness among individuals with T2DM, as demonstrated by increments in maximal oxygen consumption

($\dot{V}O_2max$) and muscular strength. The effects of exercise training on glucose control and related physiological parameters have also been extensively studied in patients with T2DM. A meta-analysis showed beneficial effects of exercise training on one aspect of glucose control in diabetic patients, the percent of HbA_{1c} (A1C) in blood. It was also found that there were reductions in two measures of abdominal obesity and little effect on the only other parameter they meta-analyzed: body mass (Snowling and Hopkins, 2006). Bouche *et al.*, (2004) explained that the cellular fate of glucose in type two diabetes begins with glucose transport and phosphorylation and the subsequent pathways of glucose utilization include aerobic and anaerobic glycolysis, glycogen formation, and conversion to other intermediates in the hexose phosphate or hexosamine biosynthesis pathways. A study showed that 8 weeks aerobic exercise significantly decreased plasma malondialdehyde levels, which is an oxidative stress marker in diabetics (Jouybari, Arkhazlue, and Hashemvarzi, 2014).

There are sufficient studies to conclude that aerobic exercise have small to moderate beneficial effects on glucose control in T2DM patients and small beneficial effects on some related risk factors for complications of diabetes (Snowling and Hopkins, 2006). Aerobic exercise is recommended for its beneficial effects on glucose control as well as its abilities to retard the progression of other co-morbidities common in patients with diabetes, such as cardiovascular disease. The capability of aerobic exercise to improve glycaemic control in diabetes is well documented, although adherence to exercise regimens is problematic (Gulve, 2008). There is some evidence of small additional benefits resulting from combining aerobic and resistance exercise (Snowling and Hopkins, 2006). A mean increase of 9.5% in VO_2max after moderate-intensity aerobic training ($\leq$70% VO_2max) compared with a 1% decrease in sedentary controls. Larger increases in aerobic capacity were found in individuals who engaged in higher-intensity endurance training ($\geq$75% VO_2max (Larose, *et al.*, 2010). A combination of

aerobic (endurance), resistance (strength) and flexibility (stretching) exercises is recommended for people with kidney disease. A target of 30 minutes each day, 5–7 days per week is recommended, exercise has many benefits for all people including:

i. help in losing weight and managing body weight;

ii. improving blood pressure control;

iii. reducing the risk of diabetes and improving glucose control in people with diabetes;

iv. improving muscle strength, physical function, and bone density

v. reducing anxiety and depression; and

vi. reducing the risk of falls by improving muscle strength and function.

2.4.4 Effects of Aerobic Exercise on Kidney Function of T2DM patients

Type 2 diabetes mellitus patients with or without kidney problems, participating in regular exercise programmes can potentially improve their metabolic control. This is because evidence has shown that a single exercise session improves and partially normalises both insulin responsiveness and sensitivity for glucose utilisation, while a single bout of physical activity often results in decreased plasma glucose levels. An improved glucose control in T2DM patients under the age of 55 years has been demonstrated by improved HbA1C levels and glucose tolerance tests following physical training programmes (Zierath and Wellberg-Heinriksson, 1992). On T2DM self-regulation, training strategies helped the patients potentially threatened to kidney disease in setting specific goals for having regular physical activity, and a significant relation has been found among using insulin, disease symptoms and physical activities. The patients conditions were compared with standard ones and when blood sugar was high, they perform physical activities that lower the blood sugar and reduce the symptoms.

(Tavakolizadeh, Moghadas, and Ashraf, 2014). Changing and improving patients' sedentary behaviors had a key role in managing their diabetes and increased physical activity delays or even prevent the onset of T2DM disease complications in about 50% of susceptible individuals (Tavakolizadeh *et al*., 2014).

Diabetic nephropathy affects 40 % of type 1 or type 2 diabetic patients and is the leading cause of end-stage renal disease and it increases the risk of death mainly from cardiovascular causes. The earliest clinical evidence of nephropathy is microalbuminuria which without specific interventions, may progress to overt nephropathy in years (Kurdak *et al*., 2010). Chronic inflammatory process and oxidative stress can promote the progression of diabetic nephropathy, while hyperglycemia, increased blood pressure levels, and genetic predisposition remain the major risk factors its development. (Kurdak *et al*, 2010; Tavakolizadeh *et al*., 2014). Appropriate exercise is recommended for the management of type s diabetes through improvements of metabolic risk factors such as blood pressure, blood glucose, plasma lipids and oxidative stress markers. Several studies have reported that exercise showed renoprotective effects in both types of diabetic subjects (Zierath and Wellberg-Heinriksson, 1992; Kurdak *et al*, 2010; Tavakolizadeh *et al*., 2014).

2.4.5 Physical Activities and Regulation of Blood Glucose

Meta-analyses on the effects of exercise have estimated that for people with T2DM, both aerobic and resistance exercise improve glycemic control to an extent comparable to some oral anti-diabetic drugs, therefore exercise should theoretically be an attractive option for people who prefer not to use drugs, or wish to obtain additional blood glucose control benefits (Adams, 2013). By increasing the intensity of any given exercise, one will increase caloric expenditure not only during exercise, but also following the exercise session. This may affect glycemic status both acutely, through

effects independent of weight loss, and chronically by increasing daily energy expenditure and subsequent weight loss if a negative energy balance is imparted (Wright and Pamela). Skeletal muscle is responsible for most of the uptake of glucose after a meal, and transport of glucose into the muscle is considered the limiting step in glucose disposal. Both exercise and insulin regulate glucose transport mainly by the translocation of the GLUT4 isoform from an intracellular compartment to the plasma membrane and transverse tubules. Glucose transport occurs primarily by diffusion utilizing glucose transporter carrier proteins considered as important determinants of insulin sensitivity. Glucose uptake is insulin-dependent at rest and post-prandially in order to replenish muscle glycogen stores. According to ADA (2016), there are a few ways that exercise lowers blood glucose which includes; increased insulin sensitivity, so that cells are better able to use any available insulin to take up glucose during and after activity and when muscles contract during physical activity. Exercise stimulates a mechanism that is completely separate of insulin which allows the cells to take up glucose and use for energy (ACSM, 2010). The protective effects of exercise could result from both short term and long term effects of contractile activity on the regulation of glucose metabolism by skeletal muscle, these effects range from the insulin-independent stimulation of glucose transport induced by exercise, to acute and chronic alterations in the biological effectiveness of insulin in muscle (Youngren, 2016).

2.5.0 Exercise Prescription for T2DM Patients

Exercise prescription commonly refers to plan of fitness-related activities that are designed for a specified purpose, which is often developed by a fitness or rehabilitation specialist for the client or patient (Wright & Pamela, 2001). Due to the unique needs and interests of the client/patient, the goal of exercise prescription should be successful integration of exercise principles and behavioral techniques that motivates the participant to be compliant, thus achieving their goals. ((Well-berg-Henriksson *et al*., 1998). From a programme standpoint, advising one to exercise every day, at least initially, would not be

conducive to optimal exercise adherence, each component of an exercise prescription (frequency, intensity, time, and type) should be designed and evaluated based on the current health status, background, and goals of the individual involved (Wright & Pamella, 2001). Many patients with insulin resistance develop chronic complications in the locomotive apparatus, for example, painful osteoarthritis or symptomatic ischaemic cardiovascular disease (Toyama *et al*., 2010). The recommendations, therefore, needs to be highly individualized, although the prescription should follow the general recommendations for the population. The goal is at least 30 min of moderate-intensity exercise (Borg 12–13 with short periods at Borg 15–16) daily or 3–4 h/week in the form of brisk walking, cycling, jogging, swimming, rowing and golf (Wellberg-Henriksson *et al*., 1998; Gould *et al*., 2014). The recommended frequency and duration of exercise is three times per week or every other day and, as adjunct for weight reduction, five to seven times per week for 30 to 45 minute at an intensity of 50 to 70% VO_2max or 60 to 80% of maximal the heart rate (Pedersen and Saltin, 2006). Because of the high incidence of ischemic heart disease in T2DM patients, patients older than 35 years of age should undergo a graded exercise stress electrocardiogram (Lehmann and Spinas, 1996). Older obese T2DM patients can achieve significant metabolic benefits from low-intensity programs, such as daily walking, which can be easily incorporated into daily living (Gould *et al*., 2014). Taking the necessary precautions, most patients with diabetes can take part in a monitored exercise program safely (Lehmann and Spinas, 1996).

Exercise training can prevent muscle atrophy and stimulate muscle development and results in preferential loss of fat from the central regions of the body and should therefore contribute significantly in preventing or alleviating insulin resistance due to its development. This is because muscle glucose uptake is equal to the product of the arterio-venous glucose difference and the rate of glucose delivery or muscle blood flow (Ivy, 1997; Deal *et al*., 2004; Barcellos *et al*., 2012). Before initiating regular physical

training for people with T2DM, a complete physical examination aimed at identifying any long term complications of diabetes is recommended (Ivy, 1997; Barcellos, *et al*., 2012). All individuals above the age of 35 years should perform an exercise stress test before engaging in an exercise programme, which includes moderate to vigorously intense exercise (Pedersen and Saltin, 2006). The stress test will identify individuals with previously undiagnosed ischaemic heart disease and abnormal blood pressure responses. It is important to diagnose proliferative retinopathy, microalbuminuria, peripheral and/or autonomic neuropathy in patients with T2DM before they participate in an exercise programme (Toyama *et al*., 2010). If any diabetic complications are present, the exercise protocol should be modified accordingly (Deal *et al*., 2004). Once enrolled in the exercise programme, the patient must be educated with regard to proper footwear and daily foot inspections (Ivy, 1997). Fluid intake is of great importance when exercising for prolonged periods or in warm and humid environments (Pedersen and Saltin, 2006). With the proper motivation and medical supervision, people with T2DM can enjoy regular physical exercise as a means of enhancing metabolic control and improving insulin sensitivity (Wellberg-Henriksson, Rincon and Zierath, 1998).

2.5.1 Intensity

Exercise is often prescribed as a weight loss modality and the more intense the exercise prescription, the greater the caloric cost of the exercise bout. also, the more intense the exercise, the greater the postexercise caloric cost. That is, following exercise cessation, the body's metabolic rate will be elevated, thus increasing energy expenditure (Wright, & Pamela, 2001). This should range from low, to moderate for healthy individuals (Wellberg & Zierath, 1998). The MET values for a variety of physical activities are of light, moderate or vigorous intensity, and for T2DM patients exercise should be of short duration with a gradual progression to longer durations, as tolerated (Taylor, Fletcher and Tiarks, 2009). Exercise intensity can be increased by increasing

speed, distance, and resistance snd intensity should be the final domain that is increased in every training program. depending on the distance, intensity may not increase after reaching the peak of stability or close to exhaustion and patients should probably have 2 or 3 months of steady training before actively increasing intensity (Yan, *et, al*, 2014). The aerobic intensity can be expressed as a percentage of a person's maximal oxygen uptake/aerobic capacity (VO2max) or oxygen uptake reserve (VO2R), which could be estimated by exercise tests and it can also be expressed as a percentage of a person's maximum heart rate (HRmax) or heart rate reserve (HRR), which could be measured by maximal exercise tests or predicted by the person's age (Snowlings and Hopkins, 2006). Exercise intensity may be measured with ratings of perceived exertion (RPE) which is an index of how hard the person feels he or she is exercising (e.g., a 0 to 10 scale).

Table 2.5.1 Exercise intensity

Intensity	**Methods to Quantify Relative Intensity**		
	VO2R(%)/HRR(%)	**HRmax(%)**	**RPE**
Light	20-39	50-63	<5 out of 10
Moderate	40-59	64-76	5–6 out of 10
Vigorous	60-84	77-93	≥7 out of 10

Source: Snowlings and Hopkins, (2006)

2.5.2 Frequency

Frequency refers to the number of days per week dedicated to an exercise session, for aerobic exercise the frequency recommended is 3-5 days per week, and it is also suggested that individuals with a less than a 3-MET capacity should engage in multiple short sessions each day while individuals with a 3- to 5-MET capacity should engage in 1-2 sessions per day (parameswari and Gopinath, 2013). Individuals with a greater than 5-MET capacity should engage in 3-5 sessions per week, that is metabolic equivalents

(METs) express aerobic intensity as mL per kg per min of oxygen being consumed (Phillipides & Rocchini, 2009).

2.5.3 Duration

Continuous aerobic activity for 20-60 minutes is recommended and should be increased after frequency and before intensity and duration should gradually increase from the beginning of the training program until a decision to begin increasing intensity is made (Phillipides & Rocchini, 2009). Duration should remain steady (or even decrease) during the period of intensity increase, for example, patients may start each run at 10-20 minutes and add 5-minutes each week, *t*his will gradually increase the aerobic base and will prepare patients for the intensity period (parameswari and Gopinath, 2013).

2.5.4 Mode

The mode of exercise according to Phillipides & Rocchini, (2009) and parameswari and Gopinath, (2013), refers to the type of exercise performed and is expressed in the table below:

Types of Activity	Light <3 METs	Moderate 3 to <6 METs	Vigorous ≥ 6 METs
Walking	• Walking slowly around home, store or office = 2.0	• Brisk walking at ~6 km/h = 5.0 • Walking ~5 km/h = 3.3	• Walking at very brisk pace (~7 km/h) = 6.3 • Jogging at 8 km/h = 8.0 • Jogging at 10 km/h = 10.0 • Running at 11 km/h = 11.5
Household Chore and Occupation	• Sitting — using computer work at desk using light hand tools = 1.5 • Standing performing light work such as making bed, washing dishes or preparing food = 2.0–2.5	• Cleaning — heavy: washing windows or car = 3.0 • Sweeping floors or carpet, vacuuming, mopping = 3.0–3.5	• Shovelling, digging ditches = 8.5 • Carrying heavy loads such as bricks = 7.5
Leisure and Sports	• Arts & crafts, playing cards = 1.5 • Playing most musical instruments = 2.0–2.5	• Badminton — recreational = 4.5 • Cycling — on flat: light effort (16–19 km/h) = 6.0 • Golf — walking pulling clubs = 4.3 • Table tennis = 4.0 • Tennis doubles = 5.0 • Volleyball — non-competitive = 3.0–4.0 • Swimming leisurely = 6.0	• Tennis singles = 8.0 • Basketball game = 8.0 • Cycling — on flat: moderate effort (20–22 mph) = 8.0; fast (23–26 mph) = 10 • Football — casual = 7.0; competitive = 10.0 • Swimming — moderate/hard = 8–11

2.6.0 Summary

Exercise has been recommended without contraindication in all forms of diabetes mellitus at low to moderate levels taking all necessary precautions into consideration. Most diabetics who have been unable to strictly observe compliance to medical advice, dietary adjustments and organized physical activities may end into any or more of the various complications such as, excessive, glycosuria, retinopathy, neuropathy and kidney disease (nephropathy). Such changes are not easily noticeable without proper monitoring in clinical situations.

Changes in muscle morphology may also be important following training. With exercise training there is an increase in the conversion of fast twitch glycolytic IIb fibres to fast twitch oxidative IIa fibres, as well as an increase in capillary density. IIa fibres have a greater capillary density and are more insulin-sensitive and -responsive than IIb fibres. Evidence has been provided that morphological changes in muscle, particularly the capillary density of the muscle, are associated with changes in fasting insulin levels and glucose tolerance. Furthermore, significant correlations between glucose clearance, muscle capillary density and fibre type have been found in humans during a euglycaemic clamp. by increasing (Ivy, 1997). Improved glucose tolerance can be achieved in type 2 diabetic patients in as little as one week with an exercise program. The beneficial effect of regular exercise on glucose control appears to reflect the cumulative effect of transient improvement in glucose tolerance following each individual bout of exercise. Increased insulin sensitivity is lost after as little as three days of inactivity. Attention should be paid to foot-care and the use of appropriate footwear and diabetic late complications, such as autonomic and peripheral neuropathy (Lehmann and Spinas, 1996).

Comparison between sedentary and physically active individuals and groups have been used to establish positive effects of exercise on several markers of diabetic

complications which showed significant impact, leading to improvement in the subjects. Dose response-relationship between the amount of exercise and favourable changes in diabetes and changes among patients suggests that exercise can exert a positive influence on blood lipids at low to moderate training volumes that may only be noticeable at certain exercise thresholds. This study incorporated the effects of 8-week aerobic exercise on kidney function in diabetic subjects without explicit sign of the kidney problems but have been diabetic for a long period enough for some negative effects to occur on the kidney function.

Chapter Three

Methodology

3.1 Introduction

The study was designed to investigate the effect of aerobic exercise using modified step aerobic on the risk factors and indices of kidney function among type two diabetic patients in Kano, Nigeria. The chapter described the method and procedures involved in achieving the objectives of the study

3.2 Research Design

The study was a pretest-posttest control group design, that involved two groups of male adults who had diabetes for three years and beyond who were attending diabetic clinics; experimental and control groups. Pre-test, mid-test and post-test results were taken, and the dependent variables were measured before (baseline), fourth, eighth and 12^{th} weeks of the bench step aerobic training. The design was effective as it has exercised some level of control on threats to internal validity factors such as history, maturation, test instrument, statistical regression, selection biases, experimental mortality, selection maturation and interaction (Thomas and Nelson, 2001).

3.3 Population of the Study

The study population comprised male adult type 2 diabetic patients between the ages of 40 and 60 years with a history of three years and above T2DM, and were regularly attending diabetic clinics in any of the three selected hospitals in Kano City; Muhammad Abdullahi Wase Specialist Hospital, Sir Muhammadu Sunusi General Hospital and Murtala Mohammed Specialist Hospital. The estimated population of type 2 diabetics attending clinics in Kano state as at 2015 was 1.7 million and it was also estimated that more than

200,000 cases have been recorded in Kano state (Hospitals Management Board (KHMB, 2015).

3.4 Sample and Sampling Technique

Purposive sampling technique was used to select 30 diabetic patients All subjects were stable, without any cardiac complications. Their blood pressure (BP < 140/90 mm Hg) was within normal range, and were being treated with/or on diet and/or oral agents. Obese, underweight (BMI between 20 and 30 kg/m^2), smokers, alcoholic, uncontrolled hyperglycaemia (>250 mg/dL) and hypertensive (Resting BP > 200/115 mm Hg) other cardiac, renal, respiratory disease and subjects on insulin therapy were excluded. Those who were involved in vigorous physical activities and above averagely physically fit were also excluded.

The subjects were listed from 1-30 and divided into two groups of odd and even numbers fifteen each, odd numbers served as experimental and the even numbers as control. A physical activity readiness questionnaire (PAR-Q) and an informed consent forms were provided to each patient in accordance with the American College of Sports Medicine guidelines (ACSM, 2014). The forms were fully explained to the patients by the research assistants with the support of the clinical staff. All patients have filled and returned their forms before they were enrolled in the training programme.

3.5 Instrumentation

The following instruments were used for data collection

i. Automatic digital blood pressure monitor (China Model Ebokan OB 11-121, 60 series) was used to measure subjects blood pressure
ii. Electronic stop watch model EE633-M04 was used for monitoring the exercise timing

iii. A Modified wooden aerobic step bench 13.75cm (5.5”) high and 45cm (18”) by 60 cm (24”) top was used as the exercise instrument

iv. Urine and blood test were carried out in Murtala Muhammad Specialist Hospital Laboratory using the standard measures from the hospital

3.6 Research assistants

Three research assistants were recruited to assists during the period of data collection. They include two physical educators and a laboratory technician. The physical educators were trained for the assessment of blood pressure and heart rate. The laboratory technician guided the subjects to the laboratory of Murtala Mohammed Specialist Hospital, Kano for testing and recording of blood sugar, urinalysis, and creatinine for the experimental and control groups. Diabetes physicians from the respective hospital helped in certifying the eligibility of the selected subjects for the study for safety and ethical compliance.

3.7 Data collection

Data was collected before the commencement of the training (baseline), immediately after fourth, eighth and twelfth weeks of the training period in the following areas:

3.7.1 Tests

3.7.1.1 Blood Pressure: The subject’s blood pressure was taken using a digital blood pressure monitor (Model Ebokan OB 11-121, 60 series). The cuff of the meter was tied around the subject’s left arm with the subject sitting comfortably on a chair with his back fully supported. Each patient was made to rest in this position for ten minutes before taking the blood pressure at the baseline, the last days of week four, week eight and week twelve.

Two readings were taken and recorded as mm Hg unit for each subject, the average of the reading was calculated and used as the subject's blood pressure for the study.

3.7.1.2 Blood Glucose: Patients were requested to do an overnight fasting and blood was collected in the hospital laboratory. It was collected via the antecubital vein for the blood sugar determination (Kerry, Anita & Katherine, 2005). The values of the blood sugar from the laboratory test were recorded in mmol/l unit as the subject's blood sugar levels.

3.7.1.3 Urinalysis.

Each patient was made to submit sample of urine to the laboratory technician who took it to the hospital laboratory for analysis of the following chemical contents:

i. **Creatinine test:**. The substance was determined in diluted urine employing the jaffe reaction standards or diluted samples are pipetted into a clear microtiter plate and the color generating reaction is initiated with picric acid (a Creatinine Detection Reagent), which is pipetted into each well. After a short incubation the intensity of the generated color is detected in a microtiter plate reader capable of measuring 490 nm wavelength. The normal range is 30 –300 mmol/l and results of each patient recorded as mmol/l at baseline, week four, week eight and week twelve

ii. **Albumin test**: The substance was determined in the urine through the method called liquid chromatography–mass spectrometry (LC-MS) which was used to analyse the urine albumin. The process is an analytical chemistry technique that combines the physical separation of the urine through the capabilities of liquid chromatography with the mass analysis capabilities of mass spectrometry (MS). The normal range was below 30 mmol/l, values between 30-300 mmol/l indicate microalbuminuria and above 300 mmol/l imply clinical albuminuria and results of

each patient recorded as mmol/l at baseline, week four, week eight and week twelve

3.8 Training protocol

The experimental group participated in the bench step aerobics training while the control group received health education lectures weekly and their variables were collected analysed and recorded alongside the experimental group throughout the training period

The participants in the exercise group sat for 2 minutes before the commencement of training in the hospital gym, where the aerobic step benches were mounted. Participants were made to watch demonstrations on how the aerobic steps are performed and then properly instructed on to proceed as well as how the light music will aid the exercise.

Due to the maximal exertion required for the bench step aerobics training, a warm up was carried out based on the Ethics Committee requirements and ACSM (2010) recommendations for training of diabetic patients. Prior to reporting to the Physiotherapy Unit at Murtala Mohammed Specialist Hospital, Kano for the testing, subjects were given the following instructions: no heavy exercise within 8 hours prior to testing, fast for 8-10 hours before the first day, collect their urin sample early morning as instructed by the laborator technician.

Baseline measurements for urine creatinine, urine albumin and blood sugar were taken in the laboratory while blood pressure was taken after the 2 minutes rest as the participants came into the gym. The participants underwent 5 minutes warm-up and passive stretches then 20 minutes bench step aerobics depending on the patient's ability at 35% - 45% of maximal heart rate (HRmax) for duration of four 4 weeks. During the 4^{th} – 8^{th} week of CE, training session lasted for 30 minutes without resistance while the intensity was increased from 50-55% of the HRmax.

Each session, had the participants three days per week for 30 minutes at 60-65% of HRmax for 4 weeks. All post-training measurements were taken at baseline, immediately after 4^{th}, 8^{th} and 12^{th} week.

a. Experimental group:

The exercise training was conducted on the improvised aerobic step bench, each patient exercise for 30 minutes three days each week for a period of twelve weeks. Each patient take part in five minutes warm up before the bench step aerobics training and five-minutes cool down after the session. The training commences with each participant standing with the aerobic step bench in front, then step up with the right foot followed by the left and then the right foot down followed by the left. The patients were initially guided with verbal instruction up-up, down-down. Each patient was to take a minimum of 20 rounds per minute.

b. Control group:

The group had their data collected at the same time with the experimental group, at base-line, and immediately after the 4^{th}, 8^{th} and 12^{th} weeks of training. The control group did not engage in the training, but were advised not to engage in any rigorous physical activity. They were advised to adhere to medications and lifestyle management as advised by the physicians. They were also attending weekly health education lecture to support them have better understanding of their health conditions and self care strategies.

3.9 Training Procedures

Exercise was continuous in nature, but the nature of exercise depended on the patient's safety and physical activity preferences. Exercise intensity for diabetics was moderate-to-vigorous in nature. Moderate intensity exercise was used in this study, at a level that elicited a heart rate response of 55-69% maximal heart rate or 7-10 on a 20 point rating of perceived exertion, as suggested by Penny, (2007). In this study it was measured using the

Borg scale (see Appendix 3). Each subject's maximal heart rate was determined using the formula, 220 – age = HRmax. In this study, bench-step-aerobic training was performed by all patients in the exercise group three days a week for 30 minutes at 55-69% maximal heart rate (HR max), which was also in line with the ACSM recommendation of 55-69% of HR max (ACSM, 2000). The training was conducted between 8:00 am to 11:00 am at Murtala Mohammed Specialist Hospital Physiotherapy Centre, Kano. The morning time was chosen to avoid congestion and to maintain good training intensity and compliance. Each training session was preceded by 5minute warm-up and concluded by 5minutes cool-down.

The subjects were made to step up and down on the flat form at a rate of maximum 30 round of steps per minute. The subjects stepped using a four-step cadence, up-up-down-down for thirty minutes split into two sessions of 15 minutes each for the first week stopping immediately after 15 minutes or at a perceived exhaustion and straight thirty minutes in the subsequent weeks stopping at the 3oth minute or at any point of exhaustion. Exhaustion was determined when a subject cannot maintain stepping rate for 15 seconds and the patients sat down on completion or exhaustion. The training proceeds as follows:

Start Position

- Centered in front of the aerobic bench.

Training Description

- Step up on the bench with the left foot
- Step up on the bench with the right foot
- Step down left foot, then down right foot.

Count Breakdown:

1. Step up on bench with left foot
2. Step up on bench with right foot

3. Step down backwards to the floor with left foot
4. Step down backwards to the floor with right foot

Notes:

- Basic left was considered as one of the simplest and most basic of all step moves for the group except where the participant differs

3.9.1 Training Intensity and Duration

The American Diabetes Association (2014), describes an activity as moderate intensity, if trainees are working hard enough that they can talk, but not sing, during the activity. Vigorous intensity is when trainees cannot say more than a few words without pausing for a breath during the activity. According to the Australian Exercise and Sports Science Position Statement and as reviewed by Matthew *et al*. (2012), moderate intensity aerobic exercise training is 55%–69%, HR max at 12–13 RPE level with a total duration of 210 minutes per week, and no more than two consecutive days without exercising. High intensity aerobic training is 70%-89%, HR max at 14-16 RPE level, with a total duration of 125 minutes per week, and no more than two consecutive days without exercising (Appendix 5). Marwic *et al*. (2009), recommend that even twice-weekly training periods may favourably influence control as acute benefits on glycaemic control can last up to 48 to 72 hours after exercise and appear to be cumulative in nature.

In this study, the intensity of the training was for 30 minutes, broken into two 15 minutes sessions maintained at 55-69% of HR max throughout the 12weeks. The subjects gradually adapt to the training.

3.9.2 Monitoring Training Intensity

The rate of perceived exhaustion (RPE) developed by Borg as described in Holland, Bouffard, and Wagner,(1992), was used during the training period to ensure safety of the

subjects as they were exercising indicating how hard the participants felt with the training. Holland, Bouffard, and Wagner,(1992), has found that exercise participants can easily sense how difficult a work-out session feels on a 20-point scale (Appendix 3), and that it closely measures the exertion of exercise as in the %HR max. Hence, using the 20-point scale, 59-75% of HR max was between 13-15 points; and 65-80% was 17-19 points on the scale.

3.10 Procedure for Data Analysis

The following statistical techniques were used to analyse the collected data:

1. Descriptive statistics of means, and standard deviation of the computed values of variables
2. Two-way repeated measure ANOVA, was used in order to explore how independent variables influence some patterning of response on the dependent variables. It was also used to assess the likelihood that the means of the two groups are sampled from the same sampling distribution of means. This was because there were several correlated dependent variables, and it was appropriate to conduct a single overall statistical test, thereby avoiding multiple individual tests.
3. Scheffe *post-hoc* test was used to locate the point of difference, where F was significant
4. An alpha level of 0.05 was set to accept or reject the null hypothesis
5. Statistical Package for Social Science (SPSS IBM Chicago Illinois, USA) version 20 was used to run all the analyses

CHAPTER FOUR
RESULTS AND DISCUSSION

4.0 Introduction

Data were collected over 12-week training period to determine the effects of bench step aerobic exercise on glycemic status (blood glucose), and markers of kidney functions (urine albumin and creatinine) of type 2 diabetic patients. Two groups (experimental and control) were used over the period. Parameters assessed during the training period were blood sugar, systolic and diastolic blood pressure, albumin and creatinine measured at 4 weekly intervals. Results of tests were presented in line with the research questions. The hypotheses were tested with discussion of findings at the end of the chapter.

4.1 Results

The main objective of this study was to investigate the effects of 12-week bench step aerobic training on the blood sugar, albumin and creatinine level, and blood pressure of type 2 diabetic patients. The variables tested over the 12-week were computed and compared. Table 4.2.1 presents the summary of the investigated variables for the experimental and control groups at the end of the 12 week training period.

Table 4.2.1: Effects of aerobic exercise on blood sugar, blood pressure albumin, and creatinine of diabetic patients in the control and experimental groups

Variables	STATUS	N	Mean	Std. Dev.	Std. Error
Blood sugar (mmol/l)	Control	15	8.3	2.381	0.307
	Experimental	15	7.98	2.752	0.355
Systolic blood pressure mmHg	Control	15	142.48	13.073	1.688
	Experimental	15	134.83	12.684	1.638
Diastolic blood pressure mmHg	Control	15	89	5.135	0.663
	Experimental	15	86.2	7.383	0.953
Albumin mmol/l	Control	15	134.45	35.578	4.593
	Experimental	15	148.82	91.507	11.813
Creatinine mmol/l	Control	15	134.7	29.365	3.791
	Experimental	15	122.77	29.112	3.758

In Table 4.2.1 above, after the 12-week subjects in the exercise group had their mean blood sugar level as 7.98mmol/l while the control group had a mean of 8.3mmo/l. When compared the exercise group have a relatively lower blood sugar. For the subjects' blood pressure, the mean levels for the systolic blood pressure for the exercise group was 134.83 mmHg and the control group had 142.48 mmHg which showed that the exercise group had lower systolic blood pressure when compared with the control group. For diastolic blood pressure the exercise group had a mean of 86.2 mmHg and the control group had a mean of 89 mmHg and therefore the exercise group had lower mean diastolic blood pressure than those of the control group.

The mean albumin concentration in the exercise group was 148.42mmol/l and that of the control group was 134.45mmol/l, which showed that the mean albumin for experimental group was higher than that of the control group. The mean creatinine levels for the exercise group was 122.77mmol/l and that of the control group was 134.0mmol/l, which showed that the subjects in the exercise group had lower mean creatinine when compared with the control group. The significance of the variability in the levels was tested in the related hypotheses. A breakdown of the objectives and research questions were assessed as follows:

Research questions one: What are the effects of bench step aerobic exercise on blood glucose levels of T2DM patients?

The blood glucose levels of the subjects in the two groups were assessed based on the periodic changes observed over the study period. Table 4.2.2 shows the mean levels of the blood sugar of the two groups.

Table 4.2.2 Mean and SD of blood sugar levels for the experimental and control groups

Periods of training	Control (mmol)		Experimental (mmol)	
	Mean	Std. Deviation	Mean	Std. Deviation
Base line	8.93	2.631	9.53	4.224
Week 4	8.53	2.386	8.27	2.282
Week 8	8.2	2.426	7.4	1.639
Week 12	7.53	2.066	6.73	1.223

The mean level of blood sugar of the experimental group dropped from 9.53mmol/l at baseline to 6.73 by the 12^{th} week which indicates an improvement and that of the control groups also drops from 8.93mmol/l at base to 7.53 at 12^{th} week. Comparably subjects in the

experimental group had a more relative decline than those in the control group. The findings clearly showed positive effect of the aerobic training on the blood glucose levels of the subjects in the experimental group.

Research questions two: What are the effects of bench step aerobic exercise on albumin levels of T2DM patients?

The effects of aerobic exercise on the albumin of experimental and the control group was compared and the mean levels for the two groups over the period are presented in Table 4.2.3.

Table 4.2.3 Mean and SD of Albumin levels over for the Experimental and Control groups

Periods of study	Albumin (mmol)			
	Control		Experimental	
	Mean	S. D	Mean	S. D.
Base line	136.87	41.248	141.6	91.156
Week 4	136.73	39.658	152.67	97.525
Week 8	133.6	31.794	152.13	94.953
Week 12	130.6	31.95	148.87	91.477

From the observation of the means and standard deviation (SD) above, the experimental group had an increase in the level of urine albumin from 141mmol/l with 91.156 SD at baseline to 148.87mmol/l with 91.47 SD at week 12 while the control group had a decline from 136.87mmol/l with 41.248 SD at baseline to 130mmol/l with 31.95 SD at week 12. This showed that effects of the aerobic exercise did not reduce the albumin of the exercise subjects but it was showing a gradual increase between baseline and week 8 while it showed an insignificant decrease thereafter. For subjects in the control group, a decrease was observed in their albumin levels, the observed decrease in albumin level continued from the

base line up to 12th week of the exercise. The rise in the albumin levels among subjects in the experimental group therefore, may be associated with their participation in the aerobic exercise since the control group had a steady decrease while they were not participating in the exercise training.

Research questions three: What are the effects of bench step aerobic exercise on creatinie levels of T2DM patients?

The effects of the bench step aerobic exercise on creatinine levels of the experimental and the control group was compared and the mean and standard deviation for the two groups over the period are presented in Table 4.2.4.

Table 4.2.4 Mean levels of Creatinine observed over the study period for the two groups (Control and Experimental)

Periods of study	Creatinine (mmol)			
	Control		Experimental	
	Mean	S. D.	Mean	S. D.
Base line	137.2	36.717	126.33	34.3
Week 4	133.93	28.333	125.6	32.41
Week 8	134.6	26.877	121.47	27.78
Week 12	133.07	27.395	117.67	22.83

From the observation the mean creatinine of the experimental group has steadily decreased from baseline 126.33mmol/l with 34.3 SD to 117.67mmol/l with 22.83 SD at week 12 while that of the control group did not show any significant decrease from baseline 137.2mmol/l with 36.717 SD to 133.07mmol/l with 27.395 SD at week 12. The observed decrease among the experimental group could therefore be associated with the participation

in the bench step aerobic exercise since it was only observed among the experimental group dropping from 126.33mmol/l at baseline to 117.67mmol/l by the 12th week.

Research questions four: What are effects of bench step aerobic exercise on systolic blood pressure of T2DM patients?

The mean systolic blood pressure levels obtained over the study periods for the two groups are indicated in Table 4.2.5

Table 4.2.5 Mean levels of Systolic blood pressure levels observed over the study period for the Control and Experimental groups

Periods of study	Systolic blood pressure (mmHg)			
	Control		Experimental	
	Mean	SD	Mean	SD
Base line	143	18.311	143	18.311
Week 4	142.93	12.533	135.93	11.164
Week 8	142.6	11.319	131.87	7.605
Week 12	141.4	9.898	128.53	5.963

From the mean and SD of the systolic blood pressure level shown in the table, both groups have the same mean and standard deviation of systolic blood pressure 143 mmHg with 18.311 SD. The experimental group showed a gradual decline from the base line 143mmHg with 18.311 SD to 128.53mmHg.with 5.963 SD at week 12. The control group did not show significant drop in their systolic blood pressure from 143mmHg with 18.311 SD at baseline to 141.4mmHg with 9.898 SD by week 12. When compared with the results clearly revealed that the bench step aerobic exercise had some major effect on the systolic blood

pressure of the T2DM patients of the experimental group since the systolic blood pressure has dropped from 143mmHg at baseline to 128mmHg at the 12th week.

Research questions five: What are effects of bench step aerobic exercise on diastolic blood pressure of T2DM patients?

The mean diastolic blood pressure levels obtained over the study periods for the two groups are indicated in Table 4.2.6

Table 4.2.6 Mean levels of Diastolic blood levels observed over the study period for the Control and Experimental

Periods of study	Diastolic (mmHg)			
	Control		Experimental	
	Mean	SD	Mean	SD
Base line	90.67	7.017	89.6	10.453
Week 4	87.93	5.535	88.53	5.167
Week 8	88.6	3.582	83.93	6.1
Week 12	88.8	3.745	82.73	4.464

The result shows the mean and standard deviation (SD) of the groups diastolic blood pressure over 12 week study. The exercise group had a gradual decrease in their diastolic blood pressure from 89.6 mmHg with 10.453 SD at baseline to 82.73mmHg with 4.464 SD at week 12 when compared with the control group that had 90.67mmHg with 7.017 SD at baseline and 88.8mmHg with 3.745 SD at week 12. The results clearly revealed that the bench step aerobic exercise had some major effects on the diastolic blood pressure of the T2DM patients involved in the exercise training by decreasing from 89.6mmHg at baseline to 82.73 by the 12th week.

Test of hypotheses

One major hypothesis and five sub-hypotheses were formulated to test the significance of the effect of the bench step aerobic exercise on the blood sugar, urine albumin, urine creatinine, systolic blood pressure and diastolic blood pressure of T2DM patients. All the five sub-hypotheses were tested at the probability of 0.05 level of significance. Two-way repeated measure analysis of variance (ANOVA) was used because the subjects were two groups selected on similar experimental conditions. The application of the two-way repeated measure ANOVA was informed by the multiple levels of the independent variables which were the different periods of the experiment and the two groups (control and experimental), involved in the study. The tests were conducted as follows:

Sub-hypotheses I: There is no significant effect of bench step aerobic exercise on blood glucose status of T2DM patients.

The effects of the bench step aerobic exercise on blood glucose levels of the T2DM patients was tested over the four periods (baseline, week 4, week 8 and week 12) of the training in the experimental group. Two way Repeated measures ANOVA was used and the model is summarized in Table 4.3.2.

Table 4.3.2: Summary of two-way repeated measure ANOVA on the effects of aerobic exercise on blood sugar of T2DM patients in Kano Metropolis

Source		Sum of Squares	Df	Mean Square	F	Sig.
Status (	Sphericity Assumed	3.008	1	3.008	0.172	0.684
	Greenhouse-Geisser	3.008	1	3.008	0.172	0.684
	Huynh-Feldt	3.008	1	3.008	0.172	0.684
	Lower-bound	3.008	1	3.008	0.172	0.684
Error(Status)	Sphericity Assumed	244.617	14	17.473		
	Greenhouse-Geisser	244.617	14	17.473		
	Huynh-Feldt	244.617	14	17.473		
	Lower-bound	244.617	14	17.473		
Period	Sphericity Assumed	71.758	3	23.919	12.16	0
	Greenhouse-Geisser	71.758	1.394	51.495	12.16	0.001
	Huynh-Feldt	71.758	1.499	47.857	12.16	0.001
	Lower-bound	71.758	1	71.758	12.16	0.004
Error(Period)	Sphericity Assumed	82.617	42	1.967		
	Greenhouse-Geisser	82.617	19.509	4.235		
	Huynh-Feldt	82.617	20.992	3.936		
	Lower-bound	82.617	14	5.901		
Status * Period	Sphericity Assumed	9.825	3	3.275	2.021	0.125
	Greenhouse-Geisser	9.825	1.714	5.732	2.021	0.159
	Huynh-Feldt	9.825	1.93	5.091	2.021	0.153
	Lower-bound	9.825	1	9.825	2.021	0.177
Error (Status*Period)	Sphericity Assumed	68.05	42	1.62		
	Greenhouse-Geisser	68.05	23.996	2.836		
	Huynh-Feldt	68.05	27.017	2.519		
	Lower-bound	68.05	14	4.861		

The result revealed that there was no significant difference on the effects of aerobic training on the blood sugar levels between the experimental and control group over the training period ($P < 0.05$). This observation was deducted from the fact that the assumption of sphericity was not violated and the adjusted degree of freedom with the Greenhouse-Geisser corrections all indicated that the calculated F-value could not be associated with a Type II error. This was further confirmed by Huynh-Feldt in the table. To identify the period of the training in which the blood sugar levels differed significantly, a *post hoc* test was carried out on the mean levels (see Table 4.2.2.) using the least Significant difference (LSD). The summary of the *post hoc* test is presented in Table 4.3.4.

Table 4.3.3: Pairwise comparison of levels of blood sugar measured (mmol) at the different period of the training

(I) Period	(J) Period	Mean Difference (I-J)	Std. Error	Sig.
Base line	Week four	0.83	0.645	0.645
	Week eight	1.43	0.645	0.183
	Week twelve	2.10*	0.645	0.017
Week four	Base line	-0.83	0.645	0.645
	Week eight	0.6	0.645	0.834
	Week twelve	1.27	0.645	0.284
Week eight	Base line	-1.43	0.645	0.183
	Week four	-0.6	0.645	0.834
	Week twelve	0.67	0.645	0.785
Week twelve	Base line	-2.10*	0.645	0.017
	Week four	-1.27	0.645	0.284
	Week eight	-0.67	0.645	0.785

* The mean difference is significant at the .05 level.

The result of the *post hoc* test revealed that the difference in blood sugar level was significant from baseline and 12th week of the training since the post hoc is to locate where

the differences are. The decrease in blood sugar level was not found to be statistically significant from the 4^{th} and 8^{th} week. The null hypothesis was therefore accepted.

Sub-hypotheses II: There is no significant effect of bench step aerobic exercise on the albumin of T2DM patients

The parameter for this test was albumin levels and the test for significance between the two groups and levels of measurement over the four periods (baseline, week 4, week 8 and week 12) of training was conducted with the two-way repeated measure ANOVA. The result for the albumin of the patients is summarized in Table 4.3.5.

Table 4.3.4: Summary of the two-way repeated measure ANOVA on effects of aerobic exercise on the kidney function albumin (mmol/l) of diabetic patients

Source		Sum of Squares	Df	Mean Square	F	Sig.
Status	Sphericity Assumed	6192.033	1	6192.033	0.524	0.481
	Greenhouse-Geisser	6192.033	1	6192.033	0.524	0.481
	Huynh-Feldt	6192.033	1	6192.033	0.524	0.481
	Lower-bound	6192.033	1	6192.033	0.524	0.481
Error (Status)	Sphericity Assumed	165584.717	14	11827.48		
	Greenhouse-Geisser	165584.717	14	11827.48		
	Huynh-Feldt	165584.717	14	11827.48		
	Lower-bound	165584.717	14	11827.48		
Period	Sphericity Assumed	608.867	3	202.956	0.561	0.644
	Greenhouse-Geisser	608.867	1.303	467.313	0.561	0.508
	Huynh-Feldt	608.867	1.382	440.663	0.561	0.517
	Lower-bound	608.867	1	608.867	0.561	0.466
Error (Period)	Sphericity Assumed	15205.883	42	362.045		
	Greenhouse-Geisser	15205.883	18.241	833.622		
	Huynh-Feldt	15205.883	19.344	786.082		
	Lower-bound	15205.883	14	1086.135		
Status x Period	Sphericity Assumed	958.7	3	319.567	0.869	0.465
	Greenhouse-Geisser	958.7	1.282	747.644	0.869	0.39
	Huynh-Feldt	958.7	1.355	707.448	0.869	0.396
	Lower-bound	958.7	1	958.7	0.869	0.367
Error (Status x Period)	Sphericity Assumed	15442.55	42	367.68		
	Greenhouse-Geisser	15442.55	17.952	860.207		
	Huynh-Feldt	15442.55	18.972	813.96		
	Lower-bound	15442.55	14	1103.039		

There was no significant difference between the two groups in their albumin levels (P> 0.05) as indicated by the calculated F-value of 0.524 and a probability level of 0.481 obtained for the test. For variability in the recorded levels over the period and the interaction of the two variables, no significant difference was observed (P > 0.05). The observed Greenhouse-Geisser correction for adjusting the F-value and other corresponding parameters in the Table points to the fact that sphericity was not violated. With these observations, there the null hypothesis was accepted.

Sub-hypotheses III: There is no significant effect of bench step aerobic exercise on creatinine level of T2DM

.

The parameter observed for this test was creatinine levels. The test for significance between the two groups and levels of measurement over the period of training was conducted with the two-way repeated measure ANOVA. The result for the urine creatinine of the patients is summarized in Table 4.3.5.

Table 4.3.5: Summary of the two-way repeated measure ANOVA on effects of aerobic exercise on creatinine (mmol) of diabetic patients

Source		Sum of Squares	Df	Mean Square	F	Sig.
Status	Sphericity Assumed	4272.133	1	4272.133	3.83	0.071
	Greenhouse-Geisser	4272.133	1	4272.133	3.83	0.071
	Huynh-Feldt	4272.133	1	4272.133	3.83	0.071
	Lower-bound	4272.133	1	4272.133	3.83	0.071
Error(Status)	Sphericity Assumed	15617.117	14	1115.508		
	Greenhouse-Geisser	15617.117	14	1115.508		
	Huynh-Feldt	15617.117	14	1115.508		
	Lower-bound	15617.117	14	1115.508		
Period	Sphericity Assumed	662.8	3	220.933	2.387	0.082
	Greenhouse-Geisser	662.8	1.608	412.225	2.387	0.123
	Huynh-Feldt	662.8	1.785	371.351	2.387	0.117
	Lower-bound	662.8	1	662.8	2.387	0.145
Error(Period)	Sphericity Assumed	3886.95	42	92.546		
	Greenhouse-Geisser	3886.95	22.51	172.676		
	Huynh-Feldt	3886.95	24.988	155.555		
	Lower-bound	3886.95	14	277.639		
Status * Period	Sphericity Assumed	206.667	3	68.889	1.197	0.323
	Greenhouse-Geisser	206.667	2.014	102.605	1.197	0.317
	Huynh-Feldt	206.667	2.354	87.799	1.197	0.32
	Lower-bound	206.667	1	206.667	1.197	0.292
Error(Status*Period)	Sphericity Assumed	2417.083	42	57.55		
	Greenhouse-Geisser	2417.083	28.199	85.716		
	Huynh-Feldt	2417.083	32.954	73.347		
	Lower-bound	2417.083	14	172.649		

For the creatinine, levels the observed variability between the groups (experimental and control) and within the periods of measurement were found to be statistically significant

as indicated with the summary of the two-way repeated measure ANOVA summarized in Table 4.3.5.

The result revealed that there was significant effect of the exercise on creatinine levels of the experimental group ($P > 0.05$). These indications were drawn from calculated F-values of 3.830 for comparing the groups and 2.387 for comparing the periods of measurement of the creatinine levels. The probability levels of significance were 0.071 and 0.320 for status and period respectively. With the Greenhouse-Geisser corrections and with Huynh-Feldt as shown in the two-way repeated measure ANOVA summary, a statistically significant difference was observed. The null hypothesis is hereby rejected.

Sub-hypotheses IV: There is no significant effect of 12week bench step aerobic exercise on systolic blood pressure of T2DM patients.

The blood systolic blood pressure was tested for the conduct of this hypothesis. Table 4.3.9 shows the summary of the result for effect of the bench step aerobic exercise on the systolic blood pressure levels of the two groups over the study period.

Table 4.3.6: Summary of the two-way repeated measure ANOVA on effect of aerobic exercise on systolic blood pressure (mm Hg) levels of diabetic patients

Source		Sum of Squares	df	Mean Square	F	Sig.
Status	Sphericity Assumed	1755.675	1	1755.675	22.13	0
	Greenhouse-Geisser	1755.675	1	1755.675	22.13	0
	Huynh-Feldt	1755.675	1	1755.675	22.13	0
	Lower-bound	1755.675	1	1755.675	22.13	0
Error(Status)	Sphericity Assumed	1110.7	14	79.336		
	Greenhouse-Geisser	1110.7	14	79.336		
	Huynh-Feldt	1110.7	14	79.336		
	Lower-bound	1110.7	14	79.336		
Period	Sphericity Assumed	1053.292	3	351.097	4.304	0.01
	Greenhouse-Geisser	1053.292	1.257	837.89	4.304	0.045
	Huynh-Feldt	1053.292	1.323	796.268	4.304	0.043
	Lower-bound	1053.292	1	1053.292	4.304	0.057
Error(Period)	Sphericity Assumed	3425.833	42	81.567		
	Greenhouse-Geisser	3425.833	17.599	194.66		
	Huynh-Feldt	3425.833	18.519	184.99		
	Lower-bound	3425.833	14	244.702		
Status * Period	Sphericity Assumed	717.492	3	239.164	13.436	0
	Greenhouse-Geisser	717.492	2.595	276.528	13.436	0
	Huynh-Feldt	717.492	3	239.164	13.436	0
	Lower-bound	717.492	1	717.492	13.436	0.003
Error(Status*Period)	Sphericity Assumed	747.633	42	17.801		
	Greenhouse-Geisser	747.633	36.325	20.582		
	Huynh-Feldt	747.633	42	17.801		
	Lower-bound	747.633	14	53.402		

The result revealed significant difference on the systolic blood pressure between the two groups ($P < 0.05$) and levels of measurement over the periods of the training. The interaction between the period and the status of the subjects during the training was also significant. It is concluded based on adjusted degree of freedom with the Greenhouse-Geisser corrections, although sphericity was violated, there was proof that the calculated F-value of 4.304 could not be associated with a Type II error. With an adjustment with Greenhouse-Geisser corrections, there was sufficient proof that the calculated F-value 4.304 could not be associated with a Type II error. This was further confirmed by Huynh-Feldt calculate F-value of 4.305 indicated in Table 4.3.9. This gave more proof for the use of the repeated measure ANOVA in this study. Based on these observations ($P < 0.05$), there was sufficient evidence to reject the null hypothesis. It was earlier observed that participants in the experimental group had lower systolic blood pressure levels. A *post hoc* test carried out using the LSD on the mean levels is summarized in Table 4.3.11.

Table 4.3.7: Pairwise comparison of mean levels of systolic blood pressure of diabetic patients

(I) Period	(J) Period	Mean Difference (I-J)	Std. Error	Sig.
Base line	Week four	3.567	3.255	0.276
	Week eight	5.767	3.255	0.079
	Week twelve	8.033*	3.255	0.015
Week 4	Base line	-3.567	3.255	0.276
	Week eight	2.2	3.255	0.501
	Week twelve	4.467	3.255	0.173
Week 8	Base line	-5.767	3.255	0.079
	Week four	-2.2	3.255	0.501
	Week twelve	2.267	3.255	0.488
Week 12	Base line	-8.033*	3.255	0.015
	Week four	-4.467	3.255	0.173
	Week eight	-2.267	3.255	0.488

*** The mean difference is significant at the .05 level.**

The result of the *post hoc* test revealed that measurement at the onset (base line) was significantly different from the observation at the termination of the exercise in the 12^{th} week. Between the $4^{th,}$ 8^{th} and 12^{th} week no significant difference was observed in the systolic blood levels. The test for the levels of the diastolic blood pressure levels is summarized in Table 4.3.12.

Table 4.3.8: Summary of the two-way repeated measure ANOVA on effect of aerobic exercise on diastolic blood levels of diabetic patients in Kano metropolis

Source		Sum of Squares	Df	Mean Square	F	Sig.
Status	Sphericity Assumed	235.2	1	235.2	6.286	0.025
	Greenhouse-Geisser	235.2	1	235.2	6.286	0.025
	Huynh-Feldt	235.2	1	235.2	6.286	0.025
	Lower-bound	235.2	1	235.2	6.286	0.025
Error (Status)	Sphericity Assumed	523.8	14	37.414		
	Greenhouse-Geisser	523.8	14	37.414		
	Huynh-Feldt	523.8	14	37.414		
	Lower-bound	523.8	14	37.414		
Period	Sphericity Assumed	358.733	3	119.578	3.852	0.016
	Greenhouse-Geisser	358.733	1.45	247.335	3.852	0.05
	Huynh-Feldt	358.733	1.574	227.879	3.852	0.046
	Lower-bound	358.733	1	358.733	3.852	0.07
Error (Period)	Sphericity Assumed	1303.767	42	31.042		
	Greenhouse-Geisser	1303.767	20.306	64.208		
	Huynh-Feldt	1303.767	22.039	59.157		
	Lower-bound	1303.767	14	93.126		
Status x Period	Sphericity Assumed	215.4	3	71.8	5.727	0.002
	Greenhouse-Geisser	215.4	1.995	107.97	5.727	0.008
	Huynh-Feldt	215.4	2.326	92.601	5.727	0.005
	Lower-bound	215.4	1	215.4	5.727	0.031
Error	Sphericity Assumed	526.6	42	12.538		
(Status x Period)	Greenhouse-Geisser	526.6	27.93	18.854		
	Huynh-Feldt	526.6	32.566	16.17		
	Lower-bound	526.6	14	37.614		

The result of the test revealed that the two groups differed significantly in their diastolic blood pressure levels after the training. Significant difference ($P < 0.05$) was observed between the periods of measurement of the levels during the training. The interaction between the period and the status of the subject was found to be significant ($P < 0.05$). The results were confirmed by the observed Greenhouse-Geisser corrections, which proved that the calculated F-value 6.286 could not be associated with a Type II error. This was further confirmed by Huynh-Feldt 6.286 as indicated in the Table. To test for the levels of diastolic blood pressure that was significantly different from the others a pair wise comparison was conducted on the means and the result of the LSD used for the conduct is summarized in Table 4.3.8

Table 4.3.9: Pairwise comparison of mean levels of diastolic blood pressure of diabetic patients

(I) Period	(J) Period	Mean Difference (I-J)	Std. Error	Sig.
Baseline	Week four	3.867*	1.581	0.016
	Week eight	3.867*	1.581	0.016
	Week twelve	4.367*	1.581	0.007
Week four	Base line	-1.9	1.581	0.232
	Week eight	1.967	1.581	0.216
	Week twelve	2.467	1.581	0.121
Week eight	Base line	-3.867*	1.581	0.016
	Week four	-1.967	1.581	0.216
	Week twelve	0.5	1.581	0.752
Week twelve	Base line	-4.367*	1.581	0.007
	Week four	-2.467	1.581	0.121
	Week eight	-0.5	1.581	0.752

The observed difference in the mean level at base line -1.9 was significantly different from the level at week 4, week 8 and week 12 of the training, there was no significant difference observed in the diastolic blood pressure levels. Between the 4^{th} week 8^{th} week and 12^{th} week of the training,

4.5 DISCUSSION

The effects of 12-week bench step aerobic exercise on the blood glucose, urine albumin, urine creatinine, systolic blood pressure and diastolic blood pressure of T2DM patients were investigated in this study with one major null hypothesis and five null sub-hypotheses. The blood glucose, urine albumin, urine creatinine, systolic blood pressure and diastolic blood pressure of the two groups of T2DM patients (control and experimental) were compared. The result revealed that subjects who were in the experimental group exposed to the training had their systolic blood pressure, diastolic blood pressure, and urine creatinine levels significantly reduced, when compared with the control group. However, the variability obtained for levels of blood sugar and urine albumin between the two groups was not found to be statistically significant. The null hypothesis could not be rejected based on the difference in blood sugar and urine albumin levels. However, the null hypothesis was rejected based on the systolic blood pressure, diastolic blood pressure and urine creatinine. The results of this study supports the reports of Rosentock, (2007) and (Anas, 2011), that exercise is directly related to the body's demands and functions and that it affects psychological, nutritional, behavioural, and physiological parameters in humans and, that exercise is recommended for the management of T2DM and that in addition to being effective in improving blood glucose it may be beneficial in preserving beta-cell function which is directly related to kidney function in humans and animal.

In the test of sub-hypothesis 1, the trend in the reduction or otherwise of the blood glucose of the periods of the measurement during the 12-week bench step aerobic exercise was tested. Four periodic measurements taken at the base line, week 4, week 8, and week 12 were compared using two-way repeated measure ANOVA for possible error type II error resulting from issue of sphericity in the levels of measurements. The result of the test did not

reveal significant difference in the blood sugar levels over the four periods during the exercise. The null hypothesis was, therefore accepted. The findings of the present study did not support the report of Yan (2014) who stated that aerobic exercise had significantly lowered blood plasma glucose level. The findings also did not support Ivy, 1997 and Dela *et al*., (2004).that physical activity exerts pronounced effects on substrate utilisation and insulin sensitivity, which in turn potentially lowers blood glucose. Also it does not complement the findings of Pedersen and Saltin, (2006) that moderate-intensity exercise has shown effects on the improvement of insulin sensitivity. The findings did not support the findings of Yan, *et al* (2014), that adding a structured aerobic exercise intervention to type 2 diabetes treatment improved glucose control over 12 weeks. These findings are in line with Ivy, (1997) that exercise training may improve control over hepatic glucose production and exerts pronounced effects on substrate utilisation and insulin sensitivity. It is alos in line with Dela *et al*., 2004), that physical activity potentially lowers blood glucose. It is also in agreement with the findings of Pedersen and Saltin, (2006), that exercise has shown significant effects on the improvement of insulin sensitivity and reduction of blood glucose. The findings are also in line with Yan, *et al*, (2014), that exercise intervention to type 2 diabetics improved glucose control over 12 weeks. It is also in line with Gould *et a.l*, (2014), that regular aerobic training enhances insulin sensitivity in the exercised muscle and enhances muscle contraction induced glucose uptake, and subsequent reduction in blood glucose. The findings are also in agreement with Snowling and Hopkins, (2006), that aerobic exercise have small to moderate beneficial effects on glucose control in T2DM patients and small beneficial effects on some related risk factors for complications of diabetes. It is also in line with Gulve, (2008), that aerobic exercise is recommended for its beneficial effects on glucose control as well as its abilities to retard the progression of other co-morbidities common in patients with

diabetes, such as cardiovascular disease and that the capability of aerobic exercise to improve glycaemic control in diabetes is well documented.

The second sub-hypothesis tested for possible significant differences in the measured levels of the subjects' urine albumin over the training period. The result of the repeated-measure ANOVA did not reveal significant difference in the observed variability of urine albumin between the two groups over the periods of measurements and based on this the null hypothesis is accepted. This would imply that with the correction of sphericity with the Greenhouse-Geisser procedure the observed significance of the variability between the two groups in the test of the major hypothesis could be attributed to Type II error. The finding here contradicted the report of Afsar (2013) who stated that physical activity could protect against albuminuria, however, the relationship between physical activity and albuminuria is not uniform and that in diabetic patients, physical activity is associated with lower albumin excretion, and physical activity has led to regression of albuminuria.

The third sub-hypothesis tested for possible significant differences in the measured levels of the subjects' urine creatinine over the training period. The result of the repeated-measure ANOVA reveal significant difference in the observed variability of urine creatinine between the two groups over the periods of measurements and their interactions, there was a significant difference observed, therefore the null hypothesis was rejected.

Sub-Hypothesis four was tested for differences between the groups and measured levels of the systolic blood pressure over the training period. The result of the repeated measure ANOVA used for the test revealed that the two groups were significantly different in their systolic blood pressure and that the variability in the measured levels were significantly different. The null hypothesis was therefore rejected. Thus the aerobic exercise significantly reduced the systolic blood pressure levels of the type 2 diabetic patients involved in the exercise compared to the control group.

The finding of this study was consistent with Marwick, *et al.*, (2009) that aerobic training in patients with T2DM was beneficial, well tolerated, and that individualised exercise prescription offers an ideal opportunity to account for improvements in T2DM. The results of this study also supports the findings of Ezema, *et al.*, (2013), that aerobic exercise significantly decreased systolic blood pressure. It also supported the findings of Gould, *et al.*, (2014) that aerobic exercise had the ability to impact beneficially on the comorbidities associated with T2DM and kidney disease and is accepted as an important intervention in the treatment, prevention and rehabilitation of other chronic diseases. The report stated that the role of exercise in kidney function is often overlooked. The findings also support Yan, *et al*, (2014) that adding a structured exercise intervention to type 2 diabetics treatment over 12 weeks demonstrated improvement in resting blood pressure and exercise capacity were also observed in the exercise group. The findings also support Ivy, 1997; Dela *et al*., 2004). That physical activity potentially improves many other physiological and metabolic abnormalities associated with T2DM such as reducing blood pressure. It also tallied with Painter, (2005) that physical activity induces a decrease in blood pressure that averages 15 mm Hg systolic. The findings also support Yan *et al.*, (2014) that a 12-week exercise training intervention significantly lower systolicc blood pressures in the exercise group than control group. This finding is in conformity with the findings of Ivy, (1997) and Dela *et al*., (2004), that physical activity exerts pronounced effects on substrate utilisation and insulin sensitivity which in turn lowers lipid levels, and improves many other physiological and metabolic abnormalities associated with T2DM such as lowering body fat, reducing blood pressure. The findings are also in line with Yan, *et al*, (2014), that exercise intervention to type 2 diabetics exerts significant improvement in resting blood pressure and exercise capacity in the exercise group.

The finding also substantiates the assertions by Dela *et al*., (2004), that physical activity has beneficial effects on the endothelial dysfunction seen in T2DM patients by increasing blood flow stress on the blood vessel wall, thereby stimulating endothelium derived nitric oxide, which induces smooth muscle relaxation and vasodilatation thereby easing blood flow around the body that improves blood pressre. The findings are also supported by Yan *et al.*, (2014), who explained that in a 12-week exercise training differences between the exercise and control groups' systolic and diastolic blood pressures at the end of the intervention were significantly lower in the exercise group than control group after co-varying for the baseline values, they further explained that exercise program reduced the mean SBP by 2mmHg, whereas the mean SBP in CON group increased 7mmHg. It has been estimated that a 2-mmHg reduction of SBP results in a 6% reduction in stroke mortality and a 4% reduction in mortality attributable to coronary heart disease. The finding is in line with Taylor, Fletcher, and Tiarks, (2009) regular exercise is especially important for a person with diabetes because it helps in controlling high blood pressure more markedly in type 2 than type 1 reduces hypertension, and normalizes lipids. The study is in compliance with the findings of Toyama, *et al*, (2010) which demonstrated that there are beneficial effects of exercise training to males with T2DM that improved resting BP over 12 weeks in the exercise group. This is also in compliance with Ezema, *et al*, (2013), that a significant decrease in systolic blood pressure (SBP) in the exercise group over control group. The findings also agreed with Painter, (2005), that physical training has reduced SBP by 7.4 mm Hg and DBP by 5.8 mm Hg.

Sub-Hypothesis five was tested for differences between the groups and measured levels of the diastolic pressure over the training period. The result of the repeated measure ANOVA used for the test revealed that the two groups were significantly different in their diastolic blood pressures and that the variability in the measured levels were significantly different.

The null hypothesis was therefore rejected. Thus the aerobic exercise significantly reduced the diastolic blood pressure levels of the T2DM patients involved in the exercise compared to the control group. The finding of this study was consistent with Marwick, *et al.*, (2009) that aerobic training in patients with T2DM was beneficial, well tolerated, and that individualised exercise prescription offers an ideal opportunity to account for improvements in blood pressure among T2DM patients. The results of this study also supports the findings of Ezema, *et al.*, (2013), that aerobic exercise significantly decreased diastolic blood pressure. It also supported the findings of Gould, *et al.*, (2014) that aerobic exercise had the ability to impact beneficially on the comorbidities associated with T2DM and kidney disease and is accepted as an important intervention in the treatment, prevention and rehabilitation of other chronic diseases, such as high blood pressure. The report stated that the role of exercise in kidney function is often overlooked. The findings also support Yan, *et al*, (2014) that adding a structured exercise intervention to T2DM treatment over 12 weeks demonstrated improvement in resting blood pressure and exercise capacity were also observed in the exercise group. The findings also support Ivy, 1997; Dela *et al*., 2004), that physical activity potentially improves many other physiological and metabolic abnormalities associated with T2DM such as reducing blood pressure. It also tallied with Painter, (2005) that physical activity induces a decrease in blood pressure that averages 4 mm Hg diastolic. The findings also support Yan *et al.*, (2014) that a 12-week exercise training intervention significantly lower diastolic blood pressures in the exercise group than control group.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Introduction

The summary of the investigation of the effects of 12-week aerobic exercise on the blood glucose, albumin, creatinine, systolic blood pressure and diastolic blood pressure of T2DM patients investigated in this study was presented and thereby conclusion and recommendations, based on the findings along with recommendation for further studies.

5.1 Summary

The problems of diabetes mellitus in general and T2DM in particular is associated with its fast spread characterized by an abnormal accumulation of sugar in the blood, affecting adversely almost all functions of the body of the patients. Given the enormous public health and economic burden posed by the disease, its prevention from progression to kidney disease and vascular complications cannot be overemphasized. Available therapies for diabetes management do not address the various components of the disease. People living with T2DM are more vulnerable to various forms of both short- and long-term complications, which often lead to premature death, increased morbidity, and mortality. In view of the enormous number of people affected and its potential spread, it becomes inevitable to seek for all preventive measures and management. Regular physical activity is known to be useful in managing diabetes and its risk factors. In Kano metropolis, most T2DM patients do not exercise enough. This study, therefore investigated the effects of bench step aerobics training among adults with T2DM at risk for kidney disease.

To determine the effects of the aerobic exercise on the diabetic patients, an experimental approach was adopted with the selection of 15 subjects each in two groups. One group was exposed to the bench step aerobic exercise, while the other group was used as the control and, therefore, not involved in the training. Index of body parameters selected for

evaluation during the training were blood glucose, albumin, creatinine, systolic blood pressure and diastolic blood pressure of the two groups of T2DM patients. Measurements of levels of the parameters were taken, at the commencement (base line) of the training and at week four, week eight and week 12 when the exercise was terminated. The data collected were analyzed using the Statistical Package for the Social Sciences (IBM version 20). Statistical procedures selected for the analysis included means and standard deviations. The hypotheses were tested with inferential statistics of the two-way repeated measure ANOVA.

The study was structured into five chapters. Chapter one gave the background of the study, the theoretical framework, and statement of the problem, the objectives, research questions, and the study's hypotheses. The scope and limitation of the study were also given within the chapter. Chapter two consisted of the review of the related literature to the study. In chapter three, the research methodology, instrumentation, data collection and statistical methods used for the analysis of the data were stated. The statistical analysis and interpretation of the findings from the analyzed data were presented in chapter four. The chapter is made up of the solution to the research questions and test of the study's hypotheses along with discussions of the findings. Five null sub-hypotheses were tested along the major hypothesis of the study. The major findings from the test and an analysis of the data are summarised below:

5.1 SUMMARY OF FINDINGS

The major findings from the analysis of the data and test of the study's hypotheses are summarised below:

1. Participation in aerobic exercise was found to have major positive effects on the health conditions of the diabetic patients involved in the study based on the positive changes that resulted from the participants' involvement in the training

2. There was no significant difference in blood sugar and albumin levels between the exercise groups who participated in the bench step aerobics those in control group who did not participate in the training ($P > 0.684$).
3. The presence of excess protein in patients urine is an important indicator of kidney problem which the study tried to analyse, in this study the aerobic exercise over the 12-week period did not significantly affect the albumin levels of subjects involved in the training ($P>0.481$),
4. The 12-week training had significant effect on creatinine which was an important protein considered in assessing kidney function ($P < 0.003$)
5. Participation in aerobic exercise had significant effect on the reduction of the systolic and diastolic blood pressure levels of subjects ($P < 0.025$)..

5.2 CONCLUSIONS

From the analysis of the data and test of the hypotheses of this study, several observations were made on the actual differences of the various parameters tested between the exercise and control groups. The researcher, therefore, concludes as follows:

1. Participation in aerobic exercise and bench step aerobic in particular has significant effect on three of the selected body parameters (systolic blood pressure, diastolic blood pressure and creatinine levels) of T2DM patients,.
2. For effective and significant effects, participants may have to train for relatively longer number of weeks, since most observed significance was obtained between the base line and the week 12 of exercise.
3. Blood sugar and albumin parameters were not found to decrease significantly by the aerobic exercise which may be connected to either intensity or duration of the exercise.

4. Since exercise was likely to influence the presence of albumin in the patients the high level albumin found in the exercise group when compared with control group may be associate with either intensity or duration of the aerobic training

5.3 Recommendations

Based on the findings the following recommendations were made:

1. T2DM patients should be engaged in regular physical activity, especially aerobic type and bench step aerobics in particular to manage diabetes and prevent complications such as the kidney disease.
2. There was need for more enlightenment to the T2DM patients and reorientation from sedentary type of living to an exercise attitude.
3. The aerobic bench-step training should be recommended to diabetics as it was cheap, easy to construct and managed and does not require space and sophistication.

5.4 Recommendations for further studies

This study used bench step aerobics training for a period of 12-week and only 30 subjects were involved. It also used the hospitals as the source of the subjects and recommendations for further research is as follows:

1. The number of subjects to be increased to at least 60 because of the ongoing increase in the number of new cases of T2DM.
2. There was need for increase in the duration and/or intensity of the exercise, when using the bench-step aerobic exercise.

3. Further study need to be carried out specifically to determine the significant effects of aerobic training on albumin level in T2DM patients.

REFERENCES

Abdul-Ghani, M. A. Matsuda, M. Sabbah, M. Jenkinson, C. Richardson, D. K. and DeFronzo, R. A. (2007).. The relative contribution of insulin resistance and beta cell failure to the transition from normal to impaired glucose tolerance varies in different ethnic groups. *Diabetes Metabolic Syndrome,* (1) 105–112

Abdul-Ghani, M. A. Matsuda, M. Jani, R. Jenkinson, C. P. Colettea, D. K. Kaku, K. and DeFronzo, A. (2008) The relationship between fasting hyperglycemia and insulin secretion in subjects with normal or impaired glucose tolerance. *American Journal of Physiology, Endocrinology and Metabolism*, 295(2); 401-406

Adams, O. P. (2013). The Impact of brief high-Intensity exercise on blood glucose levels. Diabetes, metabolic Syndrome and Obesity: targets and therapy. 2013(6): 113-122

Adebayo, B (2013). More Nigerians die of diabetes than HIV/AIDS- Experts. *Punch* January19th 2013. http://www.punchng.com/health

Adler A. I., Stevens R. J., Manley S. E., Bilous R. W., Cull C. A., Holman R. R. (2003). Development and progression of nephropathy in type 2 diabetes: the United Kingdom Prospective Diabetes Study (UKPDS 64). *Kidney International*2003 Jan;63(1):225-32. http://www.ncbi.nlm.nih.gov

Afsar, B. (2013): Microalbuminuria, kidney function, and daily physical activity. *International Journal of Nephrology.* http://www.hindawi.com/journals/ijn

Alebiosu, C. O., Ayodele, O. O., Abbas, A, and Olutoyin A. I. (2006). Chronic renal failure at the Olabisi Onabanjo university teaching hospital, Sagamu, Nigeria. *Journal of African Health Science; 2006; 6(3)*: 132–138.

Al-Rawi, N H (2011). Oxidative stress, antioxidant status and lipid profile in the saliva of type 2 diabetics. *Diabetes & Vascular Disease Research*, 8(1); 22–28

American College of Sports Medicine (ACSM) (1995). *Guidelines for Exercise Training and Prescription (5th ed.),*. Baltimore. Williams and Wilkins.

American Diabetes Association (ADA): (2013). *Nutritional Recommendation and Intervention for Diabetes*. http://www.diabetescare. diabetesjournals.org/cgi/content/full retrieved 7/8/2014

American Diabetes Association ADA (2014). *What We Recommend*: Two types of Physical Activity are Most Important for Managing Diabetes: Aerobic Exercise and Strength Ttraining. http://www.diabetes.org retrieved 12/09/2015

American Diabetes Association and American College of Sports Medicine (2010.*: Exercise tand Type 2 Diabetes* .American College of Sports Medicine and the American Diabetes Association: Joint Position Statement:: Medicine & Science in Sports & Exercise: 42 (12); 2282-2303

American Diabetes Association (2016). Blood glucose control and exercise. **www.diabetes.org/food.and.fitness**

Anas, Y. M. (2011). Effects of 8-week Cycle Ergometer Exercise on the Risk factors of Diabetes Mellitus Among Female Diabetics in Kano City. (Masters Dissertation Bayero University, Kano).

Andersen, T B (2012). Estimating renal function in children: a new GFR-model based on serum cystatin C and body cell mass. *Danish Medical Journal* 2012 July 5(97)

Andersen, T. B, Jødal L, Erlandsen E. J, Morsing A, Frøkiær, J, and Brochner M J (2013). Detecting reduced renal function in children: comparison of GFR-models and serum markers. Berlin, *Paediatric Nephrology 2013 Jan;28(1)*:83-92.

Ann, M. R (2013). *The effect of exercise training intensity on physical fitness and Physical Function in People with Type 2 Diabetes: A randomized Clinical Trial*. (Graduate Dissertation). University of Central Arkansas. Physical therapy; Kinesiology. http://gradworks.umi.com

Atkins, R. C, Briganti, E. M, Zimmet, P. Z, and Chadban, S. J. (2003). Association between albuminuria and proteinuria in the general population: the AusDiab Study. *Nephrology Dialysis Transplantation (NDT)*.http://ndt.oxfordjournals.org

Bakris, G (2014). Patient information: *Diabetic kidney disease (diabetic nephropathy) Beyond the Basics*. www.uptodate.com

Bakris, G, Sharma, K and Ecelbarger, C (2011). New insights about the Kidney's Role in Glucose Metabolism: how the kidney affects diabetes control and its complications. http://www.medscape.org

Barcellos, F. C. Santos, I. S. Mielke, G. I. del-Vecchio, F. B. and Hallal, P. C. (2012). Effects of exercise on kidney function among non-diabetic patients with hypertension and renal disease: randomised control trial. *Biomedical Central Nephrology.* 13(90)

Belli, T., Ribeiro, L.F., Ackermann, M.A., Baldissera, V., Gobatto, C.A.and da Silva, R.G. (2011). Effects of 12-week over ground walking training at ventilator threshold velocity in type 2 diabetes women. *Diabetes Research and Clinical Practice 93(3),* 337-343

Bevc S, Hojs R, Ekart R, Gorenjak M, and Puklavec L (2012). Simple cystatin C formula Compared to serum creatinine-based formulas for estimation of glomerular filtration rate in patients with mildly to moderately impaired kidney function. *Kidney and Blood Pressure Research. 2012;35(6)*:649-54.

Bieke F. Schrijvers, A. S. De Vriese and Allan Flyvbjerg (2004). *From Hyperglycemia to Diabetic Kidney Disease*: The Role of Metabolic, Hemodynamic, Intracellular Factors and Growth Factors/Cytokines.http://edrv.endojournals.org

Bouché C, Serdy S., Kahn C. R., Goldfine A. B., (2004). The Cellular Fate of Glucose and its Relevance in type 2 diabetes. *Endocrinology review 2004 Oct;25(5)*:807-30. http://www.ncbi.nlm.nih.gov/pubmed

Burks, T. N, and Cohn, R. D, (2011). *Role of TGF-β Signaling in Inherited and acquired Myopathies.*http://www.skeletalmusclejournal.com retrieved 13/11/2014

Campbell, W. W. and Anderson, A. A (1987). Effects of aerobic exercise and training on trace minerals chromium, zinc and copper. *Sports Medicine, 4 (1):* 9-18.

Cauza, E., Hanusch-Enserer, U., Strasser, B., Ludvik, B., Metz-Schimmerl, S., Pacini, G., Wagner, O., Georg, P., Prager, R.,Kostner, K., Dunky, A. and Haber, P. (2005) The relative benefits of endurance and strength training on the metabolic factors and muscle function of people with type 2 diabetes mellitus. *Archives of Physical Medicine and Rehabilitation 86*, 1527-1533.

Cerf, M. E. Chapman, C. S. and Louw, J. (2012) High- Fat Programming of Hyperglycaemia, Hyperinsulinemia, Insulin Resistance, Hyperglycaemia and Altered Islet Architecture in 3-Month-Old Wister Rats. *International Scholarly Research Notices Endocrinology. 2012(627270)*

Cerf, M. E. (2013): Beta Cell Dysfunction and Insulin Resistance. *Frontiers in Endocrinology.* 4 (37)

Christian M and John E. G, (2002): Role of kidney in hyperglycemia in type 2 diabetes. *Journal of Current Diabetes Reports. Vol 2* (3)

Dabla, P, K., (2010): Renal function in Diabetic Nephropathy. *World Journal of Diabetes May 15*, 1(2) 48-56.

Deal, F. vonLinslow, M. E. Mikines, K. J. and Galbo, H. (2004): Physical training may enhance beta-cell function in type 2 diabetes. *American Jouranal of Physiology, Endocrinology and Metabolism.* 278(5) 10124-31

De-Fronzo, R. A. Eldor, R. and Abdul-Ghani, M. (2013): Pathophysiologic approach to therapy in patients with newly diagnosed type 2 diabetes. d*iabetes care* 36(2) 127-138

Deal, F. von-Linslow, M. E. Mikines, K. J. and Galbo, H. (2004): Physical training may enhance beta-cell function in type 2 diabetes. *American Jouranal of Physiology, Endocrinology and Metabolism.* 278(5) 10124-31

Dela, F., von Linstow, M. E., Mikines, K. J., and Galbo, H (2004): Physical training may enhance B-cell function in type 2 diabetes. American Journal of Physiology Endocrinology Metab 287: 1024 –1031 retrieved 13/09/2015 from http://citeseerx.ist.psu.edu

Delanaye, Pand Ebert N (2012): Assessment of kidney function: Estimating GFR in Children. *Nature review, Nephrology.* 2012Sep;8(9):503-4.

Deshpande, A. D, Harris-Hayes, M, and Schootman, M (2008): Epidemiology of Diabetes and Diabetes-Related Complications. *Journal of the American Physical Therapy association November 1, 2008* 88*:1254-1264*

Dutse, A, (2006): Scope and prevalence of diabetes in Northern Nigeria. *Journal of Nigerian Clinical Medicine,* 15(3); 213-227

Enengedi, V, (2013): *How Renal Failure is Killing Your Favourite Celebs*. retrieved from www.thenet.ng/2013/07/special-feature on 19/01/2014

Ewing, D. J. and Clarke, B. F (1986). Autonomic neuropathy: its diagnosis and prognosis. *Clinics in Endocrinology and Metabolism. Volume 15, Issue 4*, November 1986, Pages 855–888

Ezema, C. I, Onwunali, A. A, Laminam S, Ezugwu, U. A, Amaeze, A. A, Nwankwo, M. J, and Amaeze, F. N (2013). Blood glucose response to aerobic exercise training programme among patients with type 2 diabetes mellitus at the University of Nigeria Teaching Hospital, Enugu South-East, Nigeria. *The Nigerian Journal of Exercise Science, (11)* 1796-1802

Family Doctor (2014). *Diabetic Nephropathy*, Over View. http://familydoctor.org

Futrakul, N. and Futrakul, P. (2011). Indices Indicating Early Renal Microvascular Disease in Diabetes. 18 *The Open Biomarkers Journal,* 2011, *4,* 18-20. http://benthamopen.com/tobiomj/articles/V004/18TOBIOMJ

Gao, W., Ferguson, G. Connell, P. Walshe, T. O'Brien, C. Redmond, E. M. and Cahill, P A (2014). Glucose attenuates hypoxia-induced changes in endothelial cell growth by inhibiting HIF-1α expression. *Diabetes & Vascular Disease Research* 11(4) 270–280

Gould, D. W. Graham-Brown, M. P. Watson, E. L. Viana, J. L. and Smith, A. C. (2014). Physiological benefits of exercise in pre-dialysis chronic kidney disease. *Research Gate.* Retrieved from www.researchgat.,net/journal-nephrology. on 05/05/2015

Genc H, Karadurmus N, Kisa U, Tapan S, Naharci I, Sonmez A, Dogru T. (2010). Transforming Growth Factor β (TGF-β) Levels in Otherwise Healthy Subjects with Impaired Glucose Tolerance. *Endokrynol Pol.* 2010 Nov-Dec;61(6):691-4. Retrieved from http://www.ncbi.nlm.nih.gov on 20/03/2016

George, A B, Thomas, D F, Timothy, P W, & Kenneth, M B, (2000). *Exercise Physiology (3rd ed). Human Bioenergetics and its Applications*. New York, McGraw-Hill.

George Bakris; Kumar Sharma, Carolyn Ecelarger, (2011). *New insights about the Kidney's Role in Glucose Metabolism*: how the kidney affects diabetes control and its complications. http://www.medscape.org

Gomes K B, Rodrigues, K. F, and Fernandes, A. P, (2014). The Role of Transforming Growth Factor-Beta in Diabetic Nephropathy. *International Journal of Medical Genetics Volume 2014* (2014), http://www.hindawi.com

Grundy, S. MBenjamin, I. J, Burke, G. L,Chait, A, Eckel, R. H, Howard, B. V, Mitch, W, Smith Jr, S. C. Sowers,J. R (1999). Diabetes and Cardiovascular Disease: *A Statement for Healthcare Professionals From the American Heart Association. American Heart Association.* http://www.circ.ahajournals.org/

Gulve, E, A (2008). Exercise and Glycemic Control in Diabetes: Benefits, Challenges, andAdjustments to Pharmacotherapy. *Journal of American Physical Therapy Association.2008 vol. 88 no. 11 1297-1321* http://ptjournal.apta.org

Han, L, Bai, X, Lin, H, Sun, X and Chen, X. M, (2010). Lack of independent relationship Between age-related Kidney Function Decline and Carotid Intima-media Thickness in a Healthy Chinese population. *Nephrology Dialysis Transplantation*; Official Publication of the European Dialysis and Transplant Association-European Renal Association.. June 25(6). http://www.ncbi.nlm.nih.gov/pubmed/20048122

Hansen,D, Peeters, S, Zwaenepoel, B, Verleyen, D, Wittebrood, C, Timmerman, N and Schotte, M (2013). Exercise Assessment and Prescription in Patients With Type 2 Diabetes in the Private and Home Care Setting: *Clinical Recommendations From AXXON (Belgian Physical Therapy Association)* http://ptjournal.apta.org

Hatice, K., Sunay, S., Nilay, E., Ayse, D., Kurdak, and Sadi, S (2010). The effects of Regular Aerobic Exercise on Renal Functions in Streptozotocin Induced Diabetic Rats. *Journal of Sports Science and Medicine.* http://www.researchgate.net

Hawkins, M, (2010). *The Relationship Between Physical Activity and Kidney Function/Chronic Kidney Disease*. (Doctorate Thesis Pitsburg, 2010)

Hawkins, M. S, Richardson, M. A, Fried, C. R, Arena, L. F, and Kriska,A. M, (2011). Association between physical activity and kidney function: National Health and Nutrition Examination Survey. *Medicine and Science in Sports and Exercise*. Aug. 43(8). http://www.ncbi.nlm.nih.gov/pubmed/21200336

Hejazi, S. M, Soltani,M, Zare, M, Nornematolahi, S, and Aminian, F (2012). Effect of Aerobic Exercise on HbA1C, Serum Insulin Level, C-peptide and Insulin Resistance in Middle-Aged Women with Type II Diabetes. *Life Science Journal 2012;9(4)*. http://www.lifesciencesite.com

Holland, L J Bouffard, M and Wagner, D (1992): Rating of Perceived Exertion, Heart Rate, and Oxygen Consumption in Adults With Multiple Sclerosis. Aapted Physical Activity Quarterly, (91)9. 64-73. Retrieved 7/06/2016 from *http://fitnessforlife.org*

Ibrahim, A. S., (2008). *The Relationship Between Psychiatry and Diabetes.*(Seminar Paper Bayero University Kano).

Ibrahim, Y. L *(2012)*. Physical Inactivity: Exercise to the Rescue. *International Journal of Sports Sciences and Fitness*, Volume 2, Issue 2.

Ivy, J. L. (1997). Role of exercise training in the prevention and treatment of insulin resistance and non-insulin-dependent diabetes mellitus. *Sports Medicine.* (Auckland NZ) 24(5) 321-336

Janmohamed, M. N, Kalluyya, S. E, Mueller, A, Kabangila, R, Smart, L. R, Downs, J. A, and Peck, R. N, (2013). Prevalence of Chronic Kidney Disease in Diabetic Adult outpatients in Tanzania. *BMC Nephrology,* 31;14;183 http://www.ncbi.nlm.nih.gov

Jisieike-Onuigbo N. N, Unuigbe E. I, Oguejiofor C. O, (2011). Dyslipidemias in Type 2 Diabetes Mellitus Patients in Nnewi South-East Nigeria. *Annals of African Medicine. 2011* Oct-Dec;10 (4):285-9

Jouybari, M F, Arkhazlue, P. F,Hashemvarzi, S. A, (2014). The effect of 8 weeks aerobic Exercise with Purslane Seeds Consumption on Peroxidant and Antioxidants Indicators in Women with Type2 Diabetes. *International Journal of Sport Studies*. 4 (2), 238-245.

Kali, V. R (2012). Aerobic Training on Resting State Plasma Fibrinogen and Resting State LDL Cholesterol among Middle Aged Men. *International Journal of Sports Sciences and Fitness*, 2, (2).

Kano state Hospitals Management Board (KHMB, 2015): Statistics of the Records of Clinical Attendance of Type 2 Diabetes Mellitus Patients in Kano state as at 2014 Clinical attendance Registers of the Medical Records.

Katz, P., Leiter, L. A., Mellbin, L and Rydén, L (2014). The clinical burden of type 2 diabetes mellitus in patients with acute coronary syndromes: Prognosis and implications for short- and long-term management. *Diabetes & Vascular Disease Research* 11(6) 395–409

Komatsu, W. R, Barros Neto, T. L, Chakra, A. R and Dib, S, A (2010). Aerobic Exercise Capacity and Pulmonary Function in Athletes With and Without Type 1 Diabetes. *Diabetes care Vol*. 33 No 12. December 2010. www.care.diabetesjournal.org

Kosmadakis, G.C, Bevington, A, Smith A.C. Clapp E.L, Viana, J.L. Bishop, N.C, and Feehally, J. (2010). Physical Exercise in Patients with Severe Kidney Disease. *Nephron Clinical Practice 2010;*115:c7–c16. www.wtgf.org

Kraemer, W J, Keuning, M., Ratamess, N. A., Volek, J. S., McCornick, M., Bush, J. A., Nindl, .Gordon, S. E., Mazzetti, S. A., Newton, R. U, Gomez, A. L, Wickham, R. B, Rubin, M. R and Hakkinen, K. (2001): Resistance training combined with bench-step aerobics enhances women's health profile.Medicine and Science in Sports and Exercise. 33(2). 258-69. Retrieved 13/07/2016 from https://www.ncbi.nlm.nih.gov/pubmed

Krotkiewski, M. Lönnroth P, Mandroukas K, Wroblewski Z, Rebuffé-Scrive M, Holm G, Smith, U. and Bjomtorp, P. (1985). The effects of physical training on insulin secretion and effectiveness and on glucose metabolism in obesity and type 2 (non-insulin-dependent) diabetes mellitus.*Diabetologia.* 26(2): 881-890

Kucharska, A. R., Wysocka, K., Winiarski, S., Szpala, A., and Sobera, M., (2017): An Investigation into the Relation between the Technique of Movement and Overload in Step Aerobics. Applied Bionics and Biomechanics, vol. 2017. Retrieved 2/05/2017 from https://www.hindawi.com/journals

Kurdak, H, Sandikci, S, Ergen, N, Dogan, A, and Kurdak, S. S, (2010). The Effects of Regular Aerobic Exercise on Renal Functions in Streptozotocin Induced Diabetic Rats. *Journal of Sports Science and Medicine.*. Jun 2010; 9(2): 294–299.

Lam, K S L., (2005). What's New in the Treatment of Type 2 Diabetes. Lagos, *Medi link Journal*, Vol 6: 53.

Larose, J., Sigal, R. J. Boulé, N. G., Wells, G. A., Prud'Homme, D., Fortier, M. S., Reid, R. D. Tulloch, H., Coyle, D., Phillips, P., Jennings, A., Khandwala, F., Kenny., G. P., (2010). Effect of Exercise Training on Physical Fitness in Type II Diabetes Mellitus. *Medicine and Science in Sports and Exercise* 2010;42(8):1439-1447 http://www.medscape.com/

Lazarevic, G., Antic, S., Vlahovic,P., Djordjevic, V., Zvezdanovic, L., & Stefanovic, V (2007) Effects of Aerobic Exercise on Microalbuminuria and Enzymuria in Type 2 Diabetic Patients, Renal Failure, 29:2, 199-205 retireved, 21/11/2015 from http://www.tandfonline.com

Leehey, D. J, Moinuddin, I., Bast, J. P., Qureshi, S., Jelinek, C. S., Cooper, C., Edwards, L. C., Smith, B. M., Collins, E. G., (2009). *Aerobic exercise in obese diabetic patients with chronic kidney disease: a randomized and controlled pilot study*. http://link.springer.com

Lehmann, R. and Spinas, G. A. (1996). Role of physical activity in the therapy and prevention of type 2 diabetes mellitus. *Therapeutiche Umschau. Revue Therapeutique 53(12) 925-933*

Li, H. X, Xu, G. B, Wang, X. J, Zhang, X. C, Yang, J. M (2010). Diagnostic accuracy of various glomerular filtration rates estimating equations in patients with chronic kidney disease and diabetes. *Chinese Medical Journal*. 2010 Mar 20;123(6):745-51

Liu, Z, Fu, C, Wang, W and Xu, B (2010). Prevalence of chronic complications of type 2 diabetes mellitus in outpatients - a cross-sectional hospital based survey in urban China. *Health and Quality of Life Outcomes* 2010 8:62. http://www.hqlo.com/content/8/1/62

Loimaala, A., Groundstroem, K., Rinne, M., Nenonen, A., Huhtala, H., Parkkari, J. and Vuori, I (2009). Effect of Long-term Endurance and Strength Training on Metabolic Control and Arterial Elasticity in Patients with Type 2 Diabetes Mellitus. *American Journal of Cardiology 103*, 972-977.

Maeda, Y. Inoguchi, T. Takei, R. Sawada, F. Sasaki, S. Fujii, M. Kobayashi, K. Urata, H. Nishiyama, A. and Takayanagi, R. (2010). Inhibition of chymase protects against diabetes-induced oxidative stress and renal dysfunction in hamsters.*American Journal of Physiology Renal Physiology (*299): 1328–1338.

Maiorana, A., O'Driscoll, G., Goodman, C., Taylor, G. and Green, D. (2002). Combined aerobic and resistance exercise improves glycemic control and fitness in type 2 diabetes. *Diabetes Research and Clinical Practice*56, 115-123.

Mann J. F., Gerstein H. C., Yi Q. L., Franke J., Lonn E. M., Hoogwerf B. J., Rashkow A, Yusuf S, (2003). Progression of renal insufficiency in type 2 diabetes with and without microalbuminuria: *Results of the Heart Outcomes and Prevention Evaluation (HOPE) randomized study*.

Mariappam, M. M (2012): Signalling Mechanisms in the regulation of renal matrix metabolism in Diabetes. Experimental Diabetes Research. 2012(ID749812) Hindawi Publishing corporation

Martin, H. (2011): Laboratory Measurement of Urine Albumin and Urine Total Protein in Screening for Proteinuria in Chronic Kidney Disease**.** Clinical Biochemistry Review 32(2): 97–102. Retrieved 15/11/2016 from https://www.ncbi.nlm.nih.gov

Marwick, T. H, Hordern M. D, Miller T, Chyun, D. A, Bertoni, A. G, Blumenthal, R. S, Phillipides G, and Rocchini, A (2009). Exercise Training for Type 2 Diabetes Mellitus: Impact on Cardiovascular Risk: A Scientific Statement From the American Heart Association. Dallas. *Journal of the American Heart Association*. http://www.sportmedicine.ru

Medical Express (2014). *Physical fitness level affects kidney function in type 2 diabetes*. http://medicalxpress.com.

Meyer, C, Gerich, J. E (2002). Role of Kidney in Hyperglycemia in Type 2 Diabetes. *Journal of Current diabetes Reports.* Vol 2 (3)

Monroe, M (2008): Gin Miller: Stepping Up to Success. Retrieved 8/06/2016 from http://www.ideafit.com

National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) (2013). *Kidney Disease of Diabetes retrieved from* .http://kidney.niddk.nih.gov on 19/01/2014

National Kidney and Urologic Diseases Information Clearinghouse (NKUDIC) (2006). *Kidney Disease of Diabetes* http://www.kidneyurology.org retrieved 08/06/2014

Obinna, C. (2013). Kidney Disease: High Cost of Treatment kills faster in Nigeria. *Vanguard on line*. www.vanguardngr.com/2013/03/kidney

Olokoba, A. B, Obateru, O. A, and Olokoba, L. B (2012). Type 2 Diabetes Mellitus: A Review of Current Trends. *Oman Medical Journal.* Jul 2012; 27(4): 269–273. http://www.ncbi.nlm.nih.gov/pmc

Ontario Local Health Integration Network, (LHIN) (2013). *living with diabetes and Chronic Kidney disease*. What you should know. www.centraleastlhin.on.ca retrieved 01/13/2014

Padmalayam, I (2014). *The heat stroke response*: its role in pathogenesis of type 2 diabetes and its complications, and implications for therapeutic intervention. http://www.discoverymedicine.com

Painter, P. (2005). Physical functioning in end-stage renal disease patients. *Hemodialysis International*. 9(3):218-35

Pandey, A, Tripathi, P, Pandey, R, Srivatava, R, and Goswami, S (2011). Alternative therapies useful in the management of diabetes: *A systematic review*.J Pharm Bioallied Sci. 3(4): 504–512. http://www.ncbi.nlm.nih.gov/pmc/articles

Parameswari G. and Gopinath, V. (2013). Effect of low intensity aerobic exercise on body composition of overweight men. *International Journal of Sports Sciences and Fitness*, Volume 3(1): 23-32

Pedersen, B. K, and Saltin, B. (2006). Evidence for prescribing exercise as therapy in chronic disease. *Scandinavian Journal of Medicine and Science in Sports*. 16 (1) 3-63

Penny, B (2007). Prescribing exercise for diabetics. *Australian Precriber,* 30 (5) http://www.australianprescriber.com

Philippides, G, and Rocchini, A, (2009). Exercise training for type 2 diabetes mellitus: impact on cardiovascular risk: a scientific statement from the American Heart Association; on behalf of the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee of the Council on Clinical Cardiology; *American Heart Association Circulation*. 2009; 119:3244–3262.

Pizaazz, (2010). *New exercise regimen for people with type 2 diabetes*. http://www.pizaazz.com

Plowman, S. A, and Smith, D. L, (2003). *Exercise Physiology for Health Fitness and Performance*; Francisco. Benjamin Cummins

Prigent, A, (2008). Monitoring renal function and limitations of renal function tests. *Seminars in Nuclear Medicine*2008 Jan;38(1):32-46.

Robergs, R. A, and Ketiyian, S. J. (2003). *Exercise Physiology for Fitness Performance and Health* (2 ed). New York. Mc Graw Hill

Rosentock, J, (2007). Reflecting on type 2 diabetes prevention: more questions than answers. *Diabetes, Obesity and Metabolism,* 2007. 1:3-11 http://www.ncbi.nlm.nih.gov

Rossi, A. Burris, D. Lucas, L. and Crocker, G. (2014). Exercise to improve physical function and quality of life in chronic kidney disease. *Clinical Journal of the American Society of Nephrology*. http://cjasn.asnjournals.org

Santos-Rocha, R. A. Oliveira, C. S. and Veloso, A. P. (2008): Osteogenic index of step exercise depending on choreographic movements, session duration, and stepping rate. British Journal of Sports Medicine. (40)10 860-866 retrieved 8/6/2016 from https://www.ncbi.nlm.nih.gov

Scharf-Olson, M., Williford, H. N., Blessing, D. L., and Greathouse, R., (1991): The cardiovascular and metabolic effects of bench stepping exercise in females. Medicine and Science in Sports and Exercise. 23(11): 1311-1317

Scharf-Olson, M., Williford, H. N., Blessing, D. L., and Brown, J. A., (1996): The physiological effects of bench/step exercise. Sports Medicine, Auckland. 21(3). `64-`75

Scharff-)lson and Williford (1996): The Enerfy Cost Associated with Selected Step training Exercise Techniques. Research Quarterly for Exercise and Sport. 67(4)

Scharff-Olson, M., Williford, H. N., Blessing, D. L., and Brown J. A. (1996): The Physiological Effects of Bench/Step Exercises. Sports Medicine 21(3) 154-175

Schrijvers, B. F, DeVriese A., S and Flyvbjerg, A. (2004). *From Hyperglycemia to Diabetic Kidney Disease*: The role of metabolic, hemodynamic, intracellular factors and growth factors/cytokines.http://edrv.endojournals.org/content/25/6/971.full

Sharkey, B. J. (1979). *Physiology of Fitness*. Human Kinetics Publishers. Champaign. New York

Shravya, K. G, Sharanm BSM, Bandi, H KSuresh, MPreetham, JK andMallikarjuna, R M (2012). Deterioration of pulmonary functions in type 2 diabetes mellitus. IOSR *Journal of Pharmacy and Biological Sciences.* Vol 1 Issue 1 (May-June 2012) PP 39-43. www.iosrjournals.org

Sigal, R., Kenny, G., Boule, N., Wells, G., Prud'homme, D., Fortier, M., Reid, R.D., Tulloch, H., Coyle, D., Phillips, P., Jennings, A. and Jaffey, J. (2007). Effects of aerobic training, resistance training, or both on glycemic control in type 2 diabetes. *Annals of Internal Medicine* 147, 357-369.

Sims, J., (2008). *Type 2 Diabetes Mellitus Symptoms, Control and Management*. http://www.weightlossresources.co.uk/diet/diabetes/symptoms_conrol.html retrieve 8/11/2014

Snowling, N, J., and Hopkins, W. G., (2006). Effects of different modes of exercise training on glucose control and risk factors for complications in type 2 diabetic patients: *A meta-analysis.* American Diabetes Association. http://care.diabetesjournals.org

Soares, A. A, Eyff, T. F, Campani, R. B, Ritter, L, Camargo, J. L, Silveiro, S. P. (2009). Glomerular filtration rate measurement and prediction equations.*Clinical Chemistry and Laboratory Medicine* 2009;47(9):1023-32.

Stanforh, D., Stanforth P. R., and Velasquez, K. S. (1993): Aerobic Requirement of bench stepping. International Journal of Sports Medicine. 14(3). 129-133

Stevens, L. A, Coresh, J, Greene, T, and Levey, A. S, (2006). Assessing kidney function: measured and estimated glomerular filtration rate. *New England Journal of Medicine* 354:2473-2483June 2006. http://www.nejm.org/doi/full/10.1056/NEJMra054415

Strejcová, B.Konopková, R.Řehořková, M. and Bunc, V.(2013). The Energetic Cost And cardio-respiratory changes during Zumba exercise in middle aged women. *International Journal of Sports Sciences and Fitness*, Volume 3(1) 2013

Tan, S, Li, W, and Wang, J (2012). Effects of six months of combined aerobic and resistance training for elderly patients with long history of type 2 diabetes. *Journal of Sports Science and Medicine* (2012) 11, 495-501. http://www.jssm.org

Taneda, S. Honda, K. Tomidokoro, K. Uto, K. Nitta, K. and Oda, H (2010). Eicosapentaenoic acid restores diabetic tubular injury through regulating oxidative stress and mitochondrial apoptosis. *Journal of Physiology Renal Physiology (*299):1451–1461,

Tavakolizadeh, J. Moghadas, M. and Ashraf, H. (2014). Effect of self-regulation training on management of type 2 diabetes. *Iranian Red Cresesnt Medical Journal.* 16(4)

Taylor, J.D., Fletcher, J.P. and Tiarks, J. (2009). Impact of physical therapist directed exercise counseling combined with fitness center-based exercise on muscular strength and exercise capacity in people with type 2 diabetes: A randomized clinical trial. *Physical Therapy* 89, 884-892.

Thomas, J. E, and Nelson, J. K, (2001). *Research methods in Physical Activity* (4th ed) Campaign: Illinois: Human Kinetics.

Topend Sports1 (2015). *Harvard Step Test*. www.topendsports.com/testing/tests/site

Topend Sports 2 (2015). *Maximum Heart Rate.* www.topendsports.com/testing/heart-rate

Toyama, K. Sugiyama, S. Oka, H. Sumida, H. Ogawa, H (2010). Exercise therapy correlates with improving renal function through modifying lipid metabolism in patients with cardiovascular disease and chronic kidney disease. *Journal of Cardiology* 2010(56): 142-146

Ulasi, I. I, and Ijioma, C. K, (2010). The enormity of chronic kidney disease in Nigeria; the situation in a Teaching Hospital in South-Eastern Nigeria. *Journal of Tropical Medicine.* Volume 3(21): 3-21. www.himdawi.com/journals/jtm/2010

Usman, A, Umar, R. A, Shehu, N. I, Wali, U and Nasir, A. (2012). Markers of diabetic nephrophthy in diabetic patienst in Gusau, Zamfara State, Nigeria.Nigerian *Journal of Basic and Applied Sciences*. 20 (2) 130-133

Vos, F. E, Schollum, J. B, and Walker, R. J, (2011). Glycated albumin is the preferred marker for assessing glycaemic control in advanced chronic kidney disease. *Clinical Kidney Journal*Volume 4,Issue 6 Pp. 368-375..

Wellberg-Henriksson, Rincon and Zierath, (1998). Exercise in the management of non-insulin-dependent diabetes mellitus. *Sports Medicine* (Auckland, NZ) 25(1) 25-35

Wiley-Blackwell. (2011). Regular exercise improves health of people with long-term kidney disease, study suggests. *ScienceDaily*. Retrieved May 5, 2015 from www.sciencedaily.com/releases/2011/10/111004221112.htm

Wolf, G. and Ritz E (2003). Diabetic nephropathy in type 2 diabetes prevention and patient management. *Journal of American Society of Nephrology.* 14 1396-1405 2003 http://jasn.asnjournals.org/content/14/5/1396.ful

Wright, D. C., and. Pamela D. S., (2001): Optimal Exercise Intensity for Individuals With Impaired Glucose Tolerance. Diabetes Spectrum Volume 14, Number 2, 2001

Wright, E, Scism-Bacon, J L and Glass, L C (2006). Oxidative stress in type 2 diabetes: the role of fasting and postprandial glycaemia. International Journal of Clinical Practice. 60(3): 308–314.

Yan, H, Prista, A, Ranadive, S. M, Damasceno, A, Caupers, P, Kanaley, J. A, and Fernhall, B (2014). Effect of aerobic training on glucose control and blood pressure in T2DDM East African males. *ISRN Endocrinology* Volume 2014 (2014), Article ID 864897, 6 pages. http://www.hindawi.com/journals

Yokoyama, H. Emoto, M. ArakiI, T. Fujiwara, S. Motoyama, K.. Morioka, T. Koyama, H. Shoji, T. Okuno, Y. Nishizawa, Y. (2004). Effect of aerobic exercise on plasma adiponectin levels and insulin resistance in type 2 diabetes. *Diabetes care*. 27(7): 12-43

Young E. E, Chinenye S, Unachukwu C. N (2012). Beta cell response to a mixed meal in Nigerian patients with type 2 diabetes. *Biomedical Central Endocrine Disorder*. 2012:12:11. June 2012 http://creativecommons.org//licenses (http://www.ncbi.nlm.nih.gov/pmc/articles)

Youngren, J. F. (2016). Exercise and regulation lf blood glucose. www.diabetesmanager.pbworks.com retrieved 20/06/2016

Yurdalak, S. U., (2013). *Physiotherapy in the Patients on Haemodialysis*. http://www.intechopen.com/books/hemodialysis. retrieved 09/06/2014

Zierath, J. R and Wellberg-Heinriksson, H. (1992). Exercise training in obese diabetic patients. Special consideration. Sports Medicine (Auckland, N Z) 14(3) 171-189

Appendix 1

Minimum Exercise Prescription Recommendations for Patients with Type 2 Diabetes or Pre-diabetes

Type of Exercise	Intensity	Duration per week	Frequency
Aerobic (large muscle activities) e.g. walking, running, cycling and swimming.	Moderate: 40–59% VO2R or HRR 55–69% HRmax RPE 12–13	210 min total	No more than two consecutive days without exercising
	Vigorous: 60–84% VO2R or HRR 70–89% HRmax RPE 14–16	125min total	
Resistance (multi joint exercises, progressive, large muscle groups)	Moderate to vigorous 8–10 exercises 2–4 sets 8–10 repetitionsa	60min (included in totals above)	2 or more times/week
	1–2 min rest intervals		

VO2R=VO2 reserve, HRR= heart rate reserve.
Resistance training repetitions should be performed at a weight that cannot be lifted more than 8–10 times (70–84% of 1RM).

Source: *M.D. Hordern et al. / Journal of Science and Medicine in Sport 15 (2012) 25–31*

Appendix 2

Maximum Heart Rate Training Table

% MHR	Training Zone	Typical exercise	Effects on blood glucose
<60	Non training	A nice walk	Little, perhaps a small fall
60-70	Aerobic	Jogging/swimming	Fall after 20-30 mins
70-85	Mixed	Running, cross training at Gym, Football, Rugby	Steady and marked fall
>85	Anaerobic	Sprint running, Intense Squash match	Rising blood glucose

Source: http://www.runsweet.com

Appendix 3

Chart to estimate heart rate in beats per minute for each intensity zone

	50%	**55%**	**65%**	**75%**	**85%**	**95%**
Age	*(220-Age) x .5*	*(220-Age) x .55*	*(220-Age) x .65*	*(220-Age) x .75*	*(220-Age) x .85*	*(220-Age) x .95*
20	100	110	130	150	170	190
25	97.5	107.25	126.75	146.25	165.75	185.25
30	95	104.5	123.5	142.5	161.5	180.5
35	92.5	101.75	120.25	138.75	157.25	175.75
40	90	99	117	135	153	171
45	87.5	96.25	113.75	131.25	148.75	166.25
50	85	93.5	110.5	127.5	144.5	161.5
55	82.5	90.75	107.25	123.75	140.25	156.75
60	80	88	104	120	136	152
65	77.5	85.25	100.75	116.25	131.75	147.25

Source: http://www.hanford.gov/health

Appendix 4

Borg's Rate of Perceived Exertion (RPE) Scale

How hard do the subject feel the exercise is?	
Rating number	**Perceived exertion**
6	Very, very light
7	
8	Very light (feel comfortable)
9	
10	Light
11	
12	Somewhat hard (feel tired but can keep going)
13	
14	Hard
15	
16	Very hard (feel very tired, and is pushing self to continue)
17	
18	
19	Very, very hard (the most difficult exercise ever done)
20	

Appendix 5

Interpretation of Borg's Rate of Perceived Exertion (RPE) Scale

RPE	What It Means
0-1	No exertion. The only movement you're getting is pushing buttons on the remote.
2-3	Light exertion. This is how you should feel when you're warming up, cooling down, and stretching.
4-5	Medium exertion. You're breathing a little faster. Your heart is pumping a little faster. You're feeling a little warmer.
6-7	Moderate exertion. You're breathing pretty hard now, you're probably sweating. You can talk, but it's getting tougher.
8-9	Hard exertion. You're breathing really hard and you can only say a few words at a time. You're wondering how long you can go on like this.
10	Hardest exertion. You can not keep this pace for more than a minute. Speaking is impossible. This is your limit.

KANO STATE

HOSPITALS MANAGEMENT BOARD

BOARD HEADQUARTERS
P.M.B 3540, Post Office Road, Kano

HMB/GEN/488/VOL. I

25/09/2015

Yakubu Muhammad Anas
Department Physical & Health Education,
ABU, Zaria.

PROVISIONAL ETHICAL CLEARANCE

Sequel to conduct a research title "EFFECT OF ACROBIC EXERCISE ON KIDNEY FUNCTION AMONG TYPE II DIABETES PATIENTS IN MMSH ". In the light of the above, I am mandated to convey provisional clearance to proceed on your study based on the following conditions.

i. That the consent of all participants must be obtained by filling in consent form.
ii. That you should liase with the Management of the facility for appropriate guidance.
iii. That any publication related to the study should be brought to the knowledge of the Ethical Committee for approval.
iv. That a copy of your finding should be submitted for documentation, record and final approval, please.

Best regards.

Hafsat Abubakar Umar
Asst. Secretary II
FOR: EXECUTIVE SECRETARY

Informed Consent for Participation in Aerobic Exercise Training For Type 2 diabetic subjects

I volunteer to participate in Aerobic Exercise Training. I understand that the project is designed to gather information about the effects of aerobic exercise on kidney function of type 2 diabetic patients. I will be one of approximately 30 people selected for this research.

1. My participation in this project is voluntary. I understand that I will not be paid for my participation. I may withdraw and discontinue participation at any time without penalty. If I decline to participate or withdraw from the study, no one will be told.
2. I understand that I will find the process interesting and beneficial to my health. If, however, I feel uncomfortable in any way during the training session, I have the right to decline.
3. Participation involves aerobic exercise training which will last approximately 20-30 minutes per session for three days a week for twelve weeks.
4. I understand that the researcher will not identify me by name in any reports using information obtained from this study, and that my confidentiality as a participant in this study will remain secure. Subsequent uses of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions.
5. Precaution will be exercised to prevent my individual records from having any negative repercussions.
6. I understand that this research study has been reviewed and approved by the Ethical committee of the Hospitals Management Board Kano State for Studies Involving Human Subjects
7. For research problems or questions regarding subjects, the Ethical committee may be contacted through the diabetes unit of this hospital.
8. I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.
9. I have been given a copy of this consent form.

_____ _____

My Signature Date

_____ _____

My Name Signature of the Investigator