

**ASSESSMENT OF THE EFFECTS OF JOGGING ON SELECTED RISK
FACTORS AND BIOMARKERS OF CARDIO-METABOLIC SYNDROME OF
ADOLESCENTS IN KANO METROPOLIS, NIGERIA**

BY

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DECEMBER, 2017

DECLARATION

I declare that the work in this thesis titled “**Assessment of the Effects of Jogging on Selected Risk Factors and Biomarkers of Cardio-metabolic Syndrome of Adolescents in Kano Metropolis, Nigeria**” has been carried by me in the Department of Physical and Health Education, Ahmadu Bello University Zaria. The information derived from the literature have been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

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CERTIFICATION

This thesis titled “**Assessment of the Effects of Jogging on Selected Risk Factors and Biomarkers of Cardio-metabolic Syndrome among Adolescents in Kano Metropolis, Nigeria**” by Jamilu Lawal **AJIYA**, meets the regulation governing the award of Doctor of Philosophy degree (PhD) in Exercise and Sport Science, Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the seekers of knowledge in the field of Exercise and Sport Science.

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All praise belongs to the Lord of the heavens and the earth and all that is in them and all that is between them and all that we know, and all that we know not. May the peace and blessings of Allah be upon his last and final messenger, Muhammad *sallallahu alaihi wasallam*, who has come to teach and guide humankind

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ABSTRACT

This study assessed the effects of jogging on selected risk factors and biomarkers of cardio-metabolic syndrome (CMS) of adolescents in Kano Metropolis, Nigeria. For the purpose of this study, an experimental research design was used in which the participants were randomly assigned into two groups (experimental and control). Forty (40) male adolescents between the ages of 14 and 17 years, whose body mass indexes (BMI) (kg/m²) were above 85th percentile, constituted the population of the study. The participants' body mass index (BMI), visceral fat, systolic blood pressure (SBP), diastolic blood pressure (DBP), C-reactive protein (CRP) and micro-albuminuria were measured at base line, during intervention (6th week) and post-intervention (12th week). Jogging exercise was performed in group, 3 days per week for 12 weeks at low-to-moderate intensity. Descriptive statistics of mean, standard deviation and standard error of the estimate were used to analyze the data of each variable. Inferential statistics of two-way repeated-measures ANOVA was used to test the hypotheses at an alpha level of 0.05. The results of this study showed that jogging exercise caused significant reduction on the BMI ($p = 0.037$), SBP ($p = 0.017$), DBP ($p = 0.029$) and CRP ($p = 0.014$), but not on the visceral fat ($p = 0.296$) and micro-albuminuria ($p = 0.911$) of male adolescents in Kano metropolis. Based on these results, it was concluded that low-moderate intensity jogging exercise of 12 weeks duration reduced selected risk factors and biomarkers of CMS among adolescents in Kano metropolis. It was recommended that regular jogging exercise can be utilized to reduce the risk factors and prevent the development of biomarkers of CMS among adolescents.

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ABBREVIATIONS

ADA	American Diabetes Association
AHA	American Heart Association
ANOVA	Analysis of Variance
BMI	Body Mass Index
CDC	Centres for Disease Control and Prevention
CMS	Cardio-metabolic Syndrome
CRP	C-reactive Protein
CVD	Cardiovascular Disease
DBP	Diastolic Blood Pressure
HDL-C	High-density Lipoprotein Cholesterol
HR	Heart rate
IDH	International Diabetes Federation
LMAE	Low-to-Moderate Aerobic Exercise
NCEP	National Cholesterol Education Programme
NCHS	National Centre for Health Statistics
NCCDPHP	National Centre for Chronic Disease Prevention and Health Promotion
SBP	Systolic Blood Pressure
TG	Triglycerides
T2DM	Type 2 Diabetes Mellitus

OPERATIONAL DEFINITION OF TERMS

The following terms are defined for the purpose of this research:

1. **Risk factors of cardio-metabolic syndrome:** These are the causal indices of cardio-metabolic syndrome as abnormal body mass index, high visceral fat and raised blood pressure (SBP and DBP) of adolescents in Kano state.
2. **Biomarkers of cardio-metabolic syndrome:** These are the non-causal indices of cardio-metabolic syndrome as elevated C-reactive protein (CRP) and micro-albuminuria of adolescents in Kano metropolis.
3. **Adolescent:** This refers to boys between the age of 14 and 17 years in Kano metropolis.
4. **Low-to-moderate aerobic exercise:** This refers to the jogging exercise training intensity which was between 45-55% of the maximal heart rate of the participants.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Cardio-metabolic syndrome (CMS) is an area that has received much attention in recent time, due to the prevalence of the syndrome worldwide. It has become a major threat to the global public health (American Heart Association (AHA), 2009; International Diabetes Federation (IDF), 2012; American Diabetes Association (ADA), 2016). CMS is described as a cluster of risk factors for cardiovascular disease and type 2 diabetes mellitus (T2DM), which occur together more often than by chance alone (Matthew, Singh & Arora, 2011; Okafor, 2012). Research indicates a strong association between CMS and subsequent risks for diabetes and cardiovascular event. Mathew *et al.* (2011) suggested that it may be a risk factor for the incident of chronic kidney disease. Studies have shown that the syndrome develops during childhood and is prevalent among overweight children and adolescents (Weiss, Bremer, and Lustig, 2013; Skinner, Perrin, Moss & Skelton, 2015; Mansour, Nassef, & Malt, 2016).

The World Health Organization (WHO) (1999), adapted a criterion for defining CMS in children, which requires three or more of obesity, abnormal blood glucose, high systolic blood pressure (SBP), high triglycerides (TG), low high-density lipoprotein cholesterol (HDL-C) or high total cholesterol (TC). The criterion for the CMS in adults developed by the United States (US) National Cholesterol Education Programme (NCEP) (2001), was modified and revised by many investigators as child-specific definition which includes abnormalities in any three of high blood glucose, high TG, high systolic blood pressure (SBP), high diastolic blood pressure (DBP), low HDL-C and high body mass index (BMI). The IDF (2007), provided a definition of CMS for use in children as an individual who has central adiposity plus at least two of the following criteria: high TG, low HDL-C, high SBP, high DBP, high fasting plasma glucose or previously diagnosed T2DM.

Studies (Okafor, 2012; Broodai, Cherry, Scattar & Relly, 2014) revealed that several risk factors exist for the syndrome. Obesity is the most common component that characterizes CMS. It is commonly associated with insulin resistance. In Africa, it has been observed that unhealthy weight gain and CMS are not limited to adult population. Adolescent and young people are also affected (IDF, 2007; Okafor, 2012; Weiss et al., 2013). The BMI cut off points are used generally to establish overweight/obesity as recommended by IDF (2007). However, BMI does not provide any insight into regional fat distribution, but visceral fat does. Anthropometric measures of waist circumference and abdominal skin fold are used for rapid, but accurate estimation of visceral fat (Chen, Chen, Chuang, Chiang, Chiao &

Chang, 2014). Recently, digital machines from different manufacturers are used to estimate visceral fat after entering height and gender information. Previous research findings suggest that abdominal visceral fat affects the metabolic processes and is an important risk factor for morbidity and mortality and more often a common component that characterizes CMS (Srinivasan, Myers, & Berenson, 2002). The visceral fat (also known as organ fat or intra-abdominal fat) is located inside the abdominal cavity.

Elevated blood pressure is associated with an increased CMS risk (Thoenes, Bramiage, Zhong, Shang, Volpe, & Spink, 2012). Hypertension is frequently clustered with other metabolic disorders, such as an elevated BMI, waist circumference (WC), fasting glucose, low HDL-C, all of which are associated with adverse cardiovascular outcomes. According to the guidelines of European Society of Hypertension (ESH) and European Society of Cardiology (ESC) (2003), an intensified diagnostic and therapeutic measures are required in patients with an elevated SBP and DBP because of their associations with several other cardio-metabolic risk markers (ESH, ESC, 2003).

The C-reactive protein (CRP) is found in the blood plasma, the level of which rises in response to body inflammation. Research suggests that patients with elevated basal level of CRP are at risk of T2DM, hypertension and CVD (Dehgan, Kardys, Demant, Litterlinden, Sijbrands, Bootsma, Stipen, Hofman, Schram, & Witterman, 2007; Horluchi & Moge, 2011) Increased CRP is also an extra criterion for CMS (IDF, 2007). The results of numerous studies suggest that CRP is elevated in children and adolescents with higher CVD risk (Jarvisalo *et al.*, 2007). Some studies have shown that childhood CRP values predict adult CRP (Juonala *et al.*, 2006). It is not yet clear whether high CRP levels during childhood and adolescence lead to an increased risk of CVD in later life.

Micro-albuminuria is a term used to describe a moderate increase in the level of urine albumin. It occurs when the kidney leaks small amount of albumin into the urine. Micro-albuminuria is an indicator of CVD, T2DM and hypertension. The IDF (2007), identified the increase in urine albumin as an extra criterion for CVD and T2DM screening. The prevalence of microalbuminuria in Nigerian adolescents is high (Okpere & Anochie, 2012). The prevalence of microalbuminuria is rapidly increasing worldwide to the extent that some international organizations such as American Diabetes Association (ADA, 2016), called for annual screening for albumin in children with diabetes. The International Diabetes Federation (2007), identified increase in urine albumin as an extra criterion for CVD and T2DM. It is unlikely that microalbuminuria directly causes the cardiovascular disease. Instead, the patho-physiology is not completely elucidated. It seems that microalbuminuria is an early marker of generalized endothelial dysfunction and permeability (Weir, 2007; Gerstein *et al.*, 2001).

The pathological processes and risk factors of CMS have been shown to begin during child-hood. Researchers believed that the risk of developing the CMS is likely triggered or

exacerbated by concurrent obesity, physical inactivity, poor eating habits, and hormonal changes associated with puberty (WHO, 2002; Pettman, Misan, Owen, Warren, Coates, Buckley & Peter, 2008). Physical activity levels of Nigerian youths are moderate while sedentary behaviour (inactive lifestyle) are high (Akinroye, Oyeyemi, Odukoya, Adeniyi, Adedoyin, Ojo, Alawode, Ozomata, & Awotidebe, 2014). As a response to the increased global sedentary and consequent risks of negative cardio-metabolic outcomes, particularly among adolescents, one response that has been adopted by many organizations concerned with health and environment is the promotion of “active life style”, which seeks to promote walking, jogging and cycling as safe and common to organized exercise training and sports. In many countries today, the most commonly used vehicle for road transport is a bicycle, which resembles walking and jogging. Given that many journeys are for relatively short distances, there is considerable scope for adolescents to replace car use with walking or cycling to schools and markets.

1.2. Statement of the Problem

The on-going global rise in the prevalence of CMS among all age and ethnic groups is accompanied by a higher increase in serious health risks, such as T2DM and the development of cardiovascular damage. The CMS is becoming a major challenge to the public health in the developing world. For example, 30% of obese Saudi children had three or more of the components of the CMS (Taha, Ahmed & Sadiq, 2009). Data in Kuwait indicate the same (30%) prevalence with Saudi adolescents (Boodai, Chery, Sattar & Reilly, 2014). Contrary to earlier thoughts, CMS is no longer rare in Africa. In Nigeria, using the IDF criteria, 14.3% of CMS was found among overweight and obese adolescents 14 years of age and above (Onyenekwu, Dada & Babatunde, 2017). This warrants effort to develop preventive and risk-reduction strategies which are easier and natural like jogging exercise (Okafor, 2012).

Previous research works suggests that the occurrence of CMS in pre-adult life persists into adulthood and the existence of obesity in childhood predisposes and individual to developing CMS in adulthood (Okafor, 2012; Onyenekwu *et al.*, 2017). Early detection followed by lifestyle intervention is vital to halt the progression of CMS and safeguard the future health of children and adolescents. Adolescents who have one risk factor are likely to have others as well, especially if they are overweight. Similarly, body fat, blood pressure and inflammatory biomarkers are all affected by puberty (Cook, Weitzman, Auinger, Nguyen & Dietz, 2003) Thus, puberty is a crucial time for the development of CMS. The rapid prevalence and severity of obesity in children is likely to lower the age of onset of T2DM and increase the incidence of CVD worldwide. The understanding of the pathophysiology and improvement of the preventive and therapeutic approaches to CVD involve knowledge of novel risk factors and biomarkers. Although several risk factors and

biomarkers are evidenced, substantial research is required for the identification and prevention strategies to reduce cardio-metabolic risk in children and adolescents.

The underlying patho-physiology of CMS is probably multi-factorial with obesity and hypertension being the most common components occurring among adolescents (Okafor, 2012; Skinner *et al.*, 2015). Obesity is a significant health problem that has reached epidemic proportion around the world. Childhood obesity is not limited to industrialized countries; recent studies revealed rapidly increasing prevalence of obesity among school children in developing countries. With at least 1.1 billion children or close to 20% of the world's population being overweight, which point to the fact that the incidence of the CMS is expected to continue to rise among children and adolescents by 2030 (Mathew *et al.*, 2011). Onyenekwu *et al.* (2017), found 97% prevalence of obesity making it the most prevalent risk factor among Nigerian adolescents followed by hypertension with 40% prevalence. In Nigeria, the prevalence of hypertension in adolescent boys between the ages of 13 and 17 years was put at 16.9% in the urban area with less prevalence in the semi-urban area (Ejike, Ugwu & Ezeanyika, 2010).

There is paucity of data on the prevalence of CMS and its risk factors among the Hausa Fulani of north-western Nigeria. The Hausa Fulani usually have lean physique that should prevent from CMS. However, with modernization some have become obese and adopted sedentary life-style that is risk factors for CMS (Sabir, Jimoh, Iwuala, Isezue, Bilbis, Aminu, Abubakar & Sa'idu, 2016). Hence, more studies, involving adolescents are required to standardize the definition of CMS in children, establish relevant cut-off points for research and determine the efficacy of various exercise modalities.

Available data suggest that the presence of cardiovascular risk factors that constitute the CMS is linked to the level of aerobic fitness in children and adolescents (Makowski & Copper, 2000; Nassis, Papantakou & Skenderi, 2005; Tjønnå, Stølen & Bye, 2008; Louise, Naylor, Davis & Green, 2016). However, evidence from the previous studies is moderate. Most of the data are cross-sectional and conflicting (Ramirez-Lopez, Gonzalez-Villalponde & Sanchez-Corana, 2001; Kelishade, Razaghi & Gouga, 2007). There is need for studies that directly measure the effect of exercise on the CMS risk factors and biomarkers.

Moreover, the pattern of physical activity in terms of both volume and intensity on individual components of CMS has not been well studied on adolescents, especially in Nigeria (Haram, Kemi, Lee, Bendheim, Al-Share, Waldum, Gilligan, Koch, Britton, Najjar & Wisloff, 2008; Gardener, Parker, Krshman & Charmers, 2013). Few studies available were in conflict, some (Taha *et al.*, 2009; Banks, Manlhiot, Dobbin, Gibson, Stearne, Davies-Shaw, Chahal, Fisher & McCrindle, 2012; Jago, Drews, McMurray, Baranowski, Galassetti, Foster, Moe & Buse, 2013), demonstrated positive relationship between changes in fitness and CMS parameters; while others do not (Marcell, McAuley, Trastadottir & Reaven, 2005; Nassis, Papantakou & Skenderi, 2005). This calls for a thorough

understanding of the phenomenon to enable optimal preventive measures at an affordable scale with socio-economic cost. Similarly, international public health authorities (Centres for Disease Control and Prevention (CDC), 2008; WHO, 2010), suggest that children and adolescents should accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily, but this higher intensity is more challenging to the cardiovascular system and can only be achieved by a few. Therefore, there is need to evaluate dose-response relationship between cardio-metabolic risk and physical activity, especially low-to-moderate intensity exercise in adolescents of varying anthropometry categories. Hence, the choice of this study to determines the effects of jogging exercise on the adolescent population.

Regular walking and jogging is a healthy, low-to-moderate intensity exercise that can be enjoyed by people of all ages from young children to older adults. It is said to be an important form of aerobic exercise, which is relatively simple and affordable that can provide some benefit. It is also fun for the adolescents, cheap and affordable. Presently, in Kano metropolis, there tends to be an increase in the number of children trekking or riding bicycles to schools and markets, but no study has attempted to evaluate the health effects, especially among children with CMS risk. This study therefore hopes to determine the effects of jogging on risk factors and biomarkers of CMS among adolescents in Kano Metropolis, Nigeria.

1.3 Research Questions

This research attempted to answer the following questions:

1. Will regular jogging exercise modify body mass index of male adolescents in Kano Metropolis?
2. Will regular jogging exercise modify visceral fat of male adolescents in Kano Metropolis?
3. Will regular jogging exercise modify systolic blood pressure of male adolescents in Kano Metropolis?
4. Will regular jogging exercise modify diastolic blood pressure of male adolescents in Kano Metropolis?
5. Will regular jogging exercise modify C-reactive protein of male adolescents in Kano Metropolis?

6. Will regular jogging exercise modify micro-albuminuria of male adolescents in Kano Metropolis?

1.4. Basic Assumptions

Based on the research questions, it is assumed that:

1. Cardio-metabolic syndrome risk factors and biomarkers are prevalent among adolescents in Kano Metropolis.
2. Overweight/obesity is likely associated with the incidence CMS risk factors among adolescents in Kano Metropolis.
3. Jogging exercise can modify risk factors and biomarkers of cardio-metabolic syndrome of male adolescents in Kano Metropolis.

1.5 Research Hypotheses

To achieve the purpose of this study, the following hypotheses were tested:

Major Hypothesis:

There is no significant effect of regular jogging exercise on the risk factors and biomarkers of CMS on male adolescents of Kano Metropolis, Nigeria.

Sub-hypotheses:

1. There is no significant effect of regular jogging exercise on body mass index of male adolescents in Kano Metropolis, Nigeria.
2. There is no significant effect of regular jogging exercise on visceral fat of male adolescents in Kano Metropolis, Nigeria.
3. There is no significant effect of regular jogging exercise on systolic blood pressure of male adolescents in Kano Metropolis, Nigeria.
4. There is no significant effect of regular jogging exercise on diastolic blood pressure of male adolescents in Kano Metropolis, Nigeria.
5. There is no significant effect of regular jogging exercise on C-reactive protein of male adolescents in Kano Metropolis, Nigeria.

6. There is no significant effect of regular jogging exercise on micro-albuminuria of male adolescents in Kano Metropolis, Nigeria.

1.6 Significance of the Study

Many studies have been conducted on risk factors and biomarkers of CMS and the therapeutic value of exercise, with most of the studies focusing on adults and high intensity exercises. It is believed that exercising at moderate-to-vigorous-intensity is associated with low CMS risk score; and that low intensity may not be sufficient to influence CMS risk factors in adolescents. Similarly, guidelines from international health authorities encourage exercising at moderate-to-vigorous intensity to improve cardio-metabolic health. The result of this study will clarify whether exercising at low-to-moderate intensity exercises like jogging, is sufficient to modify the risk factors and biomarkers of CMS in adolescents.

Nigerian youths, including Hausa Fulani of the north-western states are at risk of adiposity and other CMS risk factors (Akinpelu, Oyewole & Oritogun, 2008) and more interventions targeting this population especially involving jogging exercises, which are suitable are warranted for these youths. It is hoped that the findings of this study will provide parents, teachers as well as exercise specialists with clear information on the benefit of jogging exercise in minimizing the risk of overweight and its associated health problems.

1.7 Delimitation of the Study

This study is delimited to:

1. Male adolescents between the ages of 14 and 17 years in Kano Metropolis.
2. Overweight/obese adolescents (BMI = / > 85th percentile for their own age) who were not involved in any organized exercise programme.
3. Aerobic exercise (group jogging)
4. Six risk factors/biomarkers of CMS (body mass index, visceral fat, systolic blood pressure, diastolic blood pressure, C-reactive protein and micro-albuminuria).

CHAPTER TWO

2.0 REVIEW OF RELATED LITERATURE

2.1 Introduction

This study is designed to evaluate the effects of 12-week jogging exercise on selected risk factors and biomarkers of CMS among male adolescents in Kano Metropolis. The purpose of this chapter is to review and synthesize current literature on CMS risk factors and aerobic exercise focusing on male adolescents, under the following sub-headings:

2.3 Definition of Cardio-metabolic Syndrome

2.3.1 Components of Cardio-metabolic Syndrome

- 2.3.2 Risk factors of Cardio-metabolic Syndrome
- 2.3.3 Biomarkers of Cardio-metabolic Syndrome
- 2.7.1 Diagnostic Criteria for Cardio-metabolic Syndrome
- 2.8 Prevalence of Cardio-metabolic Syndrome among Adolescents
- 2.9 Cardio-metabolic Syndrome and Exercise
 - 2.9.1 Effects of Aerobic Exercise on Risk Factors of Cardio-metabolic Syndrome
 - 2.9.2 Effects of Aerobic Exercise on Biomarkers of Cardio-metabolic Syndrome
- 2.10 Exercise Guidelines for Adolescents with Cardio-metabolic Risks
- 2.11 Summary and Uniqueness of the Study

2.2 Definition of Cardio-metabolic Syndrome

Cardio-metabolic syndrome (CMS) has been known as a cluster of risk factors for cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM), which occur together more often than by chance alone (Alberti, Zimmet & Shaw, 2005; Carnethon & Craft, 2008; Haram *et al.*, 2008; Matthew *et al.*, 2011). The term is sometimes known as metabolic syndrome, Syndrome x, Insulin resistance, Resistance syndrome or Reaven's syndrome named after Reaven who first identified the problem in 1988. This clustering has been shown to occur not only in adults but also in adolescents (Nelson, Widman & Abresch, 2008; Taha *et al.*, 2009). Although the metabolic syndrome is particularly important in adults, the pathological processes and risk factors have been shown to begin during childhood (Franks, Hanson, Knowler, Moffett, Enos, Infante, Krakoff & Looker, 2007; Fu, Liang, Zou, Hong, Wang, & Wang, 2007; Kwiterovich, 2008).

According to the WHO (1999), criteria adapted for children, defining CMS requires three or more of the following components: obesity, abnormal glucose, high systolic blood pressure, high triglycerides, low HDL-C or high total cholesterol. The criteria for the cardio-metabolic syndrome in adults developed by National Cholesterol Education Programme (NCEP) (2001), were modified and devised by many investigators as a child-specific definition, which includes abnormalities in any three of the following factors: high fasting glucose level, high triglycerides level, low HDL-C level, high systolic, diastolic blood pressure and abnormal BMI. The IDF (2007), provided a definition of CMS for use in children. According to the IDF definition, an individual has the metabolic syndrome, if he or she has central adiposity plus at least two of the following: TG, HDL-C, SBP, DBP, fasting plasma glucose or previously diagnosed T2DM.

Since after these definitions, substantial information has emerged on the clustering of obesity, insulin resistance and other risk factors and their collective role in conveying heightened risk for cardiovascular disease and T2DM. However, across all definitions, CMS is a cluster of several cardiovascular disease risk factors that include glucose intolerance, hypertension, elevated TG, low HDL-C and obesity. Although the cut-off points differ from one definition to the other, all the expert groups agree on the core components of the metabolic syndrome: obesity, insulin resistance, dyslipidaemia and hypertension. They apply the criteria differently to identify the cluster. Many experts call attention to the fact that the stability of the CMS, especially for adolescents, is low, which raises questions to the utility of the CMS in a clinical setting. The American Heart Association's scientific position (AHA, 2009), presented a balanced and clinical appraisal of the strengths and weaknesses of the CMS concept in paediatrics, while recognizing the components of the CMS in children and their importance as predictors of longitudinal risk of CVD and T2DM. In their clinical meeting they attempted not to define CMS, but focused on its utility in research and clinical meetings. However, IDF suggests that CMS should not be diagnosed in children younger than 10 years. For children older than 16 years, the IDF adult criteria can be used.

The underlying patho-physiology of the metabolic syndrome is probably multi-factorial, thus it has been difficult to define a single unifying pathogenic process that leads to this condition (Sookoian & Pirola, 2007). However, the two most commonly accepted etio-pathogenic factors for development of CMS are central obesity and insulin resistance (Grundy, 2004; Eckel, 2005; Lee, Okumura, Davis, Herman & Gurney, 2006). There is debate regarding whether obesity or insulin resistance is the initial cause of the metabolic syndrome or if they are consequences of a more far-reaching metabolic derangement. The risk of developing the cardio-metabolic syndrome is likely triggered or exacerbated by concurrent obesity, unhealthy lifestyle, poor eating habits, and hormonal changes associated with puberty. The CMS is therefore, highly prevalent among overweight youths (Velasquez-Mieyer, Neira, Nieto & Cowan, 2007).

2.2.1 Components of Cardio-Metabolic Syndrome

Cardio-metabolic syndrome is a cluster of cardiovascular disease risk factors that include glucose intolerance, hypertension, elevated triglycerides, low high density lipoprotein cholesterol and obesity (Alberti, *et al.*, 2005; Carnethon & Craft, 2008; Haram, *et al.*, 2008; Matthew, *et al.*, 2011). A number of International bodies have identified components of metabolic syndrome, including WHO and IDF. Common among these components are abdominal obesity, high BP, hyperglycaemia, increased TG, and reduced HDL-C. The prevalence of CMS varies with the number of components present in an individual.

2.2.1.1 Obesity

Childhood obesity is a health problem that has reached epidemic proportions around the world and is associated with CMS (McLaughlin, Allison, Abbasi, Lamendola & Reaven, 2004). Childhood obesity is not limited to industrialized countries (Bhargava, Sachdev, Fall, Osmond, Lakshmy, Barker, Biswas, Ramji, Prabhakaran, & Reddy, 2004). The prevalence of obesity is increasing among school children in developing countries. In Nigeria, the prevalence of obesity among school children in the age group 6-19 years is 3.2% for males and 5.1% for females. Also 18% of children aged 5-15 years from a relatively privileged section of a community were found to be obese (Owa & Adejuyigbe, 1997). Similarly, insulin resistance is a common feature of childhood obesity and is considered to be an important link between adiposity and the associated risk of CMS (Srinivasan *et al.*, 2002; Reavan, 2011). With at least 1.1 billion people or close to 20% of the world's population being overweight, the incidence of the CMS is expected to continue to rise. This warrants effort to develop prevention and treatment strategies which are easier and natural like exercise.

Obesity and lipid abnormalities in children may increase premature cardio-metabolic disease risk, but the relationship of dyslipidaemia with adiposity among obese children is not well defined. Dhuper, Sakowitz, Daniels, Buddhe & Cohen (2009) performed a cross-sectional analysis of children and adolescents (N=698) in 3 age groups (3–8 years, 9–11 years, and 12–18 years; 53% female, 81% African American, and 16% Hispanic) attending an obesity treatment programme. More than 50% of the sample had abnormal levels of TG or HDL-C or both. Only HDL-C and TG were significantly associated with adiposity measures and insulin resistance (measured by homeostasis model assessment-HOMA) and only in adolescents. All measures of adiposity, adjusted for age and sex, among adolescents were modest predictors of abnormal TG and HDL-C, but these associations were attenuated when adjusting for HOMA. Despite the high prevalence of dyslipidaemia in overweight children and adolescents, severity of adiposity appears to be a poor predictor of lipid values except among adolescents. Insulin resistance may in part mediate the relationship of adiposity and dyslipidaemia among obese adolescents.

Abnormal body fat distribution has been associated with CMS (IDF, 2007). Previous literature suggest that abdominal visceral fat affects the metabolic processes and is an important risk factor for morbidity and mortality, more often a common component that characterizes CMS (Srinivasan, *et al.*, 2002; Despress & Lemieux, 2006). Visceral fat (also known as organ fat or intra-abdominal fat) is located inside the abdominal cavity. Obesity is commonly associated with insulin resistance. In Africa, it has been observed that unhealthy weight gain and CMS are not limited to adult population. Adolescent and young people are also affected (Okafor, 2012). Visceral fat can be precisely and reliably measured using magnetic resonance imaging (MRI) or computed tomography (CT). However the procedure is not only expensive, but limited to hospitals or research centres for clinical and

epidemiological studies. Anthropometric measures are more commonly used to estimate visceral fat (Koot *et al.*, 2013; Chen, 2014).

2.2.1.3 Hypertension

Hypertension or high blood pressure is a common component of CMS with diagnostic indications (Okafor, 2012). The prevalence of hypertension has been increasing for the last decade. In 1994, 24% of USA adults had hypertension. Today, that figure has risen to 29%, according to data from the National Health Survey. The relationship between high blood pressure and insulin resistance is confounded by the significant independent relationship between hypertension and obesity. Hypertension is one of the common cardiovascular disorders today in Africa (WHO, 2008; Ogun, 2006). In Nigeria, the prevalence of hypertension in people of 18 years and above was put at 21.1% (Ekwunife, Udegaranye & Nwatu, 2000). In Nigeria, a survey in a market population showed that 42% of the subjects had hypertension (Akinkugbe, 1992). Some studies (Ejike, Ugwu, Ezeanyika & Obayemi, 2008; Farpour-Lambert, Aggoun & Marchand, 2009) identified high blood pressure (BP) in a group of pre-pubertal obese children.

2.2.1.4 Hyper-glycaemia

Diabetes mellitus increases the likelihood of developing metabolic syndrome. This can be attributed to insulin resistance, which is the pathogenic hall-mark. T2DM is no longer rare in Africa. Though dysglycaemia is becoming common, it is ranked lowest in few studies in terms of contributing to the components of the syndrome (Fezeu *et al.*, 2007).

2.2.1.5 Dyslipidaemia

Dyslipidaemia has been demonstrated in subjects with CMS (Isozuo, & Ezunu, 2005). Reduced HDL-C and hyper-triglyceridaemia are the two main types of dyslipidaemia associated with CMS. Dyslipidaemia manifesting as reduced HDL-C was extremely common as demonstrated in Nigeria. Hyper-triglyceridaemia has also been demonstrated to contribute to dyslipidaemia in Africans with CMS, but its contribution seems to be less frequent as demonstrated in Nigeria (Unadike *et al.*, 2009).

2.2.2 Risk Factors of Cardio-Metabolic Syndrome

A risk factor is a biological characteristic of an individual that precede a well defined outcome of that disease, and are directly on the causal path (Balogopal, de Farrenti, Cook, Daniel, Gidding, Mietus-Snyder & Stenberger, 2011; Cook *et al.*, 2011). Risk factors help to identify asymptomatic individuals, who have greater chance of developing a disease in future, compared to the general population. Central obesity, hypertension, hyperglycaemia, high TG and low HDL-C were common risk factors of CMS that have been linked to each other. BMI, visceral fat and BP have been selected by the researcher to be part of this

study. These risk factors were described appropriately under section on components of CMS.

2.2.3 Biomarkers of Cardio-Metabolic Syndrome

Biomarkers are biological indicators for processes that are involved in developing a disease that may or may not be causal. A biomarker can be a form of risk factors that is not causal (Balogopal *et al.*, 2011). The remarkable advances in technology for biomarker discovery facilitated research for prevention strategies and help to fashion clinical practices. A number of biomarkers exist for CMS, which include elevated free fatty acids, urine albumin, CRP, inflammatory cytokines, small LDL particles, liver fat content and decreased a diponectin plasma level. CRP and micro-albuminuria were selected to be monitored in this study.

2.2.3.1 C-reactive Protein

C-reactive protein (CRP) is an annular (ring-shaped) protein found in the blood plasma, the level of which rise in response to inflammation. CRP is synthesized by the liver in response to factors released by macrophages and fat cells (adiposities). It is a member of the pentaxin family of proteins. CRP is used mainly as a marker of inflammation. Apart from liver failure, there are few known factors that intervene with CRP production. Measuring and charting CRP values can prove useful in determining disease progress or the effectiveness of treatment (Pepys & Hirschfield, 2003; Horluchi & Mogi, 2006).

Normal concentration of CRP in healthy human serum is usually lower than 10 mg/L, slightly increasing with ageing. Higher levels are found in pregnant women, mild inflammation and viral infections (10-40 mg/L), active inflammation, bacterial infection (40-200 mg/L), severe bacterial infection and burns (> 200 mg/L) (Clyne & Olshaker, 1999). Although the results of numerous studies suggest that CRP is elevated in children and adolescents with higher CVD risk (Jarvisalo, Harmoinen, Hakanen, Paakunainen, Vilkkari, Hartiala, Lehtimäki, Simell & Raikataro, 2007). Some studies have shown that childhood CRP values predict adult CRP (Juonala, Vilkkari, Ronnema, Taittonen, Marmmiemi & Raitakari, 2006).

Research findings suggest that patients with elevated basal level of CRP are at a risk of T2DM, hypertension and CVD (Dehgan, Kardys, Demant, Litterlinden, Sijbrands, Bootsma, Stipen, Hofman, Schram & Witterman, 2007; Horluchi & Mogi, 2011). Also increased CRP is an extra criterion for CMS highlighted by IDF (2007). Interestingly, studies have shown that childhood CRP values predict adult CRP (Juonala *et al.*, 2006). However, it is not clear whether high CRP levels during childhood and adolescence lead to an increased risk of CVD in later life (Balogopal *et al.*, 2011).

2.2.3.1 Micro-albuminuria

Micro-albuminuria is a term used to describe a moderate increase in the level of urine albumin. It occurs when the kidney leaks small amount of albumin into the urine. Albumin at levels as 5 mg/g of creatine is predictive of incident hypertension, major cardiovascular events, diabetes mellitus and all-cause mortality, even in patients without a baseline history of cardiovascular disease (Gerrsten, Mann & Yi, 2001; Forman, Fisher, Schopick & Curhan, 2008; Abdelhafiz, Ahmed & El-Nahas, 2011). A low level of albumin in the urine is an indication that kidneys are functioning well. Generally, less than 30 mg/L is considered normal. The prevalence of micro-albuminuria in Nigerian adolescents is high (Okpere & Anochie, 2012). The prevalence of micro-albuminuria is rapidly increasing worldwide to the extent that some international organizations such as American Diabetes Association (ADA, 2016) called for annual screening for albumin in children with diabetes. The International Diabetes Federation (2007) identified increase in urine albumin as an extra criterion for CVD and T2DM. It is unlikely that micro-albuminuria directly causes the cardiovascular disease. Instead, the patho-physiology is not completely elucidated. It seems that micro-albuminuria is an early marker of generalized endothelial dysfunction and permeability (Weir, 2007; Gerstein *et al.*, 2001).

2.3 Diagnostic Criteria of Cardio-metabolic Syndrome

The metabolic syndrome, however, defined is associated with an approximate 2-fold increased risk of incident cardiovascular morbidity and mortality (Dekker, 2005). Epidemiological studies indicate a strong association between CMS and subsequent risks for diabetes and cardiovascular events. Accumulating evidence suggests it may also be a risk factor for incident chronic kidney disease and cardiovascular events. Although a uniform definition of the syndrome in paediatrics is lacking, several studies have shown that the syndrome develops in childhood and is prevalent among overweight children and adolescents. The pathological processes and risk factors have been shown to begin during childhood.

Since the first descriptions of this clustering of metabolic risk factors, different organizations and researchers have proposed additional names and criteria to diagnose this condition. WHO (1999) suggested that the first diagnostic definition of the CMS as a clinical entity using specific cut-off points for a set of physical and biochemical components. The European Group for Study of Insulin Resistance (EGIR), the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults EPDET-HBCA, ATPIII of the NCEP and the American Association of Clinical Endocrinologists (AACE) (Balkau & Charles, 1999; Alberti & Zimmet, 1998), have also proposed their own criteria for clinical diagnosis of the metabolic syndrome.

Most of the definitions require performing laborious and not well and widely standardized laboratory measures to demonstrate insulin resistance, or include less specific tests as glucose tolerance or micro-albuminuria. In 2001, the ATP III of the US NCEP adopted the term 'metabolic syndrome' provided by previous definitions, and proposed the first that did not require complex laboratory tests (for example, insulin resistance measurements). Thus, metabolic syndrome can be diagnosed in an individual patient more easily by determining waist circumference and blood pressure and performing simple laboratory determinations, as blood glucose, TG and HDL-C levels.

The WHO (1999) clinical criteria for the CMS states that in order to make a diagnosis of the CMS, a patient must be present with glucose intolerance, impaired glucose tolerance (IGT) or diabetes and/or insulin resistance, together with two or more of the following components:

1. Impaired glucose regulation or diabetes
2. Insulin resistance (under hyperinsulinaemic euglycaemic conditions, glucose uptake below lowest quartile for background population under investigation)
3. Raised arterial pressure $\geq 140/90$ mm Hg
4. Raised plasma TG (≥ 1.7 mmol/L; 150 mg/dL) and/or low HDL cholesterol (< 0.9 mmol/L, 35 mg/dL men; < 1.0 mmol/L, 39 mg/dL women)
5. Central obesity (males: waist-to-hip ratio > 0.90 ; females: waist-to-hip ratio > 0.85) and/or BMI > 30 kg/m² for males and females
6. Micro-albuminuria (urinary albumin excretion rate ≥ 20 g/dL or albumin: creatinine ratio ≥ 30 mg/g)

The CMS is defined according to the WHO criteria adapted for children, a definition which requires three or more of the following components:

- (1) Obesity: BMI > 95 th percentile for age and sex.
- (2) Abnormal glucose homeostasis: it includes any of the following factors (a) fasting hyperinsulinaemia; (b) Impaired fasting glucose; (c) Impaired glucose tolerance.
- (3) Hypertension: Systolic blood pressure > 95 th percentile for age and sex.

- (4) Dyslipidaemia: It occurs due to any of the following factors: (a) high TG (>105 mg/dL (>1.2 mmol/L) in children <10 years of age, and >136 mg/dL (>1.5 mmol/L) in children ≥ 10 years of age); (b) low HDL-C (<35 mg/dL (<0.9 mmol/L).

The ATP III clinical identification of the metabolic syndrome requires three or more of the following five risk factors:

1. Central obesity:
Men: WC > 102 cm (> 40 in); Women: Waist circumference > 88 cm (> 35 in)
2. TG ≥ 150 mg/dL (1.7 mmol/L)
3. HDL C:
Men < 40 mg/dl (1.03 mmol/L) and Women < 50 mg/dl (1.29 mmol/L)
4. Blood pressure $\geq 130/ \geq 85$ mm Hg
5. Fasting glucose ≥ 110 mg/dL (6.1 mmol/L)

According to the new IDF definition (Zimmet & Serrano, 2005), for persons to be defined as having the metabolic syndrome they must have: Central obesity (defined as waist circumference ≥ 94 cm for European men and ≥ 80 cm for European women, with ethnicity specific values for other groups) plus any two of the following four factors:

1. Raised TG level: ≥ 150 mg/dl (1.7 mmol/L), or specific treatment for this lipid abnormality
2. Reduced HDL-C: < 40 mg/dL (1.03 mmol/L) in males and < 50 mg/dL (1.29 mmol/L) in females, or specific treatment for this lipid abnormality.
3. Raised blood pressure: systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg, or treatment of previously diagnosed hypertension.
4. Raised fasting plasma glucose (FPG) ≥ 100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes.

Based on the above definition, the diagnosis of CMS is established by the presence of three of any of the five following criteria: 1) abdominal obesity, 2) high blood pressure, 3)

hyperglycaemia, 4) increased TG, and 5) reduced HDL-C. Subsequently, IDF supported this definition of the metabolic syndrome because of its straight-forwardness and easy application in clinical practice; even though it proposed that the increased waist circumference criterion is required for the diagnosis. It also suggests that different cut off points for this parameters must be applied in different populations (IDF, 2007), based in evidence that suggests significant ethnicity-dependent variations in the association between central adiposity and other metabolic risk factors. Despite significant criticisms to the clinical definition and its usefulness (Reaven, 2005), the ATP III criteria for diagnosing the CMS has prevailed, and it is the most well-known and commonly used tool for identification of patients suffering from this chronic and high risk condition.

In 2009, a Joint Interim Statement (JIS) of the IDF Task force on Epidemiology and prevention (National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of obesity) was published, in an attempt to harmonize the definition. Unlike the first IDF definition, the abdominal obesity should not be an obligatory criterion, though the waist circumference was agreed to be a useful preliminary screening tool. According to this definition, any 3 of 5 criteria listed below constitute the diagnosis of metabolic syndrome: elevated waist circumference (according to population- and country-specific definitions), elevated TG (≥ 150 mg/dl or drug treatment for elevated TG), reduced HDL-C (< 40 mg/dL in men and < 50 mg/dl in women or drug treatment for reduced HDL-C), elevated BP (≥ 130 mmHg systolic B or ≥ 85 mmHg diastolic BP and/or drug treatment for hypertension) and elevated fasting plasma glucose (≥ 100 mg/dL or drug treatment for elevated glucose).

Research confirms that adult's CMS track from childhood (Mansour *et al.*, 2016; Schmidt, Dwyer, Magnussen & Venn, 2010). However, early identification of CMS risk in its incipient stages may justify early and more aggressive intervention to prevent progression and complications (Jeffery & Freiman, 2007; Srinivasan *et al.*, 2002; Velasquez-Mieyer, *et al.*, 2007).

The IDF consensus group has highlighted a number of other parameters (Table 2.1 below) that appear to be related to the metabolic syndrome below which should be included in research studies to help determine the predictive power of the extra criteria for CMS. The use of these additional factors in research may also allow further modification of the definition, if necessary and the validation of the new clinical definition in different ethnic groups.

Table 2.1 Extra-criteria for Cardio-metabolic Syndrome

Criteria	Variables
Abnormal body fat distribution	- General body fat distribution - Central fat distribution - Adipose tissue biomarkers: leptin, adiponectin - Liver fat content
Atherogenic dyslipidaemia (beyond elevated triglyceride and low HDL)	- ApoB (or non-HDL-c) - Small LDL particles
Dysglycaemia	- OGTT
Insulin resistance (other than elevated fasting glucose)	- Fasting insulin/proinsulin levels - HOMA-IR - Insulin resistance by Bergman Minimal Model
OGTT)	- Elevated free fatty acids (fasting and during - M value from clamp
Vascular dysregulation (beyond elevated blood pressure)	- Measurement of endothelial dysfunction - Micro-albuminuria
Pro-inflammatory state	- Elevated high sensitivity C-reactive protein - Elevated inflammatory cytokines (for example TNF-alpha, IL-6) - Decrease in adiponectin plasma levels
Prothrombotic state	- Fibrinolytic factors (PAI-1 etc) - Clotting factors (fibrinogen etc)
Hormonal factors	- Pituitary-adrenal axis

International Diabetes Federation, 2007

2.4 Prevalence of Cardio-metabolic Syndrome among Adolescents

It was estimated that around a quarter of the world's adult population have metabolic Syndrome (Dunstan, Zimmet & Welborn, 2002) and they are twice as likely to die from and three times as likely to have a heart attack or stroke, compared with people without the syndrome (Isomaa, Almgren & Tuomi, 2001; Almgren & Tuomi, 2001; Roger, 2012). In addition, people with CMS have a five-fold greater risk of developing T2DM (Stern, Williams & Gonzalez-Villalp&o, 2004).

Contrary to earlier thoughts, metabolic syndrome is no longer rare in Africa, Nigeria inclusive. The prevalence is increasing worldwide. This increase in the prevalence of metabolic syndrome in the continent is thought to be due to departure from traditional African to western lifestyles. In Africa, it is not limited to adults, but is also becoming common among the young ones (Okafor, 2012). Obesity and dyslipidaemia seem to be the most common occurring components. While obesity appears more common in females, hypertension tends to be more predominant in males. Insulin resistance has remained the

key underlying patho-physiology. Researchers cautioned that this syndrome continues to increase in both developed and developing countries, and it has already become a major threat to the global public health (Yoshinaga, Tanaka, Shimago, Sameshima, Nishi, Nomura, Kawano, Hashiguchi, Ichiki & Shimizu, 2005; Tamura & Chang, 2010; Messaih, Vidot & Arheart, 2014).

The prevalence of this syndrome varies substantially throughout the world (Dunstan, *et al.*, 2002). Statistics indicate that as many as 70 million Americans (34% of adults' population) have CMS (Ogden, Carroll & Flegal, 2008). An analysis of patients in Mexico conducted from 1997 to 1999 revealed a CMS syndrome prevalence of 60% in men and 40% in women. Study of patients in France indicates CMS prevalence of 10% in men and 7% in women (Balkau & Charles, 2003). The prevalence of metabolic syndrome in the united states among children and the adolescents is relatively low; about 4% (Zimmet *et al.*, 2005) when compared to the adult population (24%), except amongst the overweight and obese adolescents where the prevalence of the metabolic syndrome has been reported as high as 29% (Ford, 2005). Thirty percent of obese Saudi and Kuwaiti children had three or more of the components of the metabolic syndrome (Taha *et al.*, 2009; Broodai *et al.*, 2014). CMS was found in 7.4% of Egyptian adolescents. Contrary to earlier thoughts, metabolic syndrome is no longer rare in Africa. In Nigeria, using the WHO criteria, full-blown metabolic syndrome (presence of all major components) was found in 25.1% of T2DM. This increase in the prevalence of metabolic syndrome in the continent is thought to be due to departure from traditional African to western lifestyles.

2.5 Cardio-metabolic Syndrome and Exercise

Given that physical inactivity is a risk factor of diabetes, obesity, dyslipidaemia and hypertension, the prevalence of CMS was higher in subjects with poor physical activities (Bonora, Kiechl, Willeit, Oberhollenzer, Egger, Banadonna & Muggeo, 2003). IDF recommends that primary management for the metabolic syndrome is healthy lifestyle promotion. This includes moderate increase in physical activity. Sedentary behaviour is an important potential determinant of the metabolic syndrome. Several studies demonstrated that physical activity was inversely associated with the prevalence of the metabolic syndrome (Brien & Katzmarzyk, 2006; Haram *et al.*, 2008; Farpour-Lambert *et al.*, 2009; Louise, *et al.*, 2016), notably among those who spend much time in sedentary activity as watching television or video or using a computer (Ford *et al.*, 2005). The adverse effect of excess television watching on obesity and other cardiovascular risk factors are thought to be attributed, in part, to decreased energy expenditure and, in other part, to increased energy intake. Therefore, understanding how sedentary behaviour relates to the metabolic syndrome and the effectiveness of life-style intervention may provide new opportunities for clinical and public health approaches in its prevention and control (Matthew *et al.*, 2011;

Unick, Beavers, Bond, Clark, Jakicic, Kitabochi, Knowler, Wadden, Wagenknecht & Wing, 2013).

Various investigations and scientific reports have established the types and quantities of exercise to reduce the risk of CMS in adults (NCEP, 2001; Brage, Wedderkopp and Ekulund, 2004; Garber, 2011). Same is highly required for children. In the randomized study of Slentz (2004) there was a dose-response relationship between amount of exercise and amount of weight loss and fat mass. The high intensity exercise group lost significantly more body mass and fat mass than the low/moderate intensity. Both aerobic continuous (Cambuli *et al.*, 2008; Farpour-Lambert *et al.*, 2009; Davis *et al.*, 2012; Jago *et al.*, 2013) and interval training (Tjonna, 2008) in forms of walking/jogging and games indicate significance decreases in risk factors of CMS among adolescent group.

Cardio-metabolic syndrome has become prevalent among youth, especially overweight. Metabolic syndrome in childhood predicts adult cardiovascular disease years later (Morrison, Friedman, & Gray-McGuire, 2007). Regular aerobic exercise has been shown to reduce CMS (Farpour-Lambert *et al.*, 2009; Thomas *et al.*, 2009; Short & Frimberg, 2012). Cardio-respiratory fitness attenuates metabolic risk, independent of abdominal subcutaneous and visceral fat in men (Lee *et al.*, 2005). Also in children and adolescents, a number of studies demonstrated the efficacy of exercise interventions in reducing the CMS risk factors (Davis *et al.*, 2012; Banks *et al.*, 2012; Jago *et al.*, 2013; Bradley, Slorad, Mahmud, Dunga, Dearfield, Deda, Elia, Har, Hur, Scholey & Cherney, 2016). However, the evidence from previous studies is moderate. Further studies of high methodological quality are needed ((Taha *et al.*, 2009; Blohm, Ploch & Apelt, 2012; Davis *et al.*, 2012). Kamal & Raggy (2112) demonstrated that 12-week exercise may have a positive effect on reducing risk factors for the metabolic syndrome. The percentage of metabolic syndrome decreased from 12.9% before the exercise training to 7.5% after training.

2.5.1 Effects of Aerobic Exercise on Risk factors of Cardio-metabolic

Body mass index

A number of metabolic changes are caused by childhood obesity, including insulin resistance, diabetes, and dyslipidaemia. To counteract them, life-style modification with changes in dietary habits and physical activity is the primary intervention. Physical activity is beneficial for weight management and prevention of overweight and obesity in adults and children. It is unclear whether regular exercise alone (no caloric restriction) is a useful strategy to reduce adiposity and obesity-related metabolic risk factors in obese adolescents.

Jago *et al.*, (2013) examined whether a two-year change in fitness, BMI or the additive effect of change in fitness and BMI were associated with change in cardio-metabolic risk factors among youths. Their research findings indicate that changing body mass is central

to the reduction of youth cardio-metabolic risk. There was strong evidence ($P < 0.001$) that change in BMI was associated with change in cardio-metabolic risk factors. In the study of Marandi, Esfarjani, Mojtahedi & Ghasemi (2013), both light and moderate aerobic exercises significantly improved weight ($P < 0.000$), fat percent ($P < 0.045$) and BMI ($P < 0.000$). Their findings showed that both light and moderate aerobic exercise improved body composition in obese/overweight women.

Kamal & Raggy (2012) investigated the changes of body weight and body mass index before and after the exercise therapy in normal and obese children (with or without metabolic syndrome). The training programme consisted of 12 weeks walking-jogging exercise performed 3 days per week for 20-45 minutes each session. After the exercise training, both of the obese children groups, with and without metabolic syndrome, showed reduced body weight and body mass index (from 47.3 to 32.6%).

In their study, Wong, Chia, Tsou, Wansaicheong, Tan, Wang, Tan, Kim, Boh and Lim (2008) investigated the effects of a 12-week twice weekly additional exercise training, which comprised active recreational exercises, in addition to typical physical education sessions, on body composition and serum C-reactive protein (CRP) in 13- to 14-year-old obese boys contrasted with a control group. The exercises include stair climbing and games. Both the exercise group (EG, $n = 12$) and control group (CG, $n = 12$) participated in the typical 2 sessions of 40-minute physical education (PE) per week in schools, but only EG participated in additional 2 sessions per week of 45 to 60 minutes per session of exercise training, which comprised a combination of circuit-based resistance training and aerobic exercises maintained at 65% to 85% maximum heart rate. Exercise training significantly improved body mass index.

Atlantis, Barnes & Singh (2006), in their systematic review and meta-analysis, determined the efficacy of exercise alone for treating overweight in children/adolescents. They concluded, based on the small number of short-term randomized trials currently available, that an aerobic exercise prescription of 155-180 min/weeks at moderate-to-high intensity is effective for reducing body fat in overweight children/adolescents, but effects on body weight and central obesity are inconclusive.

Klijin, Baan-slootweg & Stel (2007) found a decrease in BMI among children and adolescents of 10-18 years following aerobic exercise programme. The exercise programme consists of 12 weeks, 3 times of aerobic training with diverse exercises including aqua jogging. In contrast, Nassis (2005) did not find changes in body weight of overweight and obese girls of 13 years after aerobic exercise programme of 50-60% of maximal heart rate.

Visceral fat

Lee, Deldin, White, Kim, Libman, Rivera-Vega, Kuk, Sandoval, Boesch & Arslanian (2013) examined the effects of aerobic exercise vs. resistance exercise alone on visceral adipose tissue, intra-hepatic lipid, and insulin sensitivity in obese girls. Forty-four obese adolescent girls (BMI \geq 95th percentile, 12-18 yr) with abdominal obesity (waist circumference 106.5 ± 11.1 cm) were randomized to 3 month of 180 min/wk aerobic exercises (n = 16) or resistance exercises (n = 16) or a non-exercising control group (n = 12). Total fat and VAT were assessed. The aerobic exercise group jogged on treadmill at an intensity of 60-75% of Vo_2 _{peak}. They concluded that aerobic exercises, but not resistance exercises, are effective in reducing liver fat and visceral adiposity.

Irving, Davis, Brock, Weltman, Swift, Barrett, Gaesser & Weltman (2008) examines the effects of exercise training intensity on abdominal visceral fat and body composition in obese women with the metabolic syndrome. Twenty-seven middle-aged, obese women (body mass index: 34 ± 6 kg/m²) with the metabolic syndrome completed one-of-three 16-week aerobic exercise interventions. High-intensity exercise training significantly reduced abdominal visceral fat (p=0.010), with no significant changes observed within the control or low-intensity exercise group. They concluded that body composition changes are affected by intensity of exercise training with High-intensity exercise training more effective for reducing total abdominal fat, subcutaneous abdominal fat and abdominal visceral fat in obese women with the metabolic syndrome.

Another study confirms the positive effects of aerobic exercises (3-5 times per week, 45-60 minutes) on metabolic and clinical parameters in overweight/obese children (Cambuli *et al.*, 2008). A randomized controlled efficacy trial in which 222 overweight or obese sedentary children (mean age, 9.4 years; 42% male; 58% black) was conducted (Davis *et al.*, 2012). In this trial, after 13 weeks, 20 or 40 min/day of aerobic training improved fitness and reduced general visceral adiposity in sedentary overweight or obese children, regardless of sex or race.

In another study, Slentz, Duscha & Johnson (2004) recruited overweight men and women (aged 40-65 years) and enrolled them in eight-month exercise programme of low, moderate and high intensities. Compared to control groups, all exercise groups significantly decreased abdominal, minimal waist, and hip circumference measurements. In addition, various systematic reviews and meta-analyses in randomized trials have shown that an aerobic exercise at moderate-to-high intensity is effective for reducing body fat in overweight children and adolescents (Ajiya & Yakasai, 2010; Taha *et al.*, 2009) found significant changes in percent body fat of adolescent boys following aerobic exercise programme.

In other two studies (Van der Heijden, Toffolo, Manesso, Sauer & Sunehag, 2009; Van der Heijden, Wang, Chu, Sauer, Haymond, & Rodriguez, 2010) 12 weeks aerobic exercise reduced visceral fat of adolescent children. Brandou, Dumortier, Garandeau, Mercier &

Brun (2003) also produced significant reduction in visceral fat following aerobic exercise programme of longer duration (2month) than the two studies above

Blood pressure

Kamal & Raggy (2012) investigated the changes of blood pressure before and after the exercise therapy in normal and obese children (with or without metabolic syndrome). After 12 weeks of exercise, both of the obese children groups, with and without metabolic syndrome, showed reduced blood pressure (from 18.3 to 715.1%).

Farpour-Lambert *et al.* (2009) recruited 44 Swiss children aged 6 to 11 with BMI over the 97th age- and sex-specific percentile and randomized them to three months of aerobic exercise training after school or usual exercise patterns, which meant the latter group was relatively inactive. The modified crossover design meant that, after the first three months, both groups of children were offered the chance to participate in the exercise training for a further three months. The one-hour activities included ball games, swimming, and running and were structured to include 30 minutes of aerobic work, followed by 20 minutes of strength work and 10 minutes of stretching. The programme resulted in significant improvements in blood pressure.

In their study, Wong *et al.* (2008), 12 weeks additional aerobic exercise training (65% to 85% maximum heart rate, twice a week, 45-60 minutes per session) significantly improved resting HR and systolic blood pressure of 13 to 14 year adolescent boys. In another study, Tjonna (2008) demonstrated that aerobic interval training may also be a powerful tool in combating the increased cardiovascular risk observed in overweight adolescents. In contrast, Ajiya *et al.* (2010) recorded no significant changes in blood pressure of adolescents after 8 weeks of aerobic exercise programme.

Kelly and Kelly (2003) conducted a meta-analysis of randomized control trials after which they concluded that short term exercise does not reduce resting systolic and diastolic blood pressure in children and adolescents. In study, they included exercise interventions lasting for at least 8 weeks involving adolescents less than 21 years.

2.5.2 Effects of Aerobic Exercise on Biomarkers of Cardio-metabolic Syndrome

C-reactive protein

Several paediatric intervention studies have shown declines in CRP with or without weight loss (Balagopal *et al.*, 2005; Selvin, Paynter & Erlinger, 2007). In a meta analysis of 20

studies involving 1,466 patients with coronary artery disease, CRP levels were found to be reduced after exercise interventions. In the study of Kusapis and Thompson (2013), there is a short-term, transient increase in serum CRP after strenuous exercise; whereas a chronic physical activity reduces resting CRP levels by multiple mechanisms, including a decrease in cytokine production by adipose tissue or skeletal muscles.

Kamal and Raggy (2012) investigated the changes of CRP before and after the exercise therapy in normal and obese children (with or without metabolic syndrome). After 12 weeks of exercise, both of the obese children groups, with and without metabolic syndrome, showed reduced CRP level. In their study, Wong *et al.* (2008), 12 weeks additional aerobic exercise training (65% to 85% maximum heart rate, twice a week, 45-60 minutes per session) significantly improved Serum CRP of 13 to 14 year adolescent boys.

In another study, 16 weeks regular aerobic exercise reduced CRP levels in young women of 18 years and above (Arikawa, Thomas, Schimitz & Kurzer, 2011). In contrast, Marcell *et al.* (2005) and Nassis (2005) suggested that exercise training is not associated with improved level of CRP and other inflammatory biomarkers.

Micro-albuminuria

Studies exploring the relationship between physical activity and albuminuria in the general population are still complicated. In diabetic patients physical activity is associated with lower level of albumin excretion (Ochodnický, Henning, Dokkum & de Zeeuw, 2006). Studies in non-diabetic patients found no association. Finkelstein, Joshi & Hise (2006) studied 13,753 participants in the third National Health Nutrition Survey (NHANES) aged 18 years or older. After multivariate adjustment, physical activity was not significantly associated with albumin-creatinine ratio. Stratified analysis for sex, age and race did not alter the result.

In the study of Lazaravic, Viahovic, Djorojevic, Zvezdanovic & Stefanovic (2007) involving non-diabetic women, the researchers concluded that higher levels of physical activity are associated with lower urinary albumin excretion. However, studies on children are complicated and require future attempts to explain a meaningful difference.

Another study examined the effect of exercise intensity on micro-albuminuria on children of 10-18years. The subjects were subjected to three exercise groups of various intensities (60%, 80% and 100% of maximal heart rate. Micro-albuminuria significantly increased with exercise intensity (Komhauser, Malacara, Macias-Cervaster & Rivera-Cisnoros, 2011).

2.6 Exercise Guidelines for Cardio-metabolic Risk Reduction

The Centres for Disease Control and Prevention (CDC, 2008) recommends 2 hours 30 minutes (150 minutes) every week of moderate intensity exercise for adults. A recent study (Neto, Junior, Compos & Sanots, 2014) on CMS risk score suggests that adolescents perform at least 88 minutes/day of moderate-to-vigorous physical activity to promote a healthy metabolic profile. The activities should include games, sports, recreation, planned exercise and transportation.

However, both national and international public health authorities, including WHO (WHO, 2010) recommended that children and adolescents should accumulate at least 60 minutes of moderate-to-vigorous intensity daily to achieve higher results in CMS profile. American Heart Association suggested a minimal recommendation of 30 minutes of moderate intensity (40-60% HR max) aerobic activity for a total of 150 minutes/week (AHA, 2009). Other studies in exercise science adopt a minimum of three days of varying exercise intensities to achieve meaningful results. Future research is required to establish meaningful benefits of low-to-moderate exercise intensities on blood pressure and CMS biomarkers in adolescents.

2.7 Summary and Uniqueness of the Study

Cardio-metabolic syndrome is a cluster of cardiovascular disease risk factors that include glucose intolerance, hypertension, elevated triglycerides, low high density lipoprotein cholesterol and obesity. Presently, there is no universally accepted definition of cardio-metabolic syndrome for children and adolescents. In the paediatric literature reviewed, a number of attempts have been made to define CMS with a meaning similar to the adult CMS. Barriers to a consistent, accepted definition for children and adolescents include the use of adult cut-off points, or a single cut-off points for all ages throughout childhood; the fact that disturbances seen in the metabolic indicators in most children are quantitatively moderate; the lack of a normal range for insulin concentration across childhood; the physiological insulin resistance of puberty; the lack of central obesity (waist) cut-off points linked to obesity morbidity or CMS for children, and differences in base-line lipid levels among various races. The last IDF definition (2009) for children, which requires the presence of any two risk factors plus obesity, is widely recognized and used by researchers. However, WHO (2008) did not require obesity to be the necessary factor among the three.

Studies on CMS have revealed that several risk factors exist for the syndrome. Central obesity is the most common component that characterizes CMS. Hypertension (high blood pressure) is another common component of CMS with diagnostic indications. Dislipidaemia (abnormal lipid profile) has been demonstrated in subjects with CMS. Hyperglycaemia (abnormal blood glucose or diabetes mellitus) also increases the likelihood of developing CMS, and is one of its major components. Micro-albuminuria and CRP are additional CMS criteria proposed by IDF, which require future research to be established as independent criteria. This clustering has been shown to occur not only in

adults, but also in adolescents. Although the CMS is particularly important in adults, the pathological processes and risk factors have been shown to begin during childhood. The prevalence of this syndrome among children and adolescents has been shown to increase worldwide (Weiss *et al.*, 2013).

The number of children with obesity and other CMS biomarkers is increasing worldwide. Exercise therapy is widely recognized, but the choice of appropriate exercise modality is not clear. Randomized studies demonstrated a dose-response relationship between amount of exercise, including bicycling and the amount of loss in the CMS risk factors. In most of the studies, high intensity exercise group lost more significantly than the low/moderate intensity. Both aerobic continuous and interval training in forms of walking/jogging and games indicate significant changes in risk factors of CMS among adolescent group. Exercise authorities recommended 60 minutes of MVPA per day or a minimum of 150 minutes per week for children and adolescents to improve their cardio-metabolic profile (CDC, 2008). However, most of the studies are longitudinal and conflictual. There is need for more controlled studies that will directly assess the CMS risk factors in children. The present study aimed at assessing the effect of jogging exercise on the risk factors and biomarkers of CMS to fill the gap of data using low-to-moderate intensity exercises in adolescent population. Also the study will determine the effects of exercise on CRP and microalbuminuria as new criteria for CMS which have less data in adolescents of Kano metropolis.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This study was designed to evaluate the effects of jogging exercise on selected risk factors and biomarkers of CMS among male adolescents in Kano Metropolis, Nigeria. This chapter explains the research design, population, sample and sampling techniques, instrumentation, methods of data collection, training protocols and procedures for data collection.

3.2 Research Design

An experimental research design was used for this study. There were two groups assigned to experimental (exercise) and control (non-exercise) groups. This design had one (1) training mode (group jogging), two (2) groups (treatment and control) who were assessed three (3) times during the research period at baseline, immediately after the 6th and 12th weeks of training.

3.3 Population

The population for this study consisted of male school adolescents who were between the ages of 14 and 17 years residing in Kano Metropolis, Nigeria. Available data from the Kano State Ministry of Education indicated that there were five hundred and six thousand eight hundred forty nine (506,849) adolescents distributed across secondary schools in Kano State during the 2014/2015 academic year.

3.4. Sample and Sampling Technique

The sample for this study comprised forty (40) adolescents whose BMI was equal or above 85th percentile for their own age. Purposive and simple sampling techniques were used to select 40 male adolescent volunteers (age 14-17 years) from Kano Capital (Community)

secondary school. The school is located in Nassarawa Government Reserved Area (GRA), made up of students from the middle class urban dwellers. First, a random screening of body mass index was conducted using the digital body composition monitor described under instrumentation. Those who had body mass index (kg/m^2) above 85th percentile for their own age were included in the sampling. Numbered cards were mixed thoroughly with blank cards and displayed face down in a container. Eligible volunteers were lined up and were allowed to pick one card. Those who picked numbered cards were selected. Forty volunteers were sampled using the numbered cards. All selected even numbers were labelled as experimental group ($n=20$); while all odd numbers were labelled as control group ($n=20$). This is in line with the recommendation of Thomas and Nelson (1990). Among the 40 participants only 36 were able to complete the training and had their data measured three times, for reasons not disclosed to the researcher. Hence, the final analysis was conducted on the data collected from these 36 participants.

3.4.1 Exclusion Criteria

The following conditions were excluded in this study:

1. Adolescents below the age of 14 or above 17 years.
2. Adolescents with BMI (kg/m^2) below 85th percentile for their own age.
3. Adolescents participating in any organised exercise programme.
4. Adolescents who did not agree to sign the informed consent form.

3.5. Research Assistants

Three research assistants assisted during the period of data collection and training programme. One research assistant took the names, age and height of the participants. The second assisted in the field training throughout the 12 weeks. The third research assistant was a qualified laboratory technician who collected the urine and blood samples and also ran the biochemical tests. The researcher carried out the measurements of body composition and blood pressure. In addition, the researcher led preliminary exercise sessions (beginnings of 1st week & 7th week) in the two phases of the training and closely supervised the remaining exercise sessions.

3.5.1 Informed Consent

All the participants were adequately informed of the procedure of the research, including all assessment procedures, exercise protocol and the duration of the study. Also the likely benefits, discomforts and precautions to be taken during the training programme were explained. Written consent (Appendix A) was distributed and signed by parents/guardians and the participants in accordance with the guidelines of the American College of Sports

Medicine (ACSM, 2010). Permission of the school authority and Kano State Secondary Schools Board was sought before commencing the research (Appendix B). Ethical permission to use human subjects was obtained from the School of Postgraduate Studies, Ahmadu Bello University, Zaria (Appendix C).

3.6 Instrumentation

The following instruments were used to collect data for this study:

1. Stadiometer (Gulfex Medical and Scientific England, RGZ- 120).
2. Automated digital BP monitors (Andon BPM, KD-595, China).
3. Body Composition Monitor (BF 511, Japan).
4. Heart rate monitor (Omron Healthcare, inc., 2011, 1925, China)
5. CRP Latex (Grappe Diagnostics, Switzerland, 50 T, 52202002).
6. N Latex CRP mono reagent, cat QQIY 21 (Dade Behring Diagnostic, Inc. Nwark,DE).
7. Cups, test tubes & syringes and dip-stick (Randox Laboratories Limited, UK).
8. Body mass index-for-age percentiles chart (National Centre for Health Statistics; National Centre for Chronic Disease Prevention and Health Promotion, 2000).

3.7 Procedure for Data Collection

The data for this study was collected three times: before, during and at the end of the study. Participants provided a detailed medical history and underwent a physical examination, which included an assessment of the six risk factors and biomarkers associated with the cardio-metabolic syndrome as defined by the IDF (Alberti *et al.*, 2006). The following procedures were used for data collection.

3.7.1 Anthropometric measurements

Anthropometric measurements were carried out according to standard procedure of International Society for the Advancement of Kinanthropometry (ISAK) (2001) and the procedures provided by Omron Healthcare Company Limited.

3.7.2 Height and body weight

Height was measured using standard stadiometer to the nearest 0.5 cm with the subject standing erect, feet flat, neck straight and shoulders flat. The flat surface of the steel was

placed on the subject's head and the reading was taken. The height measurement was performed by a single well trained research assistant.

Body weight was measured using Omron BF 511 Scale to the nearest 0.5 kg with the subject standing on a standard weighing scale, with minimal dress and bare-footed. In each measurement, the electrical scale was turned on and waited until 0.0 kg was displayed; then the participant places his foot on the foot electrodes with his weight evenly distributed and the measurement result appears on the screen. The researcher recorded each measurement.

3.7.3 Body mass index

The Omron BF 511 was used to measure the body mass index (BMI). The machine uses age, height and gender information to generate BMI. To measure BMI, after turning the machine on and the appearance of the 0.0 kg, participant stepped onto the main unit and placed his foot on the foot electrodes with his weight evenly distributed. The display showed his weight and then the weight result blinked twice. The unit then starts to measure his BMI. When 'start' appears on the machine screen, the participant grasped the hand electrodes and extended his arms straight and horizontally at 90° to his body, while pressing his palms firmly on the electrodes. After the measurement is completed, the weight displayed again. At this point, the participant stepped down and the BMI button was pressed to see the result. Body mass index above 85th percentile was categorized as overweight or obesity. Body mass index-for-age percentiles chart (Appendix D) developed by the National centre for Health Statistics in collaboration with the National Centre for Chronic Disease Prevention and Health Promotion (2000) was used to determine the cut up points. BMI uses the following simple formula to indicate the ratio between weight and height of a person:

$$\text{BMI} = \text{Weight (kg)} / \text{height (m}^2\text{)}$$

3.7.4 Measurement of body fat percentage

The BF 511 measures the body fat percentage by the bioelectrical impedance method. Muscles, blood vessels and bones are body tissues with high water contents that conduct water easily. Body fat is tissue that has little electric conductivity. The BF511 sends extremely weak electrical current of 50 kHz throughout the body to determine the amount of fat tissue. This weak electrical current is not felt while operating the BF 511. In order for the scale to determine the body composition, it uses the electrical impedance, along with height, weight, age and gender information to generate results. To measure body fat percentage after turning the machine on and the appearance of the 0.0 kg, participant

stepped onto the main unit and places his foot on the foot electrodes with his weight evenly distributed. The display showed his weight and then the weight result blinked twice. The unit then started to measure his body fat percentage. When start appeared on the display, the participant extended his arms straight and horizontally at 90° to his body, while pressing his palms firmly on the electrodes. After the measurement was completed, the weight will display again. At this point, the participant stepped down and the body fat percentage button was pressed to see the result.

3.7.5 Measurement of visceral fat

To measure visceral fat using BF 511, age was adjusted to 18 years for each participant. After turning the machine on and the appearance of the 0.0 kg, participant stepped onto the main unit and places his foot on the foot electrodes with his weight evenly distributed. The display showed his weight and then the weight result blinked twice. The unit then starts to measure his visceral fat and other parameters. When ‘start’ appeared on the display, the participant extended his arms straight and horizontally at 90° to his body, while pressing his palms firmly on the electrodes. After the measurement was completed, the weight will display again. At this point the participant stepped down and the visceral fat button was pressed.

3.7.6 Measurement of blood pressure

Systolic and diastolic blood pressures were measured simultaneously with the aid of automated digital BP monitors, described under instrumentation. Subject sits with the arms and back properly supported and the feet flat on the floor. After placing the cuff on the arm approximately 1 inch above the anti-cubital space with the centre of the bladder over the brachial artery, the monitor was put on and the start button was pressed. The monitor automatically inflated until it exceeded the resting BP, and then begins to deflate when the cuff becomes empty of air; the readings of HR, SBP and DBP appear on the monitor screen. The measurement was repeated after one minute and the mean of the two scores was recorded for analysis.

3.7.7 Biochemical measurements

Biochemical evaluations of micro-albuminuria and CRP were conducted in Haznaf Diagnostic Laboratory, Kano with the assistance of qualified laboratory scientist.

3.7.8 Determination of urine albumin

3.7.8.1 Principle and procedure

This is a very simple test; 12-hour urine samples were collected in a sterile container to determine albumin excretion. The container was given to the participants, who also

received verbal explanations about how to collect a proper 12-hour urine sample. The participants collected the first urine sample of the next morning. At the end of the collection period, the urine samples were analyzed in the laboratory within 2-4 hours. A dipstick made with a colour-sensitive pad was put in the urine to observe the level of albumin in the urine. The values obtained were recorded (Gerber & Brendler, 2011).

3.7.9 Determination of C-reactive protein

Blood sample was collected aseptically and the serum was separated by standard laboratory techniques. No special instruction such as fasting or special diet was required.

3.7.9.1 Principle

The CRP latex kit is a rapid agglutination procedure for the direct detection and semi quantification (on slide) of C-reactive protein (CRP). The reagent, latex particles suspension coated with specific antihuman CRP antibodies, agglutinates in the presence of CRP in subject serum.

3.7.9.2 Qualitative test procedure

The test was conducted as follows:

1. All reagents as well as the sample were allowed to reach room temperature (25.8-26°C) and were mixed well before use.
2. One drop of serum sample was placed on the slide using a disposable serum dropper.
3. One drop of CRP- latex reagent was added to the above drop and mixed well with disposable applicator stick.
4. The slide was rocked gently to and fro for 2 minutes and examined immediately under good light source for agglutination.
5. For positive and negative results, the same procedures mentioned above were used by taking control serum from respective vials.

3.7.9.3 Result and Interpretation

Positive result:

The presence of agglutination indicated the presence of CRP in the sample.

Negative result:

The lack of agglutination indicated low CRP level.

3.7.9.4 Semi-Quantitative test procedure

To find out the titre of the positive sample, the following procedure provided by Agape diagnostics (2006) were followed:

1. Fifty diluted saline buffer was placed onto each of the circles of the slide.
2. Using a 50 μ micro pipette, 50 μ serum samples was added to the drop of saline buffer in 1st circle.
3. Using the same micro pipette, the sample was mixed by aspirating back and forth several times. Fifty μ was aspirated from 1st circle and transfer to 2nd circle. The same procedure was repeated up to 5 circle and discard. Following dilutions are obtained. Dilution 1/2, 1/4, 1/8, 1/16, 1/32
4. Then 1 drop of CRP latex reagents was added to the above circle, mixed and rocked the slide gently to and fro for 2 minutes; then observed the agglutination under good source of light.

3.7.9.5 Calculation

Concentration of CRP in serum was calculated as follows:

CRP Conc. (mg/L) = sensitivity \times titre (highest dilution serum showing agglutination).
Where: CRP sensitivity = 6 mg/L.

3.8 Training Programme

For the experimental group, intervention programme consisted of mainly regular outdoor jogging exercise performed in group. The training took place in the Kano Capital school playground, three days/week at low-to-moderate intensity (45 to 55% of participants' maximal heart rate). The Training intensity was in line with the American Heart Association's recommendation of 40-60% of HR max (AHA, 1996). Each training session was preceded by a warm up and cools down of stretching exercises. The intervention

programme lasted for 12 weeks. While, the control group were asked not to participate in any active physical activity or organised sport.

3.8.1 Training progression

The training intervention was conducted at two levels, after which comparison was made at the end of the programme. Data were collected at base-line, after 6 weeks and at the end of the twelfth week. Intensity and duration was slightly increased after the first level. The two levels of training are described below:

3.8.2 Training level 1 (1st - 6th week)

The training in the first six weeks consisted of group jogging, conducted at a slow pace. Below is the training schedule in the first six weeks of the training intervention:

1. Warm up for 7 minutes comprising slow walking and stretching exercises such as torso twists, row and lateral steps and traditional squats.
2. Slow pace jogging of 4 minutes × 3 repetitions with 2 minutes rest intervals of walking in group.
3. Cool down activities of slow walking and stretching exercises for 5 minutes. The stretching exercises included lunging hamstring stretch, quadriceps stretch, wide hamstring stretch and inside thigh stretch.
4. Training intensity was maintained at 45- 50% of HR max (100-110 b/m). The intensity was monitored using heart rate monitor worn by the instructor and the most active participant in the group.
5. Rating of Perceived Exertion was used to find out how hard the participants perceived the training workload. They were taught how to perceive intensity of the training using Borg's 20 point scale (Appendix E). An RPE of 10-11 (light) matched the training intensity at this level.
6. Each training session lasted for 30 minutes.

3.8.3 Training level 2 (7th – 12th week)

At second level of training, the intensity was slightly increased as well as the training duration. The training schedule is described below:

- a. Warm up for 10 minutes consisting stretching exercises.
- b. Moderate phase jogging for 5 minutes \times 4 repetitions with $2^{1/2}$ minutes rest intervals of walking in group.
- c. Cool down activities of slow walking and stretching exercises for 5 minutes. The stretching exercises included lunging hamstring stretch, quadriceps stretch, wide hamstring stretch and inside thigh stretch.
- d. Training intensity at this level was maintained at 50-55% of participants HR max (120-130 b/m).
- e. The intensity was monitored using heart rate monitor and RPE (12-13 points- somewhat hard) as described above.
- f. Each training session lasted for 45 minutes.

3.8.3 Establishment of target heart rate

Target heart rate (THR) has been described as a good approach of establishing training intensity level of an exercise programme (Ritched, 2012). The advantage of this method lies in the fact that it ensures that training starts at appropriate intensity and progresses to higher levels as fitness levels improve. It also permits fitness instructors to establish low to high intensity values, which stimulate training response for their exercising participants. Hence, using the 20-point scale, 45- 50% of HR max corresponds to 10-11 points (somewhat light) of RPE; and 50-55% corresponds to 12-13 points (somewhat hard) on the scale. The subjects were taught how to perceive training intensity using RPE. A high correlation exists between a person's perceived exertion rating times 10 and actual heart rate during physical activity (Borg, 1998, as in CDC, 2015). For example if a person's RPE is 14, then $14 \times 10 = 140$; so the heart rate should be 140 beats per minute. In this study, the THR used in calculating the intensity of exercise was determined using this Borg's method described by Ritched (2012) and the Centres for Disease Control and Prevention (2015):

$$45\% - 50\% \text{ (of HR max)} = 10-11 \text{ (RPE)} \times (10) = 100 - 110 \text{ b/m}$$

$$50\% - 55\% \text{ (of HR max)} = 12-13 \text{ (RPE)} \times (10) = 120 - 130 \text{ b/m}$$

3.8.4 Monitoring training intensity

Two methods were used throughout the training programme to monitor the training intensity. Participants' heart rate was monitored and related to their rate of perceived exertion (RPE). Heart rate monitor was used by the instructor and one of the participants in the training group. The heart rate monitors worn around the wrist during exercise was used to maintain the target heart rate (bpm) throughout the programme. The instructor and the monitor guided the group training. The participants were made to understand the role of the two monitors in guiding the phases of the training. Twenty-point rating of perceived exertion (RPE) developed by Borg (1992), was used throughout the training programme to find out how hard the participants felt about the training. Borg has found that exercise participants can easily sense how difficult they respond to a work-out session fits on a 20-point scale (Appendix B) and that it closely measures the exertion of exercise as in the %HR max (ACSM, 2010).

3.9. Procedures for Data Analysis

The data collected were analysed using the Statistical Package for the Social Sciences (IBM version 20). Means and standard deviations were obtained for the age, height, weight, body fat percentage and heart rate of subjects. The hypotheses were tested using two-way repeated-measures analysis of variance (Two-way repeated ANOVA). To identify the period of the training in which there was significant difference, post-hoc tests were carried out using the least significant difference (LSD). An alpha-level of 0.05 was used to retain or reject the null hypotheses.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

The purpose of this study was to assess the effects of jogging exercise on risk factors and biomarkers of cardio-metabolic syndrome (CMS) among adolescents in Kano Metropolis, Nigeria. The age (years), height (m), weight (kg), body fat percentage (%BF) and heart rate in beat per minute (bpm) were measured along with body mass index (kg/m^2), visceral fat (cm^2), systolic blood and diastolic blood pressure (mmHg), C-reactive protein (mg/L) and micro-albuminuria (mg/L) on which the effect of the jogging was investigated. The

participants in the experimental group were subjected to a 12 - week jogging exercise, three times per week at an intensity of 45-55% of their maximal heart rate. The results of the analyses are presented in this chapter along with the research questions and testing of hypotheses.

4.2 Results

Forty (40) participants were selected and randomized into experimental and control groups to determine the effects of jogging exercise on body mass index, visceral fat, systolic and diastolic blood pressure, C-reactive protein and micro-albuminuria. Thirty six (36) participants completed the study and the data collected from them was used in the final analyses of this study. Two participants from the experimental group did not meet the minimum attendance of the training sessions, while two from the control group withdrew for other reasons.

The physical characteristics of the participants of age (years), weight (kg), % body fat, heart rate (bpm) are presented in Table 4.2.1

Table 4.2.1: Physical Characteristics of the Participants used in this Study

Variables	Experimental Groups (n=18)		Control Groups (n=18)	
	Mean	SD	Mean	SD
Age (yrs)	15.28	1.319	15.88	1.131
Height	1.66	0.056	1.64	0.543
Weight (kg)	71.56	11.544	70.66	4.768
Body fat (%)	23.08	4.752	22.85	3.476
Heart rate (b/m)	74.83	7.155	75.39	12.078

The mean age of the experimental group was 15.28 ± 1.319 years and that of the control group was 15.88 ± 1.131 years, making the age range comparable. The mean height for the experimental group was 1.66 ± 0.056 and 1.64 ± 0.543 for control group. This is also comparable. Average weight of subjects in the experimental group was 71.56 ± 11.544 and that of control group was 70.66 ± 4.768 , making the ranges also comparable. The mean body fat% for experimental group was 23.08 ± 4.752 and 22.85 ± 3.476 for control group. The range between these two means is also comparable. The mean heart rates for the two groups were also comparable: 74.83 ± 7.155 and 75.39 ± 12.078 , respectively.

Answering of Research Questions and Hypotheses Testing

The effects of the training programme were recorded at baseline (0 week), immediately after the 6th week and 12th week of training. The summary of the measurement of the selected parameters are presented according to the research questions and hypotheses formulated for the study.

Research Question I: Will regular jogging exercise modify body mass index of male adolescents in Kano metropolis, Nigeria.

The effect of jogging exercise on body mass index of the participants is presented in table 4.2.2a:

Table 4.2.2a: Mean and Standard Deviation of the Effect of Jogging Exercise on Body Mass Index of Adolescents in Kano Metropolis, Nigeria

Variable Period	Control (n=18)			Experimental (n=18)		
	Mean	SD	SEM	Mean	SD	SEM
Base line	27.31	2.691	0.634	27.44	3.367	0.794
BMI 6 th week	27.34	2.684	0.633	26.44	2.652	0.625
(kg/m ²)12 th week	27.34	2.684	0.633	25.36	2.768	0.652

Table 4.2.2a shows the mean standard deviation and standard error of the effects of jogging exercise on body mass index of male adolescents in Kano Metropolis, Nigeria. An observation of the result revealed no change in the BMI of the control group. However, the experimental group had BMI of 27.44 ± 3.367 kg/m² at baseline. During the 6th and 12th week their BMI decreased by 26.44 ± 2.652 kg/m² and 25.36 ± 2.768 kg/m² respectively. This implies that there was a relative modification of the BMI of the subjects who participated in the jogging exercise. This was subjected to inferential statistics on the basis of hypothesis 1.

Sub-hypothesis I: There is no significant effect of regular jogging exercise on body mass index of male adolescents in Kano metropolis, Nigeria.

The effects of jogging exercise on body mass index of the subjects was tested using two-way repeated-measure analysis of variance and the result is summarized in Table 4.2.2b:

Table 4.2.2b: Summary of Two-way Repeated-measure Analysis of Variance on the Effects of Jogging Exercise on Body Mass Index of Male Adolescents in Kano Metropolis, Nigeria

Source		SS	DF	MS	F	P
Group	Sphericity Assumed	22.688	1	22.688	1.394	0.254
	Greenhouse-Geisser	22.688	1.000	22.688	1.394	0.254
	Huynh-Feldt	22.688	1.000	22.688	1.394	0.254
	Lower-bound	22.688	1.000	22.688	1.394	0.254
Period	Sphericity Assumed	19.124	2	9.567	3.631	0.037*
	Greenhouse-Geisser	19.137	1.627	11.760	3.631	0.048
	Huynh-Feldt	19.134	1.775	10.780	3.631	0.043
	Lower-bound	19.134	1.000	19.134	3.631	0.074
Group Period	Sphericity Assumed	20.165	2	10.083	3.804	0.032*
	Greenhouse-Geisser	20.165	1.614	12.406	3.804	0.043
	Huynh-Feldt	20.165	1.758	11.471	3.804	0.039
	Lower-bound	20.165	1.000	20.165	3.804	0.068

* = Significant difference between the means at 0.05 level

Repeated-measures ANOVA analysis of the BMI of the groups (experimental and control) revealed no significant difference of jogging exercise on BMI of male adolescents ($P = 0.254$). However, the analysis by period of the training and group revealed significant effects on the BMI of the participants ($P = 0.032$). With these observations, the null hypothesis is rejected.

Table 4.2.2c: Pair-wise Comparison of Body Mass Index Levels of Experimental Group Measured at Different Periods of the Training

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P
Base-line	6 th week	0.489	0.310	0.133
	12 th week	1.031	0.462	0.040*
6 th week	Base-line	-0.489	0.310	0.133
	6 th week	0.542	0.359	0.150
6 th week	Base-line	-01.031	0.462	0.040*
	6 th week	-0.542	0.359	0.150

* = Significant difference between the means at 0.05 level

Pair-wise comparison revealed that the observed significance occurred between the 6th and 12th week of jogging exercise.

Research Question II: Will regular jogging exercise modify visceral fat of male adolescents in Kano metropolis, Nigeria?

The effect of low-to-moderate exercise on visceral fat of participants is presented in table 4.2.3a:

Table 4.2.3a: Mean and Standard Deviation of the Effect of Jogging Exercise on Visceral Fat of Adolescents in Kano Metropolis, Nigeria

Variable Period	Control (n=18)			Experimental (n=18)		
	Mean	SD	SEM	Mean	SD	SEM
Base-line	8.56	2.995	0.706	8.67	2.473	0.583
Visceral 6 th week	8.56	2.995	0.706	8.22	2.157	0.508
Fat(cm ²) 12 th wk	8.44	2.833	0.668	7.72	1.873	0.441

Table 4.2.3a shows the mean standard deviation and standard error of the effects of jogging exercise on visceral fat of male adolescents in Kano metropolis, Nigeria. An observation of the results revealed slight changes in the visceral fat of the control group at the end of the 12th week.

However, the experimental group had visceral fat of $8.67 \pm 2.473 \text{ cm}^2$ at baseline. During the 6th and 12th week their visceral fat reduces to $8.22 \pm 2.157 \text{ cm}^2$ and $7.72 \pm 1.873 \text{ cm}^2$ respectively. This implies that there was a relative modification of the visceral fat of the subjects who participated in the jogging exercise. This was subjected to inferential statistics on the basis of hypothesis II.

Sub-hypothesis II: There is no significant effect of regular Jogging Exercise on visceral fat of male adolescents in Kano metropolis, Nigeria.

The effects of the regular low to moderate aerobic exercise on visceral fat of the subjects was tested for significance with two-way repeated-measure analysis of variance and the result is summarized in Table 4.2.3b:

Table 4.2.3b: Summary of Two-way Repeated-measure Analysis of Variance on the Effects of Jogging Exercise on Visceral Fat of Male Adolescents in Kano Metropolis, Nigeria

Source		SS	DF	MS	F	P
Group	Sphericity Assumed	2.676	1	2.676	0.145	0.705
	Greenhouse-Geisser	2.676	1.000	2.676	0.145	0.705
	Huynh-Feldt	2.676	1.000	2.676	0.145	0.705
	Lower-bound	2.676	1.000	2.676	0.145	0.705
Period	Sphericity Assumed	5.056	2	2.528	1.259	0.297
	Greenhouse-Geisser	5.056	1.870	2.703	1.259	0.296
	Huynh-Feldt	5.056	2.000	2.528	1.259	0.297
	Lower-bound	5.056	1.000	5.056	1.259	0.277
Group Period	Sphericity Assumed	3.130	2	1.565	0.804	0.456
	Greenhouse-Geisser	3.130	1.741	1.798	0.804	0.442
	Huynh-Feldt	3.130	1.922	1.628	0.804	0.452
	Lower-bound	3.130	1.000	3.130	0.804	0.383

Repeated-measures ANOVA analysis of the visceral fat of the groups (experimental and control) revealed no significant difference ($P = 0.705$) on the visceral fat of male adolescents. Also, the analysis by group and period of the training revealed no significant effects on the visceral fat of the participants ($P = 0.456$). With these results, the null hypothesis which states that there is no significant effect of regular jogging exercise on visceral fat of male adolescents in Kano metropolis is retained.

Research Question III: Will regular jogging exercise modify Systolic Blood Pressure of male adolescents in Kano State, Nigeria

The effect of jogging exercise on body mass index of the participants is presented in Table 4.2.4a:

Table 4.2.4a: Mean and Standard Deviation of the Effect of Jogging exercise on Systolic Blood Pressure of Adolescents in Kano Metropolis, Nigeria

Variable	Period	Control (n=18)			Experimental (n=18)		
		Mean	SD	SEM	Mean	SD	SEM
	Base-line	120.50	9.727	2.293	122.39	8.339	1.965
SBP	6 th week	121.56	8.262	1.947	121.17	8.466	1.995
(mm Hg)	12 week	121.56	8.262	1.947	117.11	5.749	1.355

Table 4.2.4a shows the mean standard deviation and standard error of the effects of jogging exercise on systolic blood pressure of male adolescents in Kano State Nigeria. An observation of the result revealed only slight changes in the systolic blood pressure of the control group. However, the experimental group who had SBP of 122.39 ± 8.339 mm Hg at baseline had reduced SBP to 121.17 ± 8.466 mmHg and 117.11 ± 5.749 mmHg after the 6th and 12th week respectively. This implies that there was a relative modification of the systolic blood pressure of the subjects who participated in the jogging exercise. This was subjected to inferential statistics on the basis of hypothesis III.

Sub-hypothesis III: There is no significant effect of regular jogging exercise on SBP of male adolescents in Kano Metropolis, Nigeria.

The effects of the regular low-to-moderate aerobic exercise on the systolic blood pressure of the subjects was tested for significance with two-way repeated measure analysis of variance and the result is summarized in Table 4.2.4b:

Table 4.2.4b: Summary of Two-way Repeated Measure Analysis of Variance on the Effects of Jogging Exercise on Systolic Blood Pressure of Male Adolescents in Kano Metropolis, Nigeria

Source		SS	DF	MS	F	P
Group	Sphericity Assumed	26.009	1	26.009	0.116	0.737
	Greenhouse-Geisser	26.009	1.000	26.009	0.116	0.737
	Huynh-Feldt	26.009	1.000	26.009	0.116	0.737
	Lower-bound	26.009	1.000	26.009	0.116	0.737
Period	Sphericity Assumed	102.907	2	51.454	2.283	0.117
	Greenhouse-Geisser	102.907	1.684	61.108	2.283	0.127
	Huynh-Feldt	102.907	1.849	55.669	2.283	0.122
	Lower-bound	102.907	1.000	102.907	2.283	0.149
Group Period	Sphericity Assumed	185.241	2	92.620	4.635	0.017*
	Greenhouse-Geisser	185.241	1.759	105.333	4.635	0.021
	Huynh-Feldt	185.241	1.946	95.205	4.635	0.018
	Lower-bound	185.241	1.000	185.241	4.635	0.046

*= Significant difference between the means at 0.05 level

Repeated-measures ANOVA of the SBP of the groups (experimental and control) revealed no significant difference ($P = 0.737$) on the male adolescents. However, the analysis by group and period of the training revealed significant effects on the SBP of the participants ($P = 0.017$). With these results, the null hypothesis which states that there is no significant effect of regular jogging exercise on systolic blood pressure of male adolescents in Kano metropolis is rejected.

Table 4.2.4c: Pair-wise Comparison of Systolic Blood Pressure Level of Experimental Group Measured at Different Periods of the Training

(I) Period	(J) Period	Mean Difference (I-J)	Std. Error	P
Base-line	6 th week	0.083	1.340	0.951
	12 th week	2.111	0.983	0.046*
6 th week	Baseline	-0.083	1.340	0.951
	12 th week	2.029	0.99	0.058
12 th week	Baseline	-2.028	0.983	0.046*
	6 th week	-2.028	0.998	0.158

* = Significant difference between the means at 0.05 level

Pair-wise comparison revealed that the observed significance occurred only between the 6th and 12th week of jogging exercise.

Research Question IV: Will regular jogging exercise modify diastolic blood pressure of male adolescents in Kano metropolis, Nigeria

The effect of jogging exercise on diastolic blood pressure on the participants is presented in table 4.2.5a:

Table 4.2.5a: Mean and Standard Deviation of the Effect of Jogging Exercise on Diastolic Blood Pressure of Adolescents in Kano State, Nigeria

Variable	Period	Control (n=18)			Experimental (n=18)		
		Mean	SD	SEM	Mean	SD	SEM
	Base-line	79.06	11.825	2.787	80.56	9.451	2.227
DBP	6thweek	79.50	9.618	2.267	79.67	8.845	2.085

(mmHg)12 th week	80.94	9.270	2.185	77.28	6.285	1.481
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Table 4.2.5a shows the mean standard deviation and standard error of the effects of jogging exercise on systolic blood pressure of male adolescents in Kano State Nigeria. An observation of the result revealed only slight changes in the diastolic blood pressure of the control group. However, the experimental group with DBP of 80.56 ± 9.451 mm Hg at base-line had their DBP relatively reduced to 79.67 ± 8.845 mmHg and 77.28 ± 6.285 mm Hg after 6th and 12th week, respectively.. This implies that there was a relative modification of the diastolic blood pressure of the subjects, who participated in the jogging exercise. This was subjected to inferential statistics on the basis of hypothesis IV.

Sub-hypothesis IV: There is no significant effect of regular jogging exercise on diastolic blood pressure level of male adolescents in Kano metropolis, Nigeria.

The effects of the regular low to moderate aerobic exercise on the diastolic blood pressure of the subjects was tested for significance with two-way repeated measure analysis of variance and the result is summarized in Table 4.2.5b:

Table 4.2.5b: Summary of Two-way Repeated-measure Analysis of Variance on the Effects of Jogging Exercise on Diastolic Blood Pressure of Male Adolescents in Kano Metropolis, Nigeria

Source		SS	DF	MS	F	P
Group	Sphericity Assumed	12.000	1	12.000	0.077	0.785
	Greenhouse-Geisser	12.000	1.000	12.000	0.077	0.785
	Huynh-Feldt	12.000	1.000	12.000	0.077	0.785
	Lower-bound	12.000	1.000	12.000	0.077	0.785

Period	Sphericity Assumed	9.056	2	4.528	0.196	0.823
	Greenhouse-Geisser	9.056	1.359	6.664	0.196	0.737
	Huynh-Feldt	9.056	1.436	6.306	0.196	0.750
	Lower-bound	9.056	1.000	9.056	0.196	0.663
Group Period	Sphericity Assumed	129.500	2	64.750	4.004	0.027*
	Greenhouse-Geisser	129.500	1.937	64.842	4.004	0.029
	Huynh-Feldt	129.500	2.000	64.750	4.004	0.027
	Lower-bound	129.500	1.000	129.500	4.004	0.062

*= Significant difference between the means at 0.05 level

Repeated-measures ANOVA of the DBP of the groups (experimental and control) revealed no significant difference ($P = 0.785$). However, the analysis by group and period of the training revealed significant effects on the DBP of the participants ($P = 0.027$). With these results, the null hypothesis which states that there is no significant effect of regular jogging exercise on DBP of male adolescents in Kano metropolis is rejected.

Table 4.2.5c: Pair-wise Comparison of Diastolic Blood Pressure Level of Experimental Group Measured at Different Periods of the Training

(I) Period	(J) Period	Mean Difference (I-J)	Std. Error	P
Base-line	6 th week	0.222	1.225	0.859
	12 th week	0.694	1.382	0.052*
6 th week	Baseline	-0.222	1.225	0.858
	12 th week	0.472	0.659	0.483
12 th week	Baseline	-0.694	1.382	0.052*
	6 th week	-0.472	0.659	0.483

* = Significant difference between the means at 0.05 level

Pair-wise comparison revealed that the observed significance occurred only after the 12th weeks of jogging exercise

Research Question V: Will regular jogging exercise modify C-reactive protein of male adolescents in Kano Metropolis, Nigeria

The effect of jogging exercise on C-reactive protein on the participants is presented in table 4.2.6a:

Table 4.2.6a: Mean and Standard Deviation of the Effect of Jogging exercise on C-reactive Pressure of Adolescents in Kano Metropolis, Nigeria

Variable	Period	Control (n=18)			Experimental (n=18)		
		Mean	SD	SEM	Mean	SD	SEM
	Base-line	3.94	0.873	0.206	4.39	0.979	0.231
CRP	6 th week	4.17	0.786	0.185	4.33	0.970	0.229
(mg/L)	12 th week	4.28	0.958	0.226	4.00	0.686	0.162

Table 4.2.6a shows the mean standard deviation and standard error of the effects of jogging exercise on C-reactive protein of male adolescents in Kano State Nigeria. An observation on the result revealed slight increases in the C-reactive protein of the control group. However, the experimental group had CRP of 4.39 ± 0.979 mg/L at baseline. During the 6th and 12th week, their CRP (mg/L) reduces to 4.33 ± 0.970 mg/L and 4.00 ± 0.686 mg/L, respectively. This implies that there was a relative modification of the CRP of the subjects, who participated in the jogging exercise. This was subjected to inferential statistics on the basis of hypothesis V.

Sub-hypothesis V: There is no significant effect of regular jogging exercise on CRP of male adolescents in Kano metropolis, Nigeria.

The modification on the subjects' CRP from involvement in the regular jogging exercise was subjected to two-way repeated-measure analysis of variance. The result of the test is summarized in Table 4.2.6b:

Table 4.2.6b: Summary of Two-way Repeated-measure Analysis of Variance on the Effects of Jogging Exercise on C-reactive Protein of Male Adolescents in Kano Metropolis, Nigeria

Source		SS	DF	MS	F	P
Group	Sphericity Assumed	0.333	1	0.333	0.189	0.669
	Greenhouse-Geisser	0.333	1.000	0.333	0.189	0.669
	Huynh-Feldt	0.333	1.000	0.333	0.189	0.669
	Lower-bound	0.333	1.000	0.333	0.189	0.669
Period	Sphericity Assumed	0.241	2	0.120	0.605	0.552
	Greenhouse-Geisser	0.241	1.567	0.145	0.605	0.523
	Huynh-Feldt	0.241	1.813	0.133	0.605	0.537
	Lower-bound	0.241	1.000	0.241	0.605	0.447
Group Period	Sphericity Assumed	2.389	2	1.194	5.580	0.008*
	Greenhouse-Geisser	2.389	1.582	1.510	5.580	0.014
	Huynh-Feldt	2.389	1.717	1.392	5.580	0.012
	Lower-bound	2.389	1.000	2.389	5.580	0.030

*= Significant difference between the means at 0.05 level

Repeated-measures ANOVA of the CRP of the groups (experimental and control) revealed no significant difference ($P = 0.669$). However, the analysis by group and period of the training revealed significant effects on the CRP of the participants ($P = 0.008$). With these results, the null hypothesis which states that there is no significant effect of regular jogging exercise on CRP of male adolescents in Kano metropolis is rejected.

Table 4.2.6c: Pair wise Comparison of C-reactive Protein Levels of Experimental Group Measured at the Different Periods of the Training

(I) Period	(J) Period	Mean Difference (I-J)	Std. Error	Sig
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Baseline	6 th week	-0.111	0.125	0.386
	12 th week	-0.028	0.103	0.054*
6 th week	Baseline	0.111	0.125	0.386
	12 th week	0.083	0.083	0.331
12 th week	Baseline	0.028	0.103	0.054*
	6 th week	-0.083	0.083	0.331

* = Significant difference between the means at 0.05 level

Pair-wise comparison revealed that the observed significance occurred only after the 12 weeks of jogging exercise.

Research Question VI: Will regular jogging exercise modify micro-albuminuria of male adolescents in Kano metropolis, Nigeria

The effect of jogging exercise on micro-albuminuria of participants is presented in Table 4.2.7a:

Table 4.3.7a: Mean and Standard Deviation of the Effect of Jogging Exercise on Micro-albuminuria of Adolescents in Kano Metropolis, Nigeria

Variable	Period	Control (n=18)			Experimental (n=18)		
		Mean	SD	SEM	Mean	SD	SEM
Microal- buminuria (mg/L)	Baseline	4.22	8.143	1.919	4.33	6.660	1.570
	6 th wk	4.11	7.925	1.868	4.33	6.660	1.570
	12 th wk	4.67	7.104	1.674	4.00	5.269	1.242

Table 4.3.7a shows the mean standard deviation and standard error of the effects of jogging exercise on micro-albuminuria of male adolescents in Kano State Nigeria. An observation of the result revealed only slight changes in the micro-albuminuria of the control group. However, the experimental group had their micro-albuminuria of 4.33 ± 6.660 mg/L at baseline, reduced to 4.33 ± 6.660 Mg/L and 4.00 ± 5.269 mg/L after the 12th week respectively. This implies that there was a

relative modification of the micro-albuminuria of the participants who participated in the jogging exercise. This was subjected to inferential statistics on the basis of hypothesis VI.

Sub-hypothesis VI: There is no significant effect of regular jogging exercise on micro-albuminuria of male adolescents in Kano metropolis, Nigeria.

To determine the modification of the subjects' micro-albuminuria levels after regular jogging exercise, the obtained data was subjected to two-way repeated measure analysis of variance. The summary of the result is presented in Table 4.2.7b

Table 4.2.7b: Summary of Two-way Repeated-measure Analysis of Variance on the Effects of Jogging Exercise on Micro-albuminuria of Male Adolescents in Kano Metropolis, Nigeria

Source		SS	DF	MS	F	P
Group	Sphericity Assumed	1.333	1.000	1.333	0.010	0.920
	Greenhouse-Geisser	1.333	1.000	1.333	0.010	0.920
	Huynh-Feldt	1.333	1.000	1.333	0.010	0.920
	Lower-bound	1.333	1.000	1.333	0.010	0.920
Period	Sphericity Assumed	4.222	2	2.111	0.075	0.928
	Greenhouse-Geisser	4.222	1.787	2.363	0.075	0.911
	Huynh-Feldt	4.222	1.982	2.130	0.075	0.927
	Lower-bound	4.222	1.000	4.222	0.075	0.944
Group Period	Sphericity Assumed	.222	2	0.111	0.005	0.995
	Greenhouse-Geisser	.222	1.814	0.123	0.005	0.995
	Huynh-Feldt			0.111	0.005	0.995
	Lower-bound			0.222	0.005	0.995

Repeated-measure ANOVA of the micro-albuminuria of the groups (experimental and control) revealed no significant difference ($P = 0.920$). The analysis by group and period of the training also revealed no significant effects on the micro-albuminuria of the participants ($P = 0.995$). With these results, the null hypothesis which states that there is no significant

effect of regular jogging exercise on micro-albuminuria of male adolescents in Kano metropolis is retained.

International health authorities and exercise leading organizations (WHO, 2010; CDC, 2008; ACSM, 2010), recommend moderate to vigorous intensities of aerobic training for improvement in cardio-metabolic risk factors and prevention of diabetes and cardiovascular diseases in adult and adolescent populations. However, the result of this study indicates that training at low-to-moderate intensity reduced the selected risk factors and biomarkers of CMS, more specifically BMI, SBP, DBP and CRP. The finding here agree with the findings of Cambuli (2008), who confirms the positive effects of physical activity on metabolic and clinical parameters in overweight/obese children through a randomized controlled trial, in which 222 overweight or obese sedentary children were involved.

High body mass index is an important risk factor of cardio-metabolic syndrome. Data from the reviewed literature revealed that aerobic exercise is beneficial to normal BMI in adolescent population. The result of the present study showed significant reduction on the BMI of the trained participants after the 12th weeks of the training. This finding is in line with the finding of Wong *et al.* (2008), who investigated the effects of a 12- week aerobic exercise training, twice weekly, in 13 to 14-year-old obese boys contrasted with a control group. The finding also agrees with the report of Marandi *et al.* (2013), who found significant reduction in BMI ($P < 0.000$) following light and moderate aerobic exercise among adolescent boys. Kamal and Raggy (2012) reported that after 12 weeks of exercise, both obese and non-obese children, with and without metabolic syndrome, showed reduced body weight and BMI (from 47.3 to 32.6%). They used different intensity from the present study. However, the finding of this study contradicts the results of Nassis (2005), who did not find significant changes in body composition of 13-year obese girls after moderate aerobic exercise (50-60% of maximal heart rate). Their intensity and age of the subjects is similar. However, gender differences might be the differential factor in the two studies.

It is well documented that aerobic exercise decreases visceral fat (Brandou, Dumortier, Garandau, Mercier, Brun, 2003). The intensity and duration however provide different results. The current study revealed no significant reduction on the visceral fat of the participants after the 12th week of the training. Van der Heijden, et al. (2010), vigorous

aerobic exercise programme ($>70\%$ vo_2 peak) decreases abdominal visceral fats in adolescent boys. Hence, intensity varied with this study. This finding contradicts the work of Irving *et al.* (2008) who examined the effects of aerobic training intensity on abdominal visceral fat (AVF) in obese middle aged women with metabolic syndrome. Training significantly reduced abdominal visceral fat ($p=0.010$), with no significant changes observed within the Control or low-intensity exercise group.

The result of this study revealed significant reduction in the SBP of the participants after the 12th week of the training. This finding is in line with the reports of Kamal and Raggy (2012), who investigated changes of blood pressure before and after an exercise therapy in obese and non-obese children. After 12 weeks of exercise, both groups (obese and non-obese) were reported to show reduced systolic blood pressure. In the study of Wong *et al.* (2008), 12 weeks of additional aerobic exercise training at 65% to 85% of maximum heart rate, twice a week, 45-60 minutes per session significantly reduced resting systolic blood pressure of 13 to 14 year old adolescent boys. Ajiya *et al.* (2010) between recorded no significant changes in systolic blood pressure of adolescents after 8 weeks of aerobic exercise programme.

The result of this study further revealed significant reduction in the diastolic blood pressure of the participants after the 12th weeks of the training. This result support the findings of Farpour-Lambert *et al.* (2009), who found significant reduction in blood pressure of obese children after three months of exercise training which include ball games, swimming, and running and were structured to include 30 minutes of aerobic work, followed by 20 minutes of strength work and 10 minutes of stretching. The finding contradicts Ajiya *et al.* (2010), who recorded no significant changes in diastolic blood pressure of adolescents after 8 weeks of high intensity aerobic exercise programme. However, these two studies used higher exercise intensities as compared to the present study.

The result of this investigation revealed significant reduction on the C-reactive protein of the participants after the 12th week of the training. The finding agrees with that of Kamal and Raggy (2012) who investigated changes in C-reactive protein (CRP) before and after an exercise therapy in normal and obese children (with or without metabolic syndrome). After 12 weeks of exercise, both obese children groups, (with and without metabolic syndrome), showed reduced CRP level. The findings, however, contradict the work of Wong *et al.* (2008), who investigated the effects of a 12-week exercise training, twice weekly on body composition and serum C-reactive protein (CRP) in 13- to 14-year-old obese boys contrasted with a control group. The study comprised a combination of circuit-

based resistance training and aerobic exercises. In addition, it involved typical physical education sessions. The training did not find significant improvement in the C-reactive protein of the subjects. However, their training was conducted twice a week as compared to three days per week in the present study. Also the age bracket in their study was lower. In another study, 16 weeks regular aerobic exercise reduced CRP levels in young women of 18 years and above (Arikawa, Thomas, Schimitz & Kurzer, 2011). However, in this study besides using different subjects, they did not provide detail of the exercise intensity used.

The result of this study revealed no significant reduction in the micro-albuminuria of the participants after the 12th week of the training. Studies exploring the relationship between physical activity and albuminuria in the general population are still complicated. In diabetic patients, physical activity is associated with lower level of albumin excretion (Ochodnický *et al.*, 2006). In the study of Lazarevic, Antic, Vlahovic, Djordjevic & Stefenovic (2007), aerobic exercise tended to decrease micro-albuminuria in type 2 diabetic patients without any change in the medication. However, they recommended for further studies not only to confirm the finding, but to elucidate potential mechanisms that would clarify the beneficial effects of exercise on micro-albuminuria.

Studies on children are also complicated and require further attempts to explain a meaningful difference. The result of this investigation supports the findings of Finkelstein *et al.* (2006), who studied 13,753 participants in the third US National Health Nutrition Survey (NHANES) aged 18 years or older. After multivariate adjustment, physical activity was not found to be significantly associated with albumin-creatinine ratio.

Another study examined the effect of exercise intensity on micro-albuminuria on children of 10-18 years. The subjects were subjected to three exercise groups of various intensities (60%, 80% and 100% of maximal heart rate). Micro-albuminuria significantly increased with exercise intensity (Komhauser, Malacara, Macias-Cervaster & Rivera-Cisnoros, 2011). This justifies the small reduction observed in this study with low-to-moderate intensity of exercise.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Introduction

The investigation into the modification of risk factors and biomarkers of CMS among male adolescents who participated in regular jogging exercise is summarized in this chapter. Among others, the chapter is made up of conclusion and recommendations based on the findings, for further studies on the subject.

5.2 Summary

Cardio-metabolic syndrome manifests in various ways and among all ages to an extent that diabetes and cardiovascular diseases, two of the major factors have become a global threat. The risk factors have been observed to be common among youths especially where they are overweight (Okafor, 2012). Review of literature revealed that the presence of cardiovascular risk factors that constitute the CMS is linked to the level of aerobic fitness in children and adolescents. Moreover, the pattern of physical activity in terms of both volume and intensity on individual components of CMS has not been well studied in adolescents (Gardener *et al.*, 2013). This study was therefore undertaken to investigate the effect of regular jogging exercise on the risk factors and biomarkers of CMS among male adolescents in Kano metropolis.

This study consists of one major null hypothesis and six sub hypotheses structured along the objectives and research questions. Forty participants were selected and randomized into experimental and control groups after meeting the inclusion criteria. Both groups were measured for the dependant variables at baseline, after 6 weeks and at the end of the 12th week. The selected variables were body mass index, visceral fat, systolic and diastolic blood pressure, C-reactive protein and micro-albuminuria levels. Thirty six (36) subjects completed the 3 tests and their data was used in the final analysis. The intervention programme consisted of regular outdoor jogging exercise performed in groups, three days/week at low-to-moderate intensity (45 to 55% of participants' maximal heart rate). 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 for the subjects' age, height, weight, body fat percentage and heart rate selected along with the investigated variables above. The hypotheses were tested with repeated measures ANOVA.

5.2.1 Summary of findings

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

1. Regular jogging exercise significantly reduced the body mass index of male adolescents in Kano Metropolis ($p= 0.037$).
2. Regular jogging exercise had no significant effect on the visceral fat of male adolescents in Kano Metropolis ($p= 0.296$).
3. Regular jogging exercise significantly reduced the systolic blood pressure of male adolescents in Kano Metropolis ($p= 0.017$).
4. Regular jogging exercise significantly reduced the diastolic blood pressure of male adolescents in Kano Metropolis ($p=0.027$).
5. Regular jogging exercise significantly reduced the C-reactive protein of male adolescents in Kano Metropolis ($p=0.014$).
6. Regular jogging exercise had no significant effect on the micro-albuminuria of male adolescents in Kano Metropolis (0.911).
7. Result revealed that all the significant reductions were found after the 12 weeks of the training.

5.2.2 Contribution to Knowledge

The present study made the following contributions to knowledge.

8. This study had found that low-to-moderate jogging exercise is enough to reduce BMI, SBP, DBP and CRP of adolescent boys, unlike other studies who reported no significant changes. Exercise specialists can use this information in prescribing exercise aimed at improving cardiovascular health in adolescents.
9. The present study has added to the available information on new CMS criteria and the benefits of exercise in reducing them.

10. The study further provided that low-to-moderate jogging exercise is not enough to illicit significant changes in variables like visceral fat and microalbuminuria in adolescent boys.
11. This study further informed the value of jogging exercise in reducing CMS risk factors and biomarkers in the adolescent group.

5.3 Conclusion

Based on the findings and within the limitation of this study, it was concluded as follows:

1. Regular jogging exercise had significantly affect the Body mass index of male adolescents in Kano metropolis.
2. Regular jogging exercise did not significantly reduce the visceral fat of male adolescents in Kano metropolis.
3. Regular jogging exercise had significantly reduced the systolic blood pressure of male adolescents in Kano metropolis.
4. Regular jogging exercise had significantly reduced the diastolic blood pressure of male adolescents in Kano metropolis.
5. Regular jogging exercise had significantly reduced the C-reactive protein of male adolescents in Kano metropolis.
6. Regular jogging exercise did not significantly affect the microalbuminuria of male adolescents in Kano metropolis.
7. The duration of the training was found to have major impact on the reduction observed in the selected risk factors and biomarkers with significant effects found only at the end of the 12th week of the training.

5.4 Limitation of the Study

The present study had the following limitation:

1. There was no absolute control of subjects in the control group; rather the subjects were relatively sedentary throughout the training periods compared to the experimental group.
2. Four subjects, two from each group could not complete the three periodic tests and their data was included in the final analysis.
3. The data collection and the training programme did not start at the initial schedule after proposal, due to the delay from the State Secondary School Management Board in giving approval. This required an arrangement with students to come to school during holiday on the training days.

5.5 Recommendations

Based on the findings from the analyzed data, the researcher would want to recommend as follows:

1. Regular jogging exercise is recommended for effective reduction in the risk factors and biomarkers of cardiometabolic syndrome among male adolescents.
2. Training duration of jogging exercise should be continuous for a period of at least 12 weeks, to achieve a significant result in reducing the risk factors and biomarkers of CMS.

5.6 Recommendations for Further Studies

1. There is need to conduct a similar study among rural adolescents in Kano State.
2. This study concentrated on male adolescents in Kano metropolis. It may be of great importance to replicate the study among pre-adolescents and girls populations.
3. This study tested four risk factors and two biomarkers of CMS. Other studies may focus on the rest of the risk factors and biomarkers.
4. There is need for further studies to establish the effects of jogging exercise on visceral fat and micro-albuminuria.

5. Further studies can evaluate low aerobic exercise, moderate aerobic exercise and vigorous aerobic exercise, using independent groups to measure their comparative effects on adolescent population.

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APPENDIX A

AHMADU BELLO UNIVERSITY ZARIA DEPARTMENT OF PHYSICAL AND HEALTH EDUCATION

INFORMED CONSENT FORM

This study is designed to evaluate the effects of 12 weeks of aerobic exercise on risk factors and biomarkers of cardio-metabolic syndrome among adolescents in Kano State. Below are the procedures of the study:

1. Laboratory measurements will be conducted three times: before the beginning of exercise programme, after 6 weeks and at the end of the 12 weeks.
2. The measurements include measures of body composition (height, weight, body mass index, % body fat), blood pressure, urine (for micro-albuminuria test) and blood test (for C-reactive protein test).
3. Participants are expected to undergo all the measurements and participate in the 12 weeks exercise programme which will be conducted 3 days per week for maximum of 60 minutes/day.
4. Safety and confidentiality are assured for the participants throughout the research programme.
5. There may be discomfort at the beginning of the exercise programme which may not last long, but generally there is no risk in participation.
6. Nigerian adolescents are at risk for adiposity and subsequent cardio-metabolic disease, exercise therapy is widely recognized, research is still needed to establish the interaction of risk factors/biomarkers and standardize exercise protocols for our children
7. The 12-week exercise programme may be enough to elicit positive changes in overall health variables of the participants. Hence, participants are likely to draw some health benefits.
8. Participants have full right to ask questions, agree or refuse to participate and or withdraw from the procedures.
9. I have read and fully understood the purpose and procedure of the measurements and exercise which I am to participate. I have been instructed to stop exercising immediately on feeling of sudden exhaustion, dizziness or any form of discomfort and to report same immediately to the exercise instructor during the course of the exercises. I have willingly accepted to participate in the research as a subject without any persuasions from the

researcher and demand no compensation or incentives directly or indirectly for participation in this research study.

_____ Name of Participant	_____ Signature and date
_____ Name of Parent/Guardian	_____ Signature and date
_____ Name of Witness (School rep.)	_____ Signature and date
_____ Name of Test Administrator	_____ Signature and date

APPENDIX B

**APPROVAL FROM KANO STATE SECONDARY SCHOOLS
MANAGEMENT BOARD**



KANO STATE SENIOR SECONDARY SCHOOLS MANAGEMENT BOARD

GIDAN MALAMAI

No. 1 Lawan Danbazau Link, P. M. B. 3065, Kano.

☎: 064-318855, 669420, 661948, 667884, 667869

Our Ref: KSSSMB /ADM/VOL/1

Your Ref:

Date: 23/10/2015

THE CO-ORDINATOR,
KANO CAPITAL SCHOOLS,
KANO.

The bearer of this note is a researcher from A.B.U Zaria.
The Board, on this research, is very much interested to have the following as evidence»

1. A written consent from the parents of the students to be tested
2. That each student should be tested with a fresh syringe.

The Board would not compromise any of the said conditions.
Be firm and resolute on this issue. Don't succumb to pressure.
The board looks forward to seeing your response.

Best regards,

Shu'aibu Kasim Abubakar
CEO/DOC/PUV.
For – Director PRS KSSSMB

*Pls acknowledge
the letter and adhere
to the conditions
stipulated by the Board*

APPENDIX C
ETHICAL PERMISSION FROM THE SCHOOL
OF POSTGRADUATE STUDIES

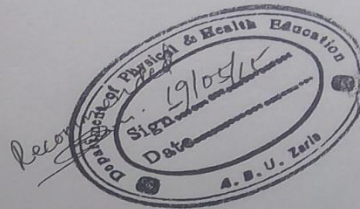
Department of Physical and Health Education
Ahmadu Bello University
Zaria.

19th May, 2015

The Dean
School of Postgraduate Studies
Ahmadu Bello University
Zaria.

Through:

The Head
Department of Physical and Health Education
Ahmadu Bello University
Zaria



Dear Sir,

**REQUEST FOR PERMISSION TO USE HUMAN BLOOD SAMPLE FOR
RESEARCH**

I am a postgraduate student from the above named Department. I am conducting a research titled "Effects of Aerobic Exercise on Risk Factors and Biomarkers for Cardiometabolic Syndrome Among Male Adolescents in Kano State, Nigeria". This research will require the use of human subjects.

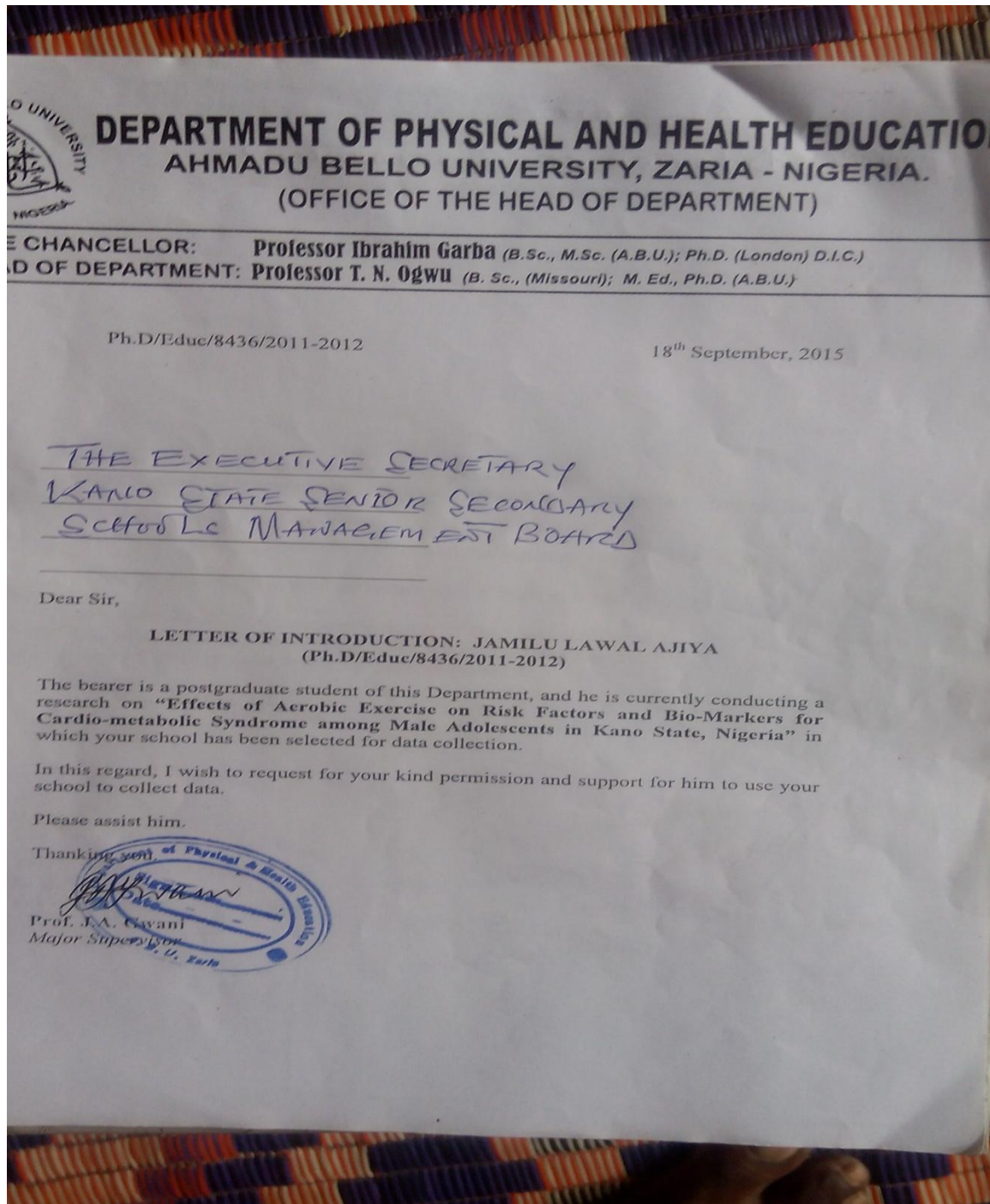
I am writing to request that an approval be granted to conduct this research. I promise to observe all ethical issues relating to research using human subjects.

Yours faithfully,

Jamilu Lawal AJIYA

APPENDIX D

LETTER OF INTRODUCTION



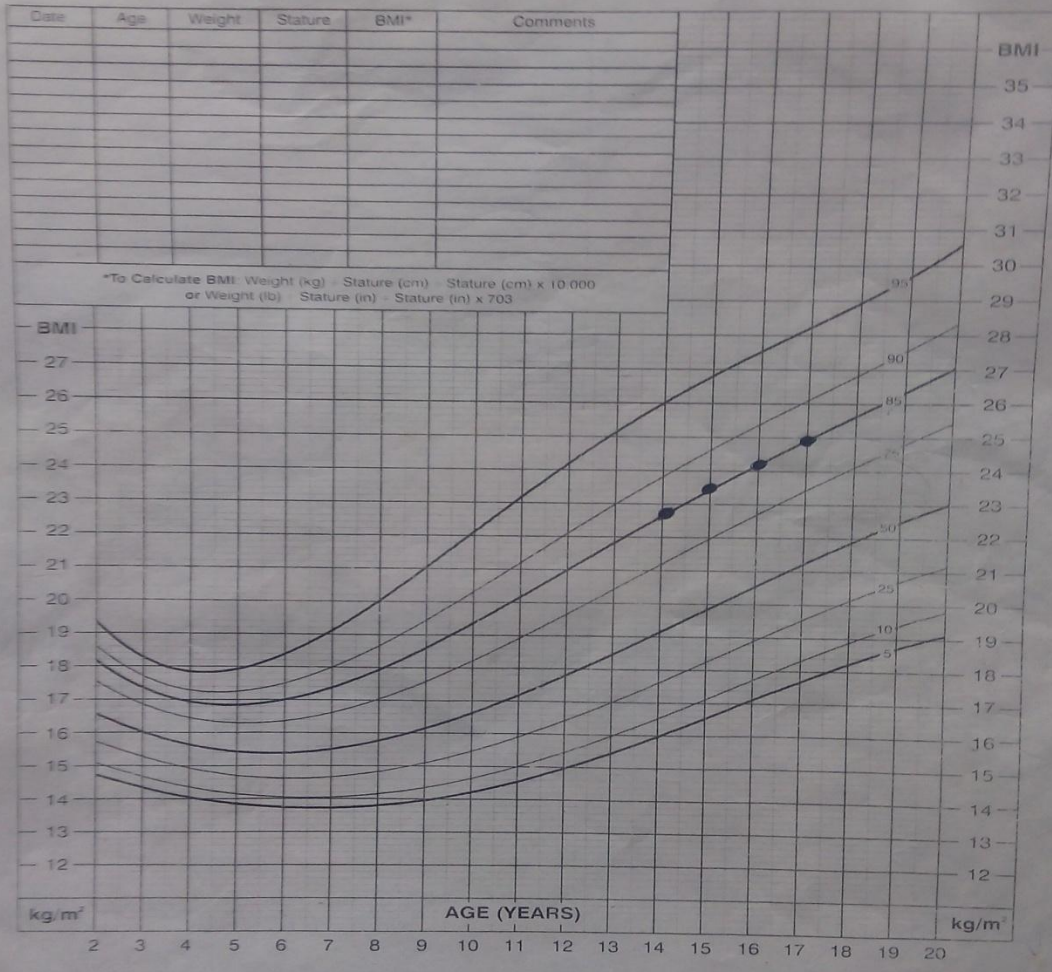
APPENDIX E

BODY MASS INDEX FOR AGE PERCENTILES (NCHS/NCCD-PHP)


2 to 20 years: Boys
Body mass index-for-age percentiles

NAME _____

RECORD # _____



Published May 30, 2000 (modified 10/16/00)
SOURCE: Developed by the National Center for Health Statistics in collaboration with
the National Center for Chronic Disease Prevention and Health Promotion (2000).
<http://www.cdc.gov/growthcharts>



SAFER • HEALTHIER • PEOPLE

APPENDIX F
BORG SCALE OF PERCEIVED EXERTION (RPE)

- 6.
- 7. Very very light
- 8.
- 9. Somewhat light
- 10.
- 11. Light
- 12.
- 13. Somewhat hard
- 14.
- 15. Hard
- 16.
- 17. Very hard
- 18.
- 19. Very very hard
- 20.

Borg 1982