EFFECT OF AEROBIC TRAINING ON PULMONARY FUNCTIONS OF ASTHMATIC ADULTS IN KADUNA STATE COLLEGE OF EDUCATION, GIDAN WAYA, NIGERIA

BY

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DEPARTMENT OF PHYSICAL AND HEALTH EDUCATION, FACULTY OF EDUCATION,AHMADU BELLO UNIVERSITY, ZARIA.

AUGUST, 2015

DECLARATION

This dissertation, entitled Effect of Aerobic Training on Pulmonary Functions of Asthmatic Adults in Kaduna State College of Education, Gidan Waya, Nigeria was written by me. The researcher also declares that this dissertation has not been submitted in any form, whether partly or wholly for any other degree. All sources of the publications and other related reports cited in this dissertation are dully aknowledged in the references.

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Ayuba Mamman	Sign	Date

CERTIFICATION

This dissertation titled "**Effect of Aerobic Training on Pulmonary Functions of Asthmatic Adults in Kaduna State College of Education, Gidan Waya, Nigeria**" by Ayuba MAMMAN meets the regulations governing the award of the degree of Doctor of Philosophy in Exercise and Sports Science, Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literaly presentation.

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DEDICATION

This dissertation is dedicated to my beloved wife, Mrs. Grace A. Mamman and our children, Philemon, Rejoice and Lois Zichat.

ABSTRACT

This study assessed the effects of aerobic training on pulmonary functions of asthmatic adults in Kaduna State College of Education, Gidan waya, Nigeria. For the purpose of this study, one group repeated trials research design, in which the subjects were given different treatments at different times were used, In this design, subjects underwent aerobic training of 40 – 50 % maximal heart rate(RPE) for a 20 to 25 minutes in the training session conducted in three (3) alternate days per week for twelve (12) weeks. A total of 30 asthmatic adults attending the college clinic at the Respiratory Unit volunteered to participate in this study. Out of the 30, 26 met the inclusion criteria and were assigned to the aerobic training; since there was no control group and the baseline values served as the control. The aerobic group engaged in treadmill walk at intensities ranging between 40% - 50% of estimated HR max. The training given was at a moderate intensity of 40 -50 % maximal heart rate (MHR) (1- 4 weeks) which was increased progressively from 51 – 60 % HRMax(5 – 8 weeks) and 61 – 70 % HRMax (9 – 12 weeks). The data collected were statistically analyzed using repeated measures analysis of variance using a level of significance of 0.05. The result of the study revealed that aerobic training programs caused an increase $P < 0.05$ in FEVI, FIVI, VC, VO_2 max, FEV/ FVC ratio and RR. It was concluded that asthmatic adults should participate in aerobic exercise regularly in order to control their asthma attacks(episodes). Health professionals and fitness centers should use this method of training for asthmatic patients and should be encouraged to exercise themselves at least 20 – 40 minutes in a week to improve their pulmonary functions.

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OPERATIONAL DEFINATION OF TERMS

i. **Asthma:** Inflammatory condition of the airways involving many types of cells, especially mast cell, eusinophils and T- lymphocytes.

ii. **Asthmatic Adults:** For the sake of this study, these are individuals between the ages of 18 and 35 years who are diagnosed with asthma at the out-patient clinic of Kaduna State College of Education Gidan Waya,Kaduna.

iii. **Spirometry:** A medical screening test that measures various aspects of breathing and lung function. The measurement is performed by using a spirometer.

iv. **Pulmonary Function:**for the purpose of this study,it is the ability of lungs to inhale or exhale sufficient air at sufficient rate during and after exercise.

v. **Pulmonary Function Test:** For the purpose of this study,it is a procedure that measures lung volume, lung capacity and respiratory airways. it is one of the many tests that measure how well our airways work.

vi. **Aerobic Exercise:** For the sake of this study, these are activities'' like jogging, running, skipping, dancing and bicycling that were used to cause the heart and lungs to work harder than at rest.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Asthma represents a continuum of disease process characterized by inflamation of the airways wall. It has been described as a chronic inflammatory condition, characterized by air-way hyper-responsiveness to a variety of stimuli that lead to recurrent episodes of wheezing, breathlessness, chest tightness and coughing. It is manifested by a wide - spread narrowing of the air-ways that change in severity, either spontaneously or as a result of treatment, largely of allergic origin, with reversible air flow limitation (National Asthma Education and Prevention Program, 2013). Asthma is also defined as a chronic inflammatory disorder of the air-ways, in which many cells play a role, including mast cells and eosinophils. In susceptible individuals, this inflammation causes symptoms which are usually associated with wide-spread but variable air-flow obstruction that is often reversible, either spontaneously or with treatment. Bronchial tubes that are chronically inflamed may become overly sensitive to allergens (specific triggers) or irritants (nonspecific triggers). The airways may become 'thitchy' and remain in a state of heightened sensitivity. This is called "bronchial hyper-activity' (BHR) (Jackson, Sul, Herbert & Church, 2009 ; Kerstin, 2010). Asthma is a chronic respiratory disease that can have varying effects on the quality of life of sufferers. It is a major cause of impaired quality of life with impact on work, recreational, physical activities and emotions (Ibe & Ele 2002 ; Fawibe,Onyedum & Sogaomu, 2012).

Researchers have discovered two major factors responsible for the aetiology of asthma. They include host factors (factors causing its development) and environmental factors (factors causing triggering its symptoms). The mechanisms that influence the development and expression of these disorders are generally complex and interactive. For example, genetic factors interact with environmental factors to determine asthma susceptibility among individuals (Wolfang, Simon, Klans & Lothar, 2010).

The asthmatic airways have hypertrophied smooth muscle that contract during an asthmatic episode, resulting in bronchoconstriction (Venkastewarlu, 2011a). Therefore, the types of inflamation differ between patients, even with the same mechanisms involved. Each individual is unique in his/ her degree of reactivity to environmental triggers. This naturally influences the type and dose of medication prescribed, which may vary from one individual to another. At the same time, the response to treatment can also vary greatly. It has been experimentally demonstrated that the management and control of asthma affect the quality of the life of the person living with the condition and that any level of symptom severity has an impact on the quality of life, even in people who only experience occasional symptoms (Cazzoletti, Marco & Jans, 2007; Krouse , 2007).

Spirometry tests are normaly carried out to assess how an individual inhales or exhales volume of air over a period of time. It also measures how fast one can blow air out, and is used as a screening test for respiratory health (Levy, Fletcher, Price & Hussein, 2006; Neas & Schwarz; 2009). The most important variables measured in spirometry are volume and flow of air in the lungs. This provides important information about the presence of any restrictive or obstructive lung disorder, which helps in measuring the effect of the disorder on pulmonary functions, assessing prognosis and screening individuals at risk of having pulmonary disease as well as assessing response to treatment. The components of pulmonary functions are the forced expiratory vital capacity (FVC), which is the volume of air that can be expired rapidly with maximum inspiration. Forced expiratory volume in one second (FEVi) is the volume of air expired in the first second of maximal expiration after a maximal inspiration, and is a useful measure of how quickly full lungs can be emptied. It represents the volume of air expired in the first second of a FVC. The estimation of FEVi is the most commonly used screening test for air-way diseases. Normally, FEVi usually a range of 75-80% of the FVC. It is useful in distinguishing between restrictive and obstructive diseases. Peak expiratory flow rate (PEFR) is the highest flow value measured during forced expiration. It is one of many tests that measure how well the air-ways work. It measures air-way obstructions and it will detect moderate or severe disease. Factors which determine FEFR are air-way obsruction, closure and compression of small air-ways, strength of expiratory muscles and the lung and chest mechanics (Desalu, Oluboyo & Salami, 2009 ; Ishee, 2012).

Forced inspiratory volume (FIV) is the volume of air that can be inspired forcefully following a normal tidal volume of inspiration. Forced inspiratory volume of air in one second (FIVi) is the volume of air inspired in the first second of normal tidal volume. It is useful in measuring how quickly lungs can be filled. Vital capacity (VC) is the sum of the inspiratory reserve volume, tidal volume and the expiratory reserve volume. It is the maximum volume of air that a person can expel from his respiratory tract after a maximum inspiration.The VC may be normal in some respiratory diseases.However, the FEV has great diagnostic value, because it decreases significantly in some respiratory disorders; particularly, it decreases significantly in obstructive diseases like asthma and emphysema.

The VO_2 max is the amount of oxygen consumped during physical activity. It is used to determine the subject’s aerobic power and pulmonary ventilation. Ventilation of the lungs allows exchange of gas between blood and atmosphere. Aerobic exercise is an important component of pulmonary rehabilitation for patients with chronic obstructive pulmonary disease (Bateman, Hurd & Banes, 2008).

Heart rate (HR) is the number of times the heart contracts each minute. Under resting condition, the heart rate is approximately 72 beats/minute and the stroke volume is approximately 70 ml/beat . Heart rate has a linear relationship with oxygen consumption and energy expenditure (Bahadori, Doyle,Waters & Marra, 2009). Pattern of breathing refers to the respiratory frequency and regularity, the depth of breathing or tidal volume, and the relative amount of time spent during inspiration and expiration. Normal respiratory rate in adults is between 14 and 18 cycles per minute. Tidal volume of a 70-kg adult is about 500 ml per breath and the ratio of inspiratory to total time 0.4 at rest (American Thoracic Society, 2005).

Today, one of the methods for the treatment of asthmatic patients is rehabilitation, which is more advantageous than drug treatment and leads to significant improvement in patients. Aerobic exercise is an important component of pulmonary rehabilitation for patients with chronic obstructive pulmonary disease (COPD). The American College of Sports Medicine (2010) defined aerobic exercise as ‘any activity that uses large muscle groups, and can be maintained continously, and is rhythmic in nature. It is a type of exercise that overloads the heart and lungs and causes them to work harder than at rest.

According to Global Asthma Report (2011), the less frequent causative factors of asthma are stress and environmental factors. The report shows that the burden of asthma has been growing over the past 30 years, particularly in low and middle -income countries, where people suffering from asthma are facing increased challenges.There are few studies on aerobic exercise and pulmonary functions in general population. For the fact that exercise has the ability to markedly improve all areas of health for all ages, it is imperative to focus on how aerobic training can affect pulmonary functions of asthmatic adults.

The human body is actually designed for vigorous physical activity (work) and movement. Unfortunately, physical exertion has not been part of modern average lifestyle . It is thus, not natural to expect the human body to function efficiently and effectively and be healthy for a long period of time, when the body is disused and abused (Chado, 2010). Physical activity is an important health behaviour that may change across life course. For instance, it is considered to be an important factor in the general wellbeing of both healthy and unhealthy individuals; especially, those affected by chronic diseases such as bronchial asthma,frequency of breathing increase during the exercise. In abnormal subjects, tidal volume can reach 2.5 liters at high ventilatory demands. Health benefits of regular participation in different forms of physical activity have been well documented for many years (Saleh. 2008). However, it is now evident that physical activity needs not be streneous to provide health benefits. In fact, thirty (30) minutes of moderate intensity, physical activity daily or most days of the week provides appreciable important health benefit (Dikki, 2001). This amount of regular physical activity can significanthy reduce or prevent the risk of respiratory disease, osteoporosis, colon cancer and breast cancer,improvement in lung functions and aerobic capacity (Venkatsewarlu, 2009).

The two major parttens of abnormal ventilatory functions are restrictive and obsructive which are characterized by a reduced FEVI and FEF 25-75 % and low FEVI/FVC ratio combined with increased total lung capacity (Douglas, 2010).

The activities of daily living by individuals include varying degrees of physical stress some of which overload the cardio- respiratory system beyond the physiological capacity. The ability of the body to withstand this daily physical extertion depends very largely on the strength and functional ability of the aerobic system. The respiratory system of the human being is often said to be influenced by what the individual does for a living, or rather what he or she does for a greater part of the day. Such activity definitely accounts for the pulmonary functions of the individual, whether it is mild, moderate or vigorous (Venkastewarlu, 2011).

Exercise pulmonary function test monitors lung functions to see if the airways are hyper- responsive. There are limited researches focusing on effect of exercise on pulmonary function of asthmatics. Therefore, if more knowledge can be gained in relation to why asthmatic adults do or do not exercise, the possibility for future interventions are encouraging.Although asthma has no current cure, if treated appropriately the disease can be well controlled (Onyedum & Desalu, 2012). Part of the currently suggested treatment includes the prescription of exercise for asthmatics (NAEPP, 2007). Asthmatics can and should participate in exercise to fully gain the numerous health benefits exercise has to offer.

This study was aimed at determining the effect of aerobic training on pulmonary functions of asthmatic adults in Kaduna State College of Education,Gidan Waya, Nigeria.

1.2 STATEMENT OF THE PROBLEM

It is estimated that 300 million people are affected with bronchial asthma. The Center for Disease Control and Prevention (2013) maintained that the prevalence of asthma is variable and more prevalent in developed countries with higher rates recorded in Australia, United Kingdom and New Zealand. According to the Center for Disease Control and Prevention (2011), more than eighteen million,seven hundred and ninety-three thousand,nine hundred and forty-six (18,793,946) adults living in the United States have been diagnosed with the disease. Over the past few decades, the incidence and severity of the disease continue to rise among adults. Asthma prevalence rate among adults between 18-65 for a decade nearly doubled from 3.6% to 7.5% from 1980 through 1995, currently 12.7% of all adults receive asthma diagnoses sometime in their life (Rowell, 2011). According to World Health Organization (2011) data on asthma, Nigeria ranked 37th in the world between 2000-2009 with an extrapolated statistics of 12,575,356. Asthma deaths in Nigeria reached 10,871 (0.64%) of total deaths with the age adjusted death rate of 15.55 per 100,000 of the population. In Nigeria, the prevalence of asthma also ranges from 7 % to 18 % in the general population (Desalu,Salami & Fawibe, 2010 ; Kolawale *et al* ; 2011) reported that out of 96,000 paediatric outpatient attenders admitted each year, 3% were found to have severe asthma during a period of 4 years in Zaria,Northern Nigeria where Kaduna State College of Education is part of. Asthmatics can and should participate in exercise to fully gain the numerous health benefits exercise has to offer.

With millions of people being affected by asthma, a significant percentage of Nigerian adults are likely to be affected by asthma and could suffer from mortality.These disease conditons increased the resistance to airflow, slow the rate at which air can be forced out of the lungs and increases the contraction of smooth muscle in the bronchioles. It also induces changes in the lung tissue that result in the destruction of the alveolar walls, collapse of the bronchioles and decreased elasticity of the lung tissue. The collapsed brochioles increase the resistance to air-flow. People with asthma could suffer from chronic bronchitis. This is because the air passages are inflamed, swelling increases mucus secretion and gradual loss of cilia result in narrowed bronchioles and an increased resistance to air-flow. (Price, Bosnic-Anticevich, Briggs & Chrystyn, 2013).

The resultant effect of this on the quality of life of Nigerian adults living with asthma is quite alarming. These impaired pulmonary functions are associated with increased mortality and morbidity. This is a national concern due to the impact asthma has on the well-being of Nigerian adult population. One of the greatest obstacles in the fight against asthma is judgemental errors and misconceptions about asthma, which has affected patient's willingness to combine pharmacological and non-pharmacological interventions, especially exercise. (Ishee, 2012).

The current study was thus aimed at determining the effect of aerobic training on some pulmonary functions of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria.

1.3 RESEARCH QUESTIONS

This research was conducted to answer the following questions:

i. Would aerobic training modify forced expiratory volume of asthmatic adults?

ii. Would aerobic training improve forced inspiratory volume of asthmatic adults?

iii. Would aerobic training improve the vital capacity of asthmatic adults ?

iv. Would aerobic training improve the VO_2 max of asthmatic adults?

v. Would aerobic training improve the FEV/FVC ratio of asthmatic adults?

vi. Would aerobic training improve the respiratory rate of asthmatic adults ?

1.4 BASIC ASSUMPTIONS

On the basis of available research evidence, the following basic assumptions were made for the purpose of this study:

i. Aerobic training improves forced expiratory volume of asthmatic adults.

ii. Aerobic training improves forced inspiratory volume of asthmatic adults.

iii. Aerobic training improves vital capacity of asthmatic adults.

iv. Aerobic training improves the (VO_2 max) of asthmatic adults.

v. Aerobic training improves FEV/ FVC ratio of asthmatic adults.

vi. Aerobic training improves respiratory rate of asthmatic adults.

1.6 HYPOTHESES

On the basis of the research questions and basic assumptions, the following major and sub-hypotheses were raised for this study:

Major hypotheses

There are no significant effects of aerobic training on forced expiratory volume, forced inspiratory volume, vital capacity, FEV/FVC ratio,VO_2 max and respiratory rate of asthmatic adults.

Sub-hypotheses

i. There is no significant effect of aerobic training on forced expiratory volume of asthmatic adults in Kaduna State College of Educaation, Gidan Waya.

ii.There is no significant effect of aerobic training on forced inspiratory volume of asthmatic adults in Kaduna State College of Educaation, Gidan Waya.

iii. There is no significant effect of aerobic training on vital capacity of asthmatic adults in Kaduna State College of Educaation, Gidan Waya.

iv. There is no significant effect of aerobic training on VO_2 max of asthmatic adults in Kaduna State College of Educaation, Gidan Waya.

v. There is no significant effect of aerobic training on FEV/FVC ratio of asthmatic adults in Kaduna State College of Educaation, Gidan Waya.

vi. There is no significant effect of aerobic training on the respiratory rate of asthmatic adults in Kaduna State College of Educaation, Gidan Waya.

1.5 SIGNIFICANCE OF THE STUDY

The study is justified on the following bases :

As this study was conducted on asthmatics who underwent training for 12 weeks, the results of the study will show whether the results of aerobic training on pulmonary functions of asthmatic adults will be similar to those observed in asthmatics who only depend on pharmachological treatment. Such an information will be useful in making aerobic training an adjucnt therapy for the correction of pulmonary disorders. Several investigations revealed that asthmatic individuals may exhibit exercise-induced arterial hypoxia during exercise. The outcome of this study would provide a guide for the management of asthma in relation to what type of exercises asthmatics should do and which activities to avoid.

As this study involved the assay of pulmonary functions of asthmatic Nigerian adults who participated in 12 weeks aerobic training, the results of this study may be used to enlighten asthmatic adults on the benefits of combining pharmacological treatment with exercise, how much exercise asthmatics can safely do each day, and how often should they exercise every week. Results of previous studies on how to inprove pulmonary functions of asthmatic adults are inconclusive. The results of this study may contribute to the body of knowledge in the identification of effect of exercise on pulmonary functions of asthmatic adults.

1.7 DELIMITATIONS OF THE STUDY

The study was delimited to the following:

1. Asthmatic adults between the ages of 18 and 35 years who were diagnosed with asthma at the out-patient Clinic of Kaduna State College of Education, Gidan Waya, Kaduna.

2. The effect of aerobic training on pulmonary functions of asthmatic adults included forced expiratory volume, forced inspiratory volume, vital capacity, tidal volume , VO_2 max, FEV/FVC Ratio and respiratory rate.

3. The participants were engaged in a brisk treadmill walk/jogging at a speed of 1km/ hr at a gradient of 0 % for the first 4 weeks. The gradient was increased later to 1 % due to improved aerobic fitness and to correlate with outdoor walking and to compensate for

lack of air resistance. The speed of the treadmill was gradually increased by 0.5 km/ h or 1 km/ h, depending on the fitness level of the subjects.

4. The training given was at moderate intensity of 40 - 50% maximal heart rate (MHR) (1- 4 weeks) which was increased progressively from 51- 60 % (5 - 8 weeks) and 61 - 70 % (9 - 12 weeks). The participants started with warm-up of 10 minutes, 15 minutes were given for the first two weeks and increased to 20 minutes from the third week onwards. The training was followed on 3 alternate days a week (Monday, Wednesday and Friday) for 12 weeks.

1.8 LIMITATIONS OF THE STUDY

The study had the following limitations, which were considered when interpreting the results**:**

i. The investigator was not able to estimate the psychological influence that the testing procedures had on the heart rate of the participants and its response to exercise. However, every attempt was made to familiarise the subjects with the testing procedures for the first two days of training.

ii. Pulmonary functions was assessed using spirometer, perhaps for the first time for some of the subjects and may exert negative effects on the pulmonary function test. The full cooperation of such individuals could be endangered due to fear. However, the researcher sought and got the presence of two (2) Trained Nurses in order to eliminate the psycological fear of the subjects and to help in the recording when administering the spirometry test in adition to familiarization of the test procedures.

iii. There was a potential problem of patients' adherence/compliance to aerobic exercise as part of treatment for asthma. However, the investigator made effort and provided extral inhallers in case any participant forgot his or her own at home. The exercises were carried out in the Department of Physical and Health Education's Fitness Laboratory to reduce exposure of participants to open air dust.

iv. Out of the 30 subjects that started the training, 4 were inconsistent and were not included in the final test of the study. Subjects were given incentives to motivate those that completed the 12 week training.

v. There was no control group, however, the baseline or pre-training measures served as control, while the 4^{th} week, 8^{th} week and 12^{th} week measures were the experimental manipulations.

CHAPTER TWO

2.0 REVIEW OF RELATED LITERATURE

All available and recent studies related to asthma were critically reviewed under the following sub-headings:

2.1 Introduction

2.2.1 Etiology of Asthma

2.2.1 Pathogenes of Asthma

2.2.2 Asthma Severity

2.2.3 Pharmachotherapy of Asthma

2.3 Pulmonary Disorders

2.3.1 Chronic Obstructive Pulmonary Disease

2.3.2 Risk Factors For Chronic Pulmonary Disease

2.3.3 Bronchitis

2.3.4 Exercise Interventions on Bronchoconstriction

2.3.5 Exercise Guidelines in Chronic Obstructive Pulmonary Disease

2.3.6. Pulmonary Functions Tests

2.3.7. Impact of Training on Cardio- Pulmonary Response

2.4.0 Pulmonary Response to Exercise

2.4.1 Impact of Age on Pulmonary Response to Exercise

2.4.2 Exercise for Patients with Interstitial Lung Disease

2.4.3 Summary

2.1 Introduction

Asthma is a common condition that has been recognized for more than 2000 years. It is a term that is derived from a Greek word, which means to pant. It is a chronic inflammatory disorder of the air-ways in which many cell types (mast cells, eosinophils, T-lymphocytes) have a role in the airway limitation that is at least partially reversible with treatment (Venkastewarlu, 2011). As reported by Kolawale, Olayemi, Erhabor & Abiodun (2011), triggers that may provoke air-way obstruction include exercise, common colds, cold air, cigarette smoke and respiratory allergens such as house dust, mite, pet hair and furs. Individual factors such as laughter and stress are sometimes implicated (Price, Bosnic, Brig & Chrystyn, 2013). Asthma also has a strong seasonal cycle due to sudden changes in ambient temperature or increase mould spores. According to Adeyeye & Onadeko (2008), asthma is a disease of high prevalence, morbidity and cost. In many individuals, this chronic inflammation causes an increase in air way hyperresponsiveness, leading to recurent episodes of wheeezing, breathlessness, chest tightness (*angina pectoris*) and coughing (Fawibe, Onyedum, Sogaolu & Ajayi, 2012).

This definition implies that asthma has multiple causes and indeed, it is a complex disorder. According to Bradley & O'Neilli (2005), the chronic inflammatory process causes excess muscous production and brochial smooth muscle constriction, which results from a release inflammatory mediators that include histamine, typtase, prostaglandins and leukotrienes from mast cells (Cezzoletti, Marcon & Jans, 2007). Air-ways may also accumulate thick, viscous secretions produced by global cells and submucosal glands, with a leakage of plasma proteins and accumulated cellular debries (ACSM, 2010). Although airway narrowing affeects the tracheobrochial tree, small bronchi (2-5 mm in diameter) are mostly affected (Bozek & Jarzab, 2010). Maximal expiratory flow rate is reduced and residual lung volumes are increased as air is trapped behind the blocked airways. As a result, during an asthma attack, the respiratory rate increases to compensate for the increased obstruction of the air-ways and the inability of the usually elastic lung recoil (dynamic hyperinflation) (Fawibe *et al*, 2011).

The patient must exert much efforts to breath as the thorax becomes over-inflated (Desalu *et al,* 2012). With progression of the attack, the diaphragm and intercostal muscles must compasate and contribute more energy during respiration (Kolawale *et al,* 2011). In a severe attack, muscle efficiency is evetually lost (Desalu *et al,* 2010). The increase breathing rate leads to respiratory muscle fatique and physical distress that may result in death. Indeed, as many as 4,200 to 5,000 people die from asthma each year in the United States (Faji & Wenzel, 2009).

2.2.1 ETIOLOGY OF ASTHMA

Asthma is a serious global health problem that affects people of all ages. According to Center for Disease Control and Prevention (2011), the disease is broadly distributed by sex, age, ethnicity and geographical location and remains the most chronic disease in adults and children world wide. The causes of asthma are unknown (Ayuk, Liloh & Oguonu, 2010). However, heredity, allergens and environmental factors (namely, aspirin, dust pollutants and emotion) play a role and can be divided into the following categories: Extrinsic asthma-allergen-induced,mediated by an immune system reaction, aspirin asthma-no allergic cause found and mixed asthma-cause by more than one factor. Asthma occurs in 5-12% of the population world wide at any age but is most common in childhood and reduces at puberty. In some instances, the incidence increases as people get older. Asthma runs in families with other allergic conditions, suggesting a general atopic constitution (genetic predisposition) associated with chromosomes 5 and 11 (Everson & Pompell, 2010).Early onset indicates an allergic basis for the disease. Atopic asthma is common cause for treatment resistant asthma in children. This type of the disease occurs in 30-50% of the general population. In the USA, asthma prevalence increased to 60% in children and 45% in adults between 1980-1999 (Saleh, 2008).

An asthma attack is the result of an orderly sequence of events that can be initiated by a wide variety of factors. For instance, in mast cells, one of the cells that is part of tissue in the bronchial tubes it is believed that a variety of factors such as dust, chemicals, antibodies and exercise initiate an asthma attack by increasing calcium ion (Ca^{++}) influx into the cell, causing a release of chemical mediators such as histamine and a special chemical that attracts white blood cells (Manoharan & Swaminathan, 2009). The mediator in turn triggers the following effects: increase smooth muscle contraction(via an elevation of Ca^{++} in the muscle cell) leading to bronchoconstriction, initiation of a bronchoconstriction reflex response via the vagus nerve and causing an inflammation response (swelling of tissue)(Fawibe *et al*, 2011).

2.2.2 PATHOGENESIS OF ASTHMA

Views on the pathogenic mechanisms of asthma have changed with the recognition that chronic inflammation underlines the syndrome. A genetic background sets the stage for a cytokine imbalance that promotes the formation of IgE(immunoglobin E). Previously, it was thought that abnormal contractility of the air-way smooth muscle gave rise to variable airflow obstruction- responsible for the common symptoms of wheezing and shortness of breath. For many years, researchers also assumed that mast cell mediators played the critical role in the patho-physiology (Desalu *et al*, 2009).

Recent research, however, established that asthma, even in its mildest form involves the activation of many different inflammatory cells in the asthmatic airways (Bahadori *et al*, 2009). Inflammatory cells produce a variety of mediators, in particular mast cells, eosinophils and T-lymphocytes which act on target cells of the airways to produce the typical features of asthma (Onyedum,Desalu, Nwosu & Ezeudo, 2012). The inflammatory process leads to airway hyperactivity, plasma execudation, mucus secretion and the activation of neural mechanisms (Adeyeye & Onadeko, 2008). Airway obstruction occurs due to spasm of the bronchial muscle, oedema of the airway, increased mucus production, cellular infiltration and subsequently injury to the epithelium (Berenson, 2005). Classic symptomatic features are wheezing, increased shortness of breath, coughing and chest tightness. Tighness can sometimes be the only effect some people complain of especially in young healthy adults. It was reported by Ayuk *et al*, (2010) that chronic inflammation leads to structural changes such as an increase in airway smooth muscle and irreversible fibrosis (Venkartewarlu, 2011). There is also increased evidence that ranscription factors such as nuclear factor kappa B play a pivotal role in the expression of inflammatory genes in asthma (Vermeeren, Creutzberg &Schol, 2006).

Epidemiological studies linked IgE antibodies to the severity of asthma when inhaled allergens encounter the dendritic cells that line the airway, this stimulates dendritic cells to migrate to draining lymph nodes and present the processed antigen to the T- and B-Lymphocytes (Onyedum *et al*, 2012). Interactions between these cells elicit responses that are influenced by cytokines and co-stimulating molecules (Brusasco, Crapo & Viegi, 2005). Mast cells are stimulated to release hitamine and leukotrienes, responsible for airway smooth muscle constriction. After four to six hours, however, a prolonged phase of airflow obstruction may follow, because of cytokines and chemokins generated by resident inflammatory cells (Denker,Thorsson & Linden, 2006). This is known as the late asthmatic phase that illustrates the danger in the situations where an asthma sufferer is not observant and gets caught off guard, especially during the night or early morning. Decline in lung function occurs in all people, but even more so with age in adults with asthma. Previous researches on asthmatic non-smokers in Australia showed a decline of 50ml/year in FEVi compared to 35 ml/year in controls. This was confirmed by the Copenhagen Heart Study with values 38 ml/year and 22 ml/year respectively (Kolawale *et al*, 2011).When acute inflammation in the lung normally occurs in response to tissue injury and repair restores normal function, the same is not true for chronic inflammation. In asthma, the process of chronic inflammation may lead to altered structure called remodelling of the airways. Remodelling entails thickening of the airways walls withincreases in submucosal tissue, the adventitia and smooth muscle. More recent research indicates that the process of remodelling may be independent of inflammation and part of the natural history of asthma (Bahadori *et al*, 2009).

2.2.3 DISEASE SEVERITY IN ASTHMA

The degree of severity of asthma is determined by the amount of airflow limitation and the speed with which the situation is reversed. Severity is determined by the history of frequency and intensity of the symptom profile, bronchodilator needs, limitations to activities and lung function measurements (Grazzini, Standard & Gigliotti, 2005).

AmericanThoracicAssociation (2005) reported that Global Strategy Management and Prevention of asthma report degrees of severity range between intermittent asthma symptoms disappear for certain periods of time to persistent asthma, where symptoms may not go away for longer than a week. Persistent asthma is graded as mild persistent, moderate persistent and severe persistent asthma (Greener, 2010). Asthma is a variable disease, patients rarely remain in the same category over time (Dencker, Thomson & Karlsson, 2006). In addition, patients are often categorized incorrectly because they underestimate their symptoms and lung function. Asthma results from the presence of airway inflammation and abnormal air-way smooth muscle behaviour. Therefore, severity should be determined by factors that influence both aspects. The degree of inflammation present in the airways may be responsible for the increased symptoms and airways hyperresponsiveness (Frew & Holgate, 2009).

A study by NAEPP (2013) showed a heteregeneous inflammatory processin intermittent asthma, the profile and magnitude that present both similarities and differences compared with asthma.Increased eosinophils are present in persistent asthma as well as epithelial damage (Desalu *et al*, 2009). Increasing severity is also likely to be associated with skin prick test sensitivity to house dust mite and alternaria and in the absence of parasites, the total immunologlobulin E(IgE) level is likely to be a measure of severity (Medical Sports Network, 2010). Onset of asthma at an age younger than five years accompanied by a strong family history will also increase likelihood of severe disease (Boyden, Reubenfire & Franklin, 2010).

Assessment of severity will always be difficult until a golden standard definition of asthma is formulated. Determining severity, is however, necessary because all the guidelines for treatment are based on the severity grading of the patient. Health proffessionals should be aware however tha the lung function measurements do not always correspond with severity or frequency of asthma symptoms. Previous studies of the basement membrane of the airways showed that remodelling occurs in the mildest form of asthma and structural changes can be represented very early or on diagnosis (Center for Disease Control, 2011).

The severity of disease in adolescents is sometimes influenced by factors such as non-adherence to treatment regimens (Miller, Weiler & Baker, 2005). It is a healthy priority to educate people to understand why their disease can present in different degrees of severity and how to determine in which category they reside. This may be an opportunity to empower patients so that adhernce to therapeutic strategies is achieved and to relay to them the importance of environmental control measures (National Asthma Education and Prevention Program, 2013).

TABLE 2.1: DISEASE SEVERITY IN ASTHMA

CLASSIFICATION BY SEVERITY

STAGE	**CHARACTERISTICS**
O: At risk	Normal Spirometry
	Chronic symptoms(cough, sputum)
1: Mild	FEVi/FVC<70%;FEVi>80% predicted
	With/without chronic sypmtoms(cough,sputum)
II: Moderate	FEVi/FVC<70%;50%<FEVi<80% predicted
	With/without chronic symptoms(cough,sputum,dyspnea)
III: Severe	FEVi/FVC<70%;30%<FVEi**<**50% predicted
	With /without chronic symptoms(cough,sputum,dyspnea)
IV: Very Severe	FEVi/FVC**<**70%;FEVi**<**30%predicted
	<50% predicted plus chronic respiratory failure

Figure I: Stages of Chronic Obstruction Pulmonary Disease (COPD) : Classification by Severity, www.goldcopd.org

2.2.**4 PHARMACOTHERAPY IN ASTHMA**

According to O'Byrne (2010), recent research in asthma has explored the possibility of total control based on clearance of clinical features and resolution of pathological changes in the airway. The inplementation of glucocorticosteroids as asthma therapy changed the world of asthma sufferers (Petty, 2004). Guidelines now recommend inhaled corticosteroids as the mainstay of therapy. Iniation should be started as early as possible to inhibit the inflammatory process and to prevent possible remodelling caused by chronic inflammatory processes and to prevent possible remodelling caused chronic inflammation. Inhaled steroids are used as preventive therapy, but oral boasts of steroids are used during acute attacks. B, adrenergic receptor agonists are used as bronchodilators and is the reliever therapy reccommended in the case of emergency (National Asthma

Education & Prevention Program, 2013). Brochodilators activate the receptor which increases cyclic adenosine monophosphate AMP) which in turn decreases intracellular calcium and leads to relaxation of airway smooth muscle (Saey,Pepin,Brodeur & Lizotte, 2006).

Theophyllines are not used as often as in the past due to a narrow therapeutic range and unfavourable adverse effects(Pitta, Troosters, Prosbt & Spruit, 2006).Theophyllin inhibit phosphodiesterase and relax smooth muscle and acts as a respiratory stimulant. It can be valuable in patients who suffer from nocturnal coughing and increased phlegm production, and is more frequently used as addition on therapy in chronic ocbstructive pulmonary disease (Douglas, 2007). The latest research started using this compound as inhaler therapy which may present to patients yet another treatment option if it is proven effective (Desalu *et al,* 2009). Chromones act as mast cells stabilizers and inhibit the release of mast cells mediators. This is usually used as addition to therapy in cases where atopy is a problem. Leukotriene modifiers have been used as addition to therapy in uncontrolled asthma sufferes since 1995 (Clatworthy, Prince & Ryan, 2009). Leukotriene modifiers are thought to reduce the influence of inflammatory cascade caused by leukotriens, preventing bronchial hyper-activity and airway remodelling. It is very expensive treatment and therefore not available in the public health sector. Combination therapy(also known as controller therapy) was started to achieve better asthma control with the combination of a long- acting bronchodilator and an inhaled corticosteroids(Saleh *et al,* 2008).

Using only one medication device once or twice daily may improve patient compliance and adherence to the dosing regimen. More recent research showed an association between asthma and the gene ADAM33 (George, Thomas & Kenneth, 2005; Walsh, 2006; Scott & Edward, 2012). Future development will naturally target these proteins as treatment options. The treatment profile differs between patients because people present different degrees of severity. All asthma sufferers should have at least a short-acting bronchodilator such as ventolin for use during emergencies. Depending on the availability of resources,individuals suffering from asthma are treated with an inhaled-corticosteroid(Beclomethasone, Budesonide)for the purposes of maintenance therapy (NAEPP, 2013). As severity decreases, the other substances will be added on under the guidance of a respiratory specialist (allergist); fot the example, theophylline, xolair). Oral glucocorticosteroids are used during exacerbations in the form of burst dosages that are quickly titrated (for example, 40,30,20,...) or a course for 5 to 21 days depending on the severity of the asthma exacebation (Miller *et al*, 2005).

2.3 PULMONARY DISORDERS

2. 3. 1 Obstructive and Restrictive abnormalities

The pathological changes that are characteristic for COPD are found in four different compartments of the lungs, the central airways, the peripheral airways, lung paranchyma and pulmonary vasculature (Peters,Webbb & O'Donnell, 2006) . In advanced COPD, peripheral obstruction, parenchymal destruction and pulmonary vascular abnormalities reduce the lung's capacity for gas exchange, leading to hypoxaemia(Pco2). A mismatch of the ventilation and perfusion of the lung is the major mechanism behind hypoxaemia in COPD (Onyedum & Chukwuka, 2009; Ige, Falade & Arinola, 2012).

Obstructive abnormality is airway disorders such as asthma, chronic obstructive pulmonary disease (COPD) and bronchiectasis cause obstructive type of lung function abnormality. This is diagnosed by reduced FEVI/ FVC % less than 75 percent and FEVI % predicted less than 80 percent. When clinical evaluation suggests airway obstruction low FEVI % predicted suggests an obstructive abnormality (Miller, Hankinson & Burgos,

2005) Restrictive abnormaility includes chest wall, pleural and lung paranchymal diseases cause restrictive lung functional abnormality indicated by a normal FEVI/FVC ratio and reduced FVC % less than 75 percent. FVC is dependent on the patient's performance; therefore reduced FVC does not diagnose but only suggests a restrictive abnormailty. Reduction in FVC may occur due to air trapping in moderate to severe airway obstruction (Greener, 2010).

2.3.2 Chronic obstructive pulmonary disease (COPD)

Chronic obstructive pulmonary disease such as emphysema, chronic bronchitis and asthma, is defined by the American Thoracic Society as a condition characterized by airflow obstruction that reduces the ability to sufficiently empty the lungs. The incidence of COPD is presently increasing in the U.S, with an estimated 16.5 million people now suffering from shortness of breath and the effect of a reduction in airflow that can have a dramatic effect on daily activities which is disabling (Center for Disease Control & Prevention, 2011). According to Scot, Power and Edward (2012), the airflow resistance is due to less diameter and air is forced to open hence the difficulty in breathing. Chronic brochitis is characterized by a persistent production of sputum due primarily to a thickened bronchial wall with excess secretion in emphysema, the elastic recoil of alveoli and bronchioles is reduced and those pulmonary structures are enlarged (Joyner,Fiorino & Needleman,2006).The patients have a chronic inflammation in the airways that causes remodelling and narrowing of the small airways. The inflammatory processes also contribute to the distruction of the lung parenchyma, which leads to changes that weaken the ability of the airways to remain open under expiration (LaBella,Scanders & Sulliva, 2009).

The pathological changes that are characteristic for COPD are found in four different compartments of the lungs, the central airways, the peripheral airways, lung paranchyma and pulmonary vasculature (Peters,Webbb & O'Donnell, 2006). In advanced COPD, peripheral obstruction, parenchymal destruction and pulmonary vascular abnormalities reduce the lung's capacity for gas exchange, leading to hypoxaemia (Pco2). A mismatch of the ventilation and perfusion of the lung is the major mechanism behind hypoxaemia in COPD (Onyedum & Chukwuka, 2009). COPD is a growing health concern, is the fourth leading cause of death in the United States. While people habituated to smoking constitute the highest COPD susceptible population, people exposed to air pollution or other lung irritants also form a major group of potential COPD patients. COPD is a progressive disease that is characterized by the combination of chronic bronchitis, small airway obstruction, and emphysema that causes an overall decrease in the lung elasticity affecting the lung tissue (Global initiative for chronic obstructive lung disease, 2010)

The current gold standard method to diagnose COPD is by pulmonary function tests (PFT) which measures the extent of COPD based on the lung volumes. The insensitivity of PFT to the early stages of the disease, its evaluation based on global lung function and also its lack of reproductibility makes it hard to rely on in assessing the disease progression. These tests are also labor intensive and time consuming. Alternatively, pulmonary CT scans are considered as a major diagnostic tool in analyzing COPD and CT measures are also closely related to the pathological extent of the disease (Boyden , Rubenfire & Franklin, 2010). CT imaging of the lungs provides important information about airflow patterns in the COPD subjects. Densitometry analysis of CT images has been successfully used to distinguish COPD subjects from normal. Recently, textural patterns on the CT images showed significant difference in the disease progression and are proved useful in detecting COPD subjects (Douglas, 2010). Quantification of COPD based on the features derived from CT images has been recognized effective and these features are correlated well with PFT measurements (Greener, 2010). There are several other features of CT that are closely related to the lung function (Boyden, Reubenfire & Frankline, 2010). By the use of machine learning, the capability of various features in diagnosing and staging COPD can be evaluated and the best 2 combination of features can be extracted. These features may result in better diagnosis of COPD and the evaluation of its progression at different stages. Exercising may seem like a challenge when you have trouble breathing from COPD, yet, regular physical activity can actually strengthen respiratory muscles, improve circulation, facilitate more efficient oxygen use and decrease one's COPD symptoms (Partridge, 2007).

The curent trend, according to CDC (2012), is to use combination therapy in an effort to simplify a treatment schedule and to overcome the problem of non-adherence to treatment. Additional symptoms are fatigue, weight loss which can be the signs of other diseases associated with the COPD. Depression and anxiety are also common at the severe stages of COPD. COPD assessment is done by performing spirometry or pulmonary function test (PFT), which is a current gold standard diagnosis of COPD. PFT measures the lung volumes at different stages of breathing by asking the subject to breathe into a mouthpiece connected to a spirometer. COPD is diagnosed based on two lung volumes; the maximum volume of air that can be forcibly blown out after full inspiration, called as forced vital capacity (FVC), and the maximum volume of air that one can blow out in the first second of the FVC process called as forced expiratory volume at the first second of the expiration (FEV1). If FEV1/FVC is less than 0.7, then the subject is considered as a potential COPD subject suffering from airflow obstruction. Normalisation of FEV1 according to expected value based on age, height, sex is called FEV1% predicted of that specific patient. This measure is used to estimate the severity of the disease (CDCP, 2011).

According to the Global Initiative for the Chronic Obstructive Lung Disease(GOLD) guidelines (2011), COPD is classified into five severity stages as explained in Table 2:2 GOLD 0 is an asymptotic stage of the disease where subjects are likely to get COPD. GOLD1 is a mild stage where airflow limitation is mild and usually the patient is unaware that the lung function is not normal. GOLD2 is a moderate stage of COPD at which patients usually feel shortness of breath and typically seek medical attention. GOLD3 is a severe stage of the disease where the patient experiences greater shortness of breath, fatigue and reduced exercise capacity. GOLD4 is a very severe stage of COPD, characterized by severe air flow limitation and the chronic respiratory failure. Patient's quality of life severely worsens at this stage.

Table 2:2 Clasification of COPD based on Severity Stages According to GOLD Guidelines (2011).

COPD CLASS PTF	Measurement
GOLD 0 **(Asymptotic)**	FEV1/FVC > 0.7
GOLD 1 (Mild)	FEV1/FVC < 0.7 ; FEV1% pred > 80%
GOLD 2 (Moderate)	FEV1/FVC < 0.7 ; 50% < FEV1% pred < 80%
GOLD 3 (Severe)	FEV1/FVC < 0.7 ; 30% < FEV1% pred < 50%
GOLD 4 (Very Severe)	FEV1/FVC < 0.7 ; FEV1% pred < 30%

2.3.3 Risk factors for chronic pulmonary disease

Maximum lung function is normally attained at approximately 20 years of age in men, but somewhat later in women. There is a plateau phase with stable lung function until about 35 years of age. The lung function starts to decline from somewhere around 40 years of age, women usually show a decline earlier than men (Cooper, 2009). This is a rough description of normal development and may vary in different populations. Among those factors that affect normal lung function especially chronic obstructive pulmonary disease, are:

i. Smoking is one of the most well-known risk factors for accelerated decline in lung function Cooper (2009) summarized the results from several longitudinal studies regarding the effects of smoking on decline in FEVi in the range of 7 to 33 ml/year. According to the studies, there is a dose-dependent- smoking effect on lung function, reported from the Dutch Vlagtwedde, Vlaardingen studies (Gordon, 2009).

The decline in healthy non-smokers was also reported to be 15-30 ml/year from approximately 35 years of age. Low FEVi itself was related to rate of decline over time according to Fletchera phenomenon called the ‘horse –racing effect. Enviromental tobacco smoke (ETS), or passive smoking, is also reported to affect rate of decline in lung function (Greener, 2010) . After smoking cessation, decline seems to return to a non-smoking level. This was repored by Riza (2005) and has been reported by other studies. Some data also support that women may benefit more than men from smoking cessation. Earlier chronic productive cough was considered to be quite a harmless condition, not considered to affect lung function. However, Annesi (ACSM, 2010), question the innocence of chronic productive cough in their report. According to the report, chronic mucus production was significantly related to an increased over all mortality. Later studies have been published, suggesting an association with an increased decline in lung function among subjects with respiratory symptoms as chronic mucus hypersecretion (American college of Sports medicine & Diabetes Association, 2010).

ii. **When evaluating age** as a risk factor for chronic obstructive pulmonary disease (COPD), an important issue is also the spirometry criteria of COPD. A fixed ratio for the definition of airway obstruction (FEVi / FVC or VC < 0.70) will overestimate COPD in elderly (Roucell, 2010) and underestimate COPD among young adults. As individuals advance in age, however, structural changes occur that impede the ventilatory response. A loss of elastic recoil is noted, which results in reduced lung compliance. In addition, the chest wall becomes stiffer, which further affects compliance. Mechanical efficiency is also impaired through a change in chest wall configuration as a result of reduced intervertebral space and resultant increased anterior-posterior diameter (American Diabetes Association, 2007).

iii. Occupational air-borne expossure has in recent years gained increased interest as a risk factor for COPD. The impact of occupational air-borne exposure on decline in lung function and development of COPD is important both for affected subjects and the society; as it is potentially, preventable, as is the effect of smoking .In a Swedish report published in March 2004, the fraction of COPD atributed to airborne exposure aomng construction workers was close to 11 % over all and > 50% among non-smokers (Ries, 2005).

iv. Socio-economic factors are closely related to obstructive lung disease and COPD (Pitta, Troosters & Prost, 2005). Socio-economic group has in different studies been variously indexed. For example, by income, level of education, social class and occupation. Independent of particular index, the results point in the direction: Low socio-economic group is associated with COPD; because the low to middle income class is likely to live near industrial areas. Additionally, asthma has been strongly associated with the presence of cockroaches in living quarters, which is more likely in such neighborhoods. In a review in thorax 1999, the socio-economic impact on COPD was the next most important, after that of smoking. There are also reports that low lung function itself is related to socio-economic status (Heikki, 2007) .

v. A genetic basis for COPD is established only in ἁi-antitrypsin deficiency, but the deficiency is uncommon and can only explain a minority of cases of COPD (Jackson, A.S, Sul., Hebert & Church, 2009). There are studies reporting a familiar aggregation of COPD suggesting that genetic factors are well involved which contribute to development of COPD by an increased susceptibility to tobacco smoke and other polutants (Schechter, 2009).

vii. **Gender factor**: The reported prevalence of COPD has been higher among men than women. This can be explained by differences in smoking habits, while men historically have been smokers to a considerable higher extent than women. However, smoking habit is increasing with time (Gordon, 2009).

viii. Inactivity as a factor: The shortness of breath experienced by COPD patients at rest and/ or during activities of daily living can lead to an increasingly sedentary lifestyle, a progressive deterioration in functional capacity, and possible isolation at home. With progressive inactivity, cardiovascular function and skeletal muscle mass decline. The deterioration in aerobic fitness and strength creates a vicious cycle that leads to a greater breathlessness with exertion, muscular fatigue, an eventual loss of functional independence, and depression (Greener, 2010). A major goal of pulmonary rehabilitation exercise programs is, therefore, to reverse the physical disability resulting from inactivity (Grazzini *et al*, 2005) .

2.3.3 BRONCHITIS

Cough and chest pain are common symptoms in asthmatic individuals. Other diagnoses must be entertained as well, however. In the young healthy individual, noncardiac etiologies dominate, but as the subject ages, cardiac chest pain becomes more prominent (Sidiropoulouet al,2007).Common noncardiac etiologies include: pleuritis, pleurodynia, bronchitis,pneumonia, costochrondritis, intercostal muscle strains, and chest wall trauma.

Less common etiologies one should consider include pneumothorax, pleural effusion, pulmonary embolism, esophageal reflux or spasm, cervical disk disease, arthritis, breast disorders, herpes zoster, panic attacks, and performance anxiety. Cardiac etiologies include angina, ventricular and supraventricular arrhythmias, pericarditis, Wolff-Parkinson-White syndrome, hypertrophic cardiomyopathy, mitral valve prolapse, aortic stenosis, aortic dissection, and cocaine usage. Common causes of cough include bronchitis, postnasal drip, sinusitis, pneumonia, postviral bronchospasm, tonsillitis, laryngitis, and EIA. Less common causes include infectious etiologies (tuberculosis, fungal, Pneumocystis carinii pneumonia), drug-induced (ACE-inhibitors, beta blockers), gastroesophageal reflux (GERD), aspiration, foreign body aspiration, tumors (bronchogenic, mediastinal, laryngeal), interstitial lung diseases, congenital anomalies, local irritants, and post-traumatic effects (Spyros, Papiris & Manali, 2009).

2.3.4 Exercise Interventions on Bronchoconstriction

Both pharmacological and non-pharmacological intervntions are used in the treatment and prevention of Asthma.Medications can be prescribed as a daily preventative long-acting treatment or a prophylactic short-term precautionary measure.

i. Pharmachological interventions

The four common classes of medications used to prevent EIA are: inhaled corticosteroids, cromones, short and long-acting (Beta- receptor agonist -β_2) β_2-adrenergic agonists and antileukotrienes. Salbutamol, also known as albuterol, is a short-acting β_2-adrenergic agonist that begins to take effect within about fifteen or twenty minutes and last about four to six hours (Dencker, Thorsson,Karisson Linden, & Svenson, 2006).

When cromolyn sodium is used, it inhibits the chemical mediator released from the mast cell, probably by interfering with Ca++ influx into the cell (Steinbrook,2006).When Beta receptor agonists(β_2-agonist) decrease chemical mediator release and causes the relaxation of bronchiolar smooth muscle by decreasing the Ca++ concentration in mast cells(Manoharan & Swaminathan,2009). The majority of athletes use a type of short-acting β_2-adrenergic agonist,such as albuterol, about fifteen minutes prior to physical activity to prevent EIA symptoms. A study conducted by Mickeborough, Lindley and Turner found that the use of an albuterol inhaler prior to exercise caused post-exercise FEV to increase by 27% (Mickleborough, Lindley & Turner, 2007).

Use of theophylline, a Caffein-like drug aids relaxes smooth muscle in the bronchi by inhibiting phosphodiesterase, the enzyme that activates cyclic AMP;the result is higher cyclic AMP and lower Ca++ concetrations in the cell. Therefore, moderate amounts of caffein should be consumed before physical activity to help vessels in the lungs.Approximately three cups of strong coffee contain the amount of coffeine needed to cause a significant reduction in FEVi decrease.A dose of caffeine, either 3.5 or 7.5mg, was administerd to asthmatic participants. Those who received the larger dose showed a decrease in FEVi by only 10% post exercise compared with the smaller dose who displayed a 25% decrease. The caffeine did not eliminate the post-exercise FVEi decrease, a significant indicator of EIA, but the drop was reduced significantly (Medical Science Sport Exercise, 2004).

ii. Non-pharmacological interventions

One non-pharmacological intervention that EIA patients can implement is:

Management of their diet. Since excessive sodium and chloride can exacerbate EIA symptoms, dietary salt intake should be restricted in EIA patients.A study conducted by

Mickleborough et al, (2007) found that the asthmatic participants in the study who were placed on low sodium diet, 958 milligrams per day, for two weeks had an improvement in FEV and forced expiratory flow.In the same study, asthmatic participants placed on the high sodium diet, 8133milligrams per day saw a decrease in pulmonary function; therefore, salt exacerbates asthma symptoms.

Breathing technique is a key element that the muscles are oxygenated efficiently. Miller et al (2005) stated that the National Athletic Trainers Association(NATA) position statement recommends nose breathing for asthmatic athletes because this technique warms air therefore decreasing the inflammation response. Although nose breathing is not practical during high intensity exercise, EIA asthmatics should be encouraged to practice nose breathing whenever possible.

Warm-up is yet another technique that is an essential part that prepares the body for physical activity. Extensive, submaximal, continuous warm-ups and high-intensity, interval style warm-ups have both been shown to induce a refractory period in athletes (Manoharan & Swaminathan, 2009).

In a study conducted by Mickleborough, Lindley and Turner, eight moderately trained asthmatic athletes performed an exercise challenge test preceded by a warm-up consisting of 8x30 second sprints with a 45 second recovery between each run. The study concluded that with the application of warm-up, FEVi decreased-9.1±o.6% after the exercise challenge test, which is below the 10% decrease needed for EIA diagnosis.The controlled group in this study showed a decrease in FEVi of approximately-16% after the exercise challenge test(Mickleborough,Lindley & Turner, 2007).

Avoidance of winter sports and choosing to exercise indoors under climate-controlled conditions minimizes the occurrence of EIA a relative refractory period prior to the exercise event and controlling the climatic conditions. The former is generally performed 45 to 60 minutes before the exercise event. Sufficient pre-event exercise loading is required to provoke EIA. The degree of refractoriness appears to be correlated with the extent of bronchospasm induced by the pre-event exercise (Joyner,Fiorino,Matta-Arroyo & Needleman, 2006). As noted above, cool air and dry air impact the extent of bronchospasm associated with EIA. Nasal breathing or use of a surgical mask or scarf reduces water loss and warms inspired air (Center for Disease Contlol, 2012).

Primary pharmacologic options include use of inhaled beta 2 adrenergic agonists or inhaled cromolyn sodium or nedocromil sodium 15 minutes before exercise (LaBella, Sanders & Sullivan, 2009). Inhaledβ_2- adrenergic agents are effective in ameliorating or attenuating EIA in 90% of patients. Furthermore, they are the agents of choice as rescue medicines should EIA develop. Cromolyn sodium is not as effective in preventing EIA when compared with beta2-adrenergic agents, yet it is a viable option (Manoharan & Swaminathan,2009). Up to 40% of patients will not develop EIA after inhaling 1600 mg (mg = mcg) of cromolyn sodium and 73% will experience some degree of protection. Optimal dosing of cromolyn is 1600 mg (2 pults) four times daily, with an additional dose 15 minutes before exercise. For patients with chronic asthma and EIA, care should be primarily directed toward the chronic asthma (Steinbrook, 2006). Routine usage of inhaled corticosteroids improves pre-exercise FEV1 and reduces the propensity to develop EIA (Miller, Weiler, Baker, Collins & D'Alonzo, 2005). Additional agents include leukotriene modifiers and long-acting beta2-adrenergic agents. Montelukast (10 mg po qhs), a leukotriene receptor antagonist, has been shown to be superior to salmeterol (42 mcg inhaled BID), a long-acting beta2-adrenertic agonist, in preventing EIA in patients with chronic asthma over an eight-week trial (Miller, Weiler, Baker, Collins & D'Alonzo, 2005).

Training goals in the asthmatic with EIA are no different than for normal subjects as outlined above. Clark and Cochrane have outlined a method to help asthmatics define the exercise level needed to achieve 75% HRmax but maintain their VE/MVV (also termed dyspnea index) below 60%. WhenVE/MVVexceeds 60% it is unlikely that exercise will be maintained for greater than 15 minutes (Cho,Park,Lee, 2003).Asthmatics undergo incremental exercise testing to the point of exhaustion and a plot of %HRmax against dyspnea index (VE/MVV) is generated. Exercise intensity for training is chosen at a level where the patient achieves 70% HR max with a VE/MVVratio less than 60% (NATA, 2010). Repeat testing is recommended because training effects and the status of the underlying asthma will impact the plot.

Asthmatics should choose their exercise and training activities carefully, realizing that cold, dry air exacerbates asthma and is a major factor in inducing EIA (Steinbrook, 2006). Activities that do not generate high minute ventilations (tennis, handball, racquet ball, karate, wrestling, boxing, golf, sprinting, isometrics, downhill skiing, football, baseball) are preferred, as are water activities (swimming, diving, water polo). High minute-ventilation activities (long-distance running, cycling, basketball, soccer, rugby) or those taking place in a cool and dry climate (ice hocking, ice skating, and cross-country snow skiing) are more likely to induce EIA (NATA, 2010).

2.3.5 Exercise Guidelines in COPD

Persons with COPD may have co-existing cardiovascular abnormalities such as high blood pressure or coronary artery disease. A medically monitored exercise evaluation is highly recommended to assess the patient’s cardiac risk as well as physiological and subjective responses. Patients then can be stratified according to their need for medical support and surveillance during exercise. A symptom limited exercise tolerance test is very helpful for determining the appropriate range of exertion and the optimal training heart rate. Medical supervision is recommended at least twice a week (especially at the begining of the program) in order to develop the patient's understanding and self-confidence in how hard to exercise, as well as to individualize the training intensity, duration and frequency (Standardi, Grazzini & Lotti, 2005).

i. **Monitoring rate of breathing**: Since breathlessness is often the primary determinant of exertional tolerance, rating of shortness of breath can be used to monitor the patient's exercise intensity. Ideally, the exercise intensity will not be limited by shortness of breath before the patient experiences moderate exertion. Intermintent exercise (i.e short intervals of exercise alternating with regular rest periods) usually permits higher intensities. After the initial weeks of training, patients may be able to sustain a high percentage of their peak work capacity for 30 to 40 minutes per training session. The benefits of exercise typically increase as the training load is gradually progressed. Moderate exercise on a daily basis has been shown to decrease the sensation of breathlessness and produce the greatest improvements in functional capacity and health status. For most patients, 15 minutes of moderate physical activity, 3 days per week is probably the minimum amount for ensuring the exercise benefits (Wanger, Clausen & Peedersen, 2005).

Aerobic training should involve the major muscle groups of the lower extremities, as these are used in everyday tasks such as walking and climbing stairs, for a total of 20 to 30 minutes. Improved walking endurance, activity tolerance and quality of life have been reported by Venkastewarlu (2011) after programs using either stationary cycling, ground-based and treadmill walking, or a combination of all three. Since numerous daily activities require the use of the upper extremities, endurance and strength training of the upper body can also provide practical benefits. It is advisable to combine resistance training with an aerobic training program to help increase endurance. Exercises for strengthening should include all major muscle groups. The resistance should be prescribed for each person and allow for completion of at least one set of 8 to 12 repetitions of the exercise. As muscular strength and endurance improve, more sets can be added to each exercise (Douglas, 2010)

ii. Patient Education:

In addition to exercise training, education on the diaphragmatic and pursed-lip breathing strategies can help patients cope with periods of breathlessness and reduce their exercise anxiety. Patient education should also include counselling on the use and timing of prescribed medications, such as supplemental oxygen, bronchodilators, mucolytics, and/ orcorticosteroids, before and during exercise. As with any population, COPD patients should stop exercising if they experience pressure or pain in the chest, neck or jaw that might signal inadequate blood flow to heart tissue. The onset of nausea, light-headedness, dizziness and headache during exercise are other indications to terminate the activity and seek medical advice. Since breathlessness is usually a trasient symptom during exercise, patients should slow down rather than stop suddenly. However, if the labored breathing persists, then stop and rest (Bozek *e tal*, 2010)

2.4.0 **PULMONARY FUNCTION TESTS**

2.4.1 **Aerobic Fitness of Asthmatics**

Aerobic fitness is commonly studied for risk factors of several diseases especially those related to respiratory health. This study suggests that risks factors developed during childhood and adolesents persists into adulthood. It is for this reason that the aerobic fitness of asthmatics was assessed in this study. The importance of this assessement may be in its relation to health and disease and its reflection of changes in pulmonary function characteristics that may occur during specific periods in life. Infact, it has been suggested that pulmonary dysfunction may take place during ages of development. It is this period that one may either become aerobic or anaerobic in future (Boyden, Reubenfire & Franklin, 2010)

For pulmonary disorders especially COPD, decreased ventilation capacity and increasing ventilatory requirements contribute to mechanical difficulty for respiration. In such patients, maximal exercise ventilation is a high percentage (> 85 %) of the predicted VO_2 max Expiratory flow limitation may also be evident. In some patients with predominantly emphysema, oxygen desaturations may develop. According to American College of Sports Medecine and American Diabetes Association(2010) , maximal oxgygen uptake (VO_2 max) of an individual increases with the introduction of exercise due to the effects of increase in body temperature and to the rising blood levels component of epinephrine and norephinephrine. This is an indication of oxgygen transport capacity of the heart, lugs and circulation. It is also used as a measure of exercise capacity. VO_2 max peak per unit body mass does not change. However,with age, VO_2 max tends to decline in both male and female asthmatics (Christopher, 2007).

Chronic bronchitis is characterized by a persistent production of sputum due to primarilly to a thichkened bronchial wall with excess secretions. In emphysema, the elastic recoil of alveoli and bronchioles is reduced and those pulmonary structures are enlarged (ACSM, 2010). The patient with developing COPD can not perform normal activities without experiencing dyspnea; but typically, by the time this occurs, the disease is already advanced . COPD is characterized by decreased ability to exhale and because of the narrowed airways, a ‘wheezing’’ sound is made. The person with COPD experiences a decreased capacity for work, which may influence employment. But he/she passes through psychological problems, including anxiety(regarding the simple act of breathing) and depression (related to a loss of sense of self-worth)(Kolawale, Olayemi & Erhabor, 2011)

It should be no surprise then that treatment of COPD includes more than simple medication and oxygen-inhalation therapy. A typical COPD rehabilitation program focuses on the goal of the patient's ability for self-care. To achieve that goal that a number of medical and surport personnel are recruited to deal with the various manifestations of the disease process. The COPD patient receives education about the different ways to deal with the disease, including a graded exercise tests to evaluate VO_2 max maximum exercise ventilation and changes in the arterial blood gases, PO_2 and PCO_2. ( ) Exercise may seem like a challenge when you have trouble breathing from COPD. Yet, regular physical activity can actually strenthen one's respiratory muscles, improve circulation, facillitate efficient oxygen use, and decrease COPD symptoms. Physical activity can also help protect against COPD development and progression and slow lung function decline. A wide range of exercises (e.g walking, cycling, swimming, games, resistance training and breathing exercise) can be used to improve the patient's functional capacity which is limited in part, by skeletal muscle abnormalities (Boyden, Rubenfire and Franklin, 2010) .

Generally, COPD patients achieve an increase in exercise tolerance without dyspnea and an increase in the sense of well-being, but without a reversal of the disease process. The changes in the psychological variables are very important in the long run given that the person's willingness to continue the exercise program is a major factor determining the rate of decline during the course of the disease (Cooper, 2009). Exercise in patients with chronic obstructive pulmonary disease (COPD) in comparison with normal subjects, patients with COPD have increased dead space ventilation at rest and during exercise. To maintain homeostasis, increases in minute ventilation with exercise need to accommodate not only increasing VCO_2 but also increasing dead space ventilation. In an effort to conserve energy, however, patients with COPD accept somewhat elevated $PaCO_2$ levels and minimize the increases in minute ventilation associated with exercise. These patients also demonstrate a reduced MVV and quickly achieve VE/MVV levels exceeding 0.75, which is distinctly unusual for normal subjects (Terranova & Henning, 2011). Such levels cannot be sustained. Patients with COPD assume a breathing pattern similar to normal subjects, with tidal volume and frequency increasing in response to demand until tidal volume reaches 50% to 60% of vital capacity. At that point, additional increments in VE are primarily achieved through changes in respiratory frequency. At any given level of minute ventilation, patients with COPD exhibit smaller tidal volumes and higher respiratory rates. Due to alterations in respiratory mechanics, primarily hyperinflation, patients with COPD will generate higher inspiratory pressures than normal subjects at similar work rates . As patients with COPD have reduced inspiratory muscle strength, these increased pressure requirements will result in fatigue more rapidly. Patients with severe COPD, as indicated by spirometry, will likely exhibit oxygen desaturation during exercise. This results from a fall in mixed venous blood oxygen tension flowing to low ventilation-perfusion areas of the lung, as well as relative hypoventilation (World Health Organization, 2008).

Unlike patients with mild COPD, these patients cannot improve their overall ventilation-perfusion ratios with exercise. The resulting hypoxia can serve to stimulate ventilation and limit exercise even more rapidly (Global Initiative For Chronic Obstructive Lung Disease, 2010). Oxygen therapy can ameliorate this problem. Oxygen therapy may also reduce the extent of right ventricular dysfunction that is seen in patients with moderate to severe COPD as a result of pulmonary hypertension and increasing pulmonary artery pressures during exercise (Andersen, Harro & Sardinha, 2006).

Exercise in patients with COPD is limited by a variety of factors: VE/MVV, respiratory muscle inspiratory pressure/strength, dyspnea, deconditioning, acidosis associated with lactate, respiratory acidosis, cardiac dysfunction, limb muscle dysfunction, and motivation. Exercise endurance can be extended when achieving intensities equal to 60% of VO_2 max at least three times per week, however. Patients with COPD exercising at levels equal to 30% of VO_2 max do not derive any benefit of training(Cooper, 2009). An exercise study permits determination of VO_2 max as well as a workload at 60% VO_2 max (Dikki, 2001). A common alternative to a formal exercise study is to determine the level of exercise at which a subject achieves 70% of his or her maximal heart rate (Haruna, 2006). A recent study, however, has shown that in patients with COPD the relationship between percent maximum heart rate and percent VO_2 max are different from that suggested by the American College of Sports Medicine (2010). Thus, a formal exercise test affords more accurate data. Exercise training is only one aspect of a complete pulmonary rehabilitationprogram. Patients not only benefit in exercise capacity and endurance but also quality of life when participating in pulmonary rehabilitation programs . In addition to exercise training, they receive upper and lower extremity endurance training, strength training, respiratory muscle training, education, and training in energy conservation techniques and control of breathing techniques, as well as psychosocial and behavioral intervention(Heikki, 2007).

2.4.2 **FEV/FVC Ratio**

Air-way disorders such as asthma, COPD and bronchitis cause obstructive type of lung function abnormality. This is diagnosed by reduced FEV>FVC % less than 75 percent and FEVi % predicted less than 80 percent. When clinical evaluation suggests airway obstruction low FEVi % predicted suggests an obstructive abnormality. Severity can be regarded as 60-80 percent, mild 40-60 percent as well as moderate and less than 40 percent as severe (Cooper, 2009). On restrictive abnormality, chest wall, pleural and lung parenchymal diseases cause restrictive lung functional abnormality indicated by a normal FEVi/FVC ratio and reduced FVC % less than 75 percent predicted. FVC is dependent on the patient’s performance; therefore, reduced FVC does not diagnose but only suggest a restrictive abnormality. Reduction in FVC may occur due to air trapping in moderate to severe airway obstruction as well as due to reduction in FEV in the early stages of neuromuscular disorders (CDCP, 2011).

With the introduction of exercise as a good bronchodilator revesibility (BDR), FEV is increased by 200 ml and > 12 percent, both occur after a dose of exercise. Generally, COPD patients achieve an increase in exercise tolerance without dyspnea and an increase in the sense of well-being, but without a reversal of the disease process (American Diabetes Association, 2007) . The changes in the psychological variables are very important in the long run given that the person’s willingness to continue the exercise program is a major factor determining the rate of decline during the course of the disease (Global Initiative For Chronic Obstructive Lung Disease, 2010).

2.4.3 **FEV/FVC RATIO** AND **EXERCISE**

Forced expiratory vital capacity (FEVC) is the volume of air that can be expired rapidly with a maximum inspiration. Forced expiratory volume in one second (FEVi) is the volume of air expired in the first second of maximal expiration after a maximal inspiration and is a useful measure of how quickly full lungs can be emptied. It represents the volume of air expired in the first second of a FVC. Estimation of FEVi is the most commonly used screening test for airway diseases.Normally,FEVi is about 80% of the FVC. It is useful in distinguishing between restrictive and obstructive diseases. Peak expiratory flow rate (PEFR) is the highest flow value measured during forced expiration. It is one of the many tests that measures how well the air-ways function. It measures airway obstructions and it will detect moderate or severe disease. Factors which determine PEFR are airway obstruction, closure and compression of small airways, strength of expiratory muscles and the lung and chest mechanics (Cedric & Fain, 2005).

2.4.4. **Peak expiratory flow and exercise**

Peak expiratory flow (PEF) is the fastest rate at which air can move through the airways during a forced expiration, starting with fully- inflated lung. Most adults and children, even as young as 5 years of age can perform a PEF measurement. The effort required to produce measurement is short maximal blast of air. The peak flow varies according to age, sex and height. PEF monitoring is an important clinical tool at home, in the office emergency department and Hospital (Desalu,Fawibe & Salami, 2012). The PEF, according to Riza (2005), can be used for diagnosis if the PEF increases more than 15 percent. 15 to 20 minutes after inhalation of rapid acting β2-agonist, or PEF varies more than 20 percent from morning measurement upon arising to measurement 12 hours. Later (more than 10 percent in patients who are not taking a bronchodilator) or PEF decreases 15 percent after 6 minutes of sustained running or exercise. It is important to establish personal best value and minimum circulation variability (Christopher , 2007).

Patients who perform graded exercise agaisnt a power load, which usually rises by steps of 100 kmp/ min each minute till the patient can do no more, develops elevated blood pressure or ischaemic changes on electro-cardiography reaches predicted maximum expired volume (Brusasco & Crapo, 2005).

2.4.5 Impact of training on cardiopulmonary response

Training can be primarily for strength or endurance. Endurance training results in an increase in VO_2 max by 8% to 15%, primarily by enhancing maximal cardiac output and secondarily to an increased arterial-venous gradient (Stommel & Schoenborn,2009). The value of training is not at maximal exercise but at submaximal exercise.Training results in increased capacity for aerobic exercise as oxygen delivery and skeletal muscle utilization are enhanced. Furthermore, the onset of anaerobic metabolism is delayed; and thus, the rise in minute ventilation and VCO_2 out of proportion to VO_2 is delayed (Chuesakoolvanich, 2007).

In fact, for a given level of exercise lactate levels, minute ventilation and VCO_2 are reduced after training. Patients also report reduced perception of dyspnea with training.The level of training intensity appears critical if benefit is to be obtained.Duration is also an important factor. Assessing intensity is best done by measuring VO_2max and then training at a level greater or equal to 50% of VO_2 max. Alternatively, normal subjects can achieve similar results by performing exercise at 60% to 70% of their predicted maximal heart rate or 50% of their heart rate reserve (George, Thomas and Kenneth, 2005). To calculate heart rate reserve, resting heart rate is subtracted from predicted maximal heart rate (HRmax). VO_2 max is a more reliable measure for exercise intensity, however. Some have also advocated exercising at the point of lactate accumulation, which approximates 50% VO_2max or 50% of heart rate reserve. Other studies have demonstrated training benefits even when exercise is at levels below those established by lactate accumulation (Haruna,2006).

In a study conducted by Wayo, Chado, Gwani & Haruna (2012), training sessions should range between 30 to 60 minutes (However,benefit is achieved with higher intensity exercise for durations of at least 20 minutes. Frequency should be at least twice weekly; still greater benefits are associated with more frequent exercise. Recommendations for frequency generally range between three to five times per we ek(Chado, 2010). Training benefit reaches its maximum in 3 to 4 weeks if training work is initiated at 50% VO_2 max (Baena,Blaiss&Canonica, 2005). For the fact that patients and many normal subjects rarely start at these levels of training intensity, an 8-week program is advisable (Lacasse, Lecours, Pelletier&Begin, 2005). The mode of training depends on the goals, as only those muscles trained will benefit (Venkatsewarlu, 1992). Training programs anchored on running, rapid walking, or bicycling can achieve equal increases in VO_2 max . Others may choose to focus on swimming or arm cranking exercises.

According to Dikki (1997), age is not a contra-indication to exercise programs, because geriatric patients benefit as well. Exercise prescriptions for the elderly need to be tailored even in normal subjects, however, as VO_2 max and predicted maximal heart rates are reduced and anaerobic threshold is elevated(Bahadori, Doyle-Waters & Marra, 2009). Exercise prescription in these patients should be based on a higher percentage of the reduced VO_2 max value (Wasserman *et al*, 2005).

2.4.0 **PULMONARY RESPONSE TO EXERCISE**

Exercise is rarely limited by pulmonary causes in the normal subject. Normal individuals, despite steep minute rises in ventilation during exercise, maintained a substantial breathing reserve (National Athletic Trainers Associatio, 2010). Exercise can indeed be limited by a number of pulmonary disorders,however. Acute pulmonary causes such as exercise-induced bronchospasm (EIB), vocal cord dysfunction (VCD), exercise-induced anaphylaxis and exercise-induced urticaria or chronic obstructive and restrictive lung disorders may all reduce exercise tolerance (Peters *et al,* 2006).

Healthy individuals augument their ventilation (VE) to exercise loads in large part as a response to increased carbon dioxide production (VCO_2). Increament in minute ventilation and carbondioxide production are linear to increment in oxygen (O_2) consumption (VO_2) up to 50% to 60% of maximal oxygen consumption (VO_2 max). Beyond this threshold, the rise in minute ventilation is more closely linked to rises in (VCO_2) (Bozek & Jarzab, 2010). In an attempt to maitain homeostasis with regards to arterial carbondioxide and pH, minute vetilation is initially increased by tidal volume augmentation. When ploted against minute ventilation, increments in tidal volume follow a hyperbolic curve and plateau at 60% to 70% of vital capacity(Lund, Pederson, Anderson & Backer, 2009). The shape of the curve is determined by the hyperbolic relationship between transpulmonary pressure and lung volume. Increments in minute ventilation are also paralleled by a rise in breathing frequency. The maximum minute ventilation (MVV) that can be sustained voluntarily for 4 minutes can be mathematically expressed as a function of the expired volume in the first second of exhalation of a forced manuever from full inspiration (FEVi) (Patridge, 2007). An approximation commonly used is MVV= 35 X FEVi. Healthy subjects generally reach 70 % of their MVV at a VO_2 max. Hence, their breathing reserve (BR) is 30 % of their MVV (Greener, 2010).

Patients respond to increased load by increasing minute ventilation. Their response pattern and capabilities are governed by their disease states. However, patients with chronic obstructive lung disease will respond to exercise by increasing their tidal volumes, despite their reduced FEVi values (Corbridge, 2010). The energy expense of maintaining these relatively high tidal volumes is quite high, however, and patients with airflow obstruction will be forced to a more energy conserving mode by reducing their tidal volumes. These patients may achieve minute ventilation equivalent to MVV and have minimal breathing rate available. In this case, it is likely that exercise limitation is pulmonary in origin. Patients with breathing frequency because of increments in tidal volume are far too energy expensive (Douglas, 2010).

According to Bozek *et al* (2010), minute ventilation can be divided into two components, namely: Alveolar ventilation (Vn), and wasted ventilation (dead space ventilation). Alveolar ventilation parallels VCO_2 max closely, as $PaCO_2$ changes little until normal subjects reach 75 % of their VO_2 max (Clatworth, Prince & Ryan,2009). At

this point, PCO_2 falls as alveolar ventilation increases more rapidly than VCO_2, perhaps in response to rising blood lactate levels and resultant falls in arterial pH. Reduced $PaCO_2$ values may be seen in patients with interstitial lung disease, because hypoxia stimulates minute ventilation as well as VCO_2.( ) Patients with cardiac limitations to exercise are likely to have elevated alveolar minute ventilations as lactate levels rise (Adeyeye & Onadeko, 2008).Those with pulmonary hypertention also demonstrate reduced $PaCO_2$ values during exercise (ACSM, 2007). Conversely, $PaCO_2$ commonly rise duringexercise in patinets with obstructive lung disease. These elevations likely result from increased production fron the work of breathing and reduced -responsiveness to carbon dioxide. The latter should not be confused with a decreased drive, but is a blunted rise in drive for changes in $PaCO_2$
(Petty, 2004).

During exercise the normal dead space to tidal volume ratio (VD/VT) of 0.25 to 0.35 at rest falls by 5% to 20% . These fall results from augmented tidal volumes, but is partially negated by increases inanatomicdeadspaceassociated with larger airway diameter (Kolawole, Olayemi & Erhabor, 2011). Reduction in the VD/VT ratio also results from recruited perfusion to the apical portions of the lung, thus minimizing alveolar dead space (Desalu, Fawibe & Salami, 2012). The efficiency of ventilation is directly related to the VD/VT ratio, and reductions seen during increased minute ventilation minimize the impact of increasing carbon dioxide production seen with exercise (Kolawole *et al*, 2011). Patients with lung disease often have an elevated VD/VT ratio, however. Those with interstitial lung diseases breathe with reduced tidal volumes and have regions of high ventilation but low perfusion, resulting in elevated VD/VT ratios. These patients exhibit greater minute ventilations for the same VCO_2. This is not the case for patients with chronic obstructive pulmonary disease (COPD), even though they have an increased VD/VT ratio(Desalu *et al*, 2012). Their blunted alveolar ventilation responses parallel increasing VCO_2, and hence minute ventilation may be normal, yet $PaCO_2$ elevated (O'Byme, 2010).

With exercise, maximal expiratory flow rate is reduced and residual lung volumes are increased as air is trapped behind the blocked airways. As a result, during an asthmatic attack, the respiratory rate increases to compensate for the increased obstruction of the airways and the inability of the usually elastic lung recoil. Tidal volume increases in patients with COPD because they will be forced to a more energy conserving mode by reducing their tidal volumes (David & Rob, 2007).

2.4.1 Impact of age on pulmonary response to exercise

Aerobic capacity declines by 6% to 10% per decade of life(Price,Bosnic & Briggs, 2013). The respiratory system in the young adult responds to exercise by several mechanisms: reducing end-expiratory lung volume, increasing tidal volume, enhancing breathing frequency by fourfold, improving perfusion to all regions of the lung, and reducing dead space ventilation. As we age, however, structural changes occur that impede the ventilatory response. A loss of elastic recoil is noted, which results in reduced lung compliance (Dikki, 1997). In addition, the chest wall becomes stiffer, which further affects compliance. Mechanical efficiency is also impaired through a change in chest wall configuration as a result of reduced intervertebral space and resultant increased anterior-posterior diameter. These changes result in reduced vital capacity, increased functional residual capacity, and significant reductions in maximal expiratory airflow. Muscle mass is reduced as well, and this results in reduced strength of the diaphragm. Oxygen transfer from air to blood is impeded by loss of alveoli, reduced arterial compliance, and increased airway diameter (Peters,Webb & O'Donnell, 2006).

Resting measurements of dead space increase 6% to 8% per decade, and diffusing capacity of carbon monoxide falls 4% to 8% per decade. Pulmonary capillary blood volume is also reduced with age (Troosters, Casaburi, Gosselink & Decramer, 2005). In spite of these changes, the respiratory system in the elderly permits significant exercise capacity and does allow for achievement of each individual's VO_2 max. Training goals in healthy elderly subjects are similar to those of their younger counterparts. Elderly subjects should achieve 50% to 80% of VO_2 max and perform continuous or rhythmic aerobic exercise for 30 to 60 minutes(Peters *et al*, 2006). Exercising at 70% of VO_2 max may be preferred, as the anaerobic threshold is elevated in the elderly subject. Target heart rates of 70% to 90% predicted maximum roughly correlate with VO_2 max levels of 50% to 75% (O'Byrne, 2010).

2.4.2 Exercise in patients with interstitial lung disease (ILD)

Patients with interstitial lung disease also have increased dead space ventilation at rest and during exercise, and hence an increased ventilatory response at each level of exercise in comparison with normal subjects (Heikki, 2007). Additional stimuli to enhance minute ventilation may include afferent signals from mechanoreceptors, chemoreceptors, respiratory muscles, and mediators of lung inflammation. Patients with ILD have reduced MVV values and thus an increased VE/MVV value for any level of exercise(Ibe, 2009). Their breathing pattern response to exercise is similar to normal subjects, but they achieve tidal volumes equal to 50% to 60% of their vital capacity quickly, as vital capacity is markedly reduced (Helenius *et al*, 2004). Thus, the patient with restrictive lung disease is very dependent on respiratory rate to increase minute ventilation. Patients with ILD often are hypoxic at rest and most will exhibit oxygen desaturation during exercise (Scott & Edward, 2012).

An increased (A-a)DO_2 results from greater ventilation-perfusion mismatch and shunting. Diffusion limitations and low mixed venous blood oxygen tension also contribute to exercise induced hypoxia, however. Although resting PaO_2 does not appear to be normal in patients with ILD . These patients also have reduced respiratory muscle strength and yet must generate high pleural pressures because of their poorly compliant lungs (Steinbrook, 2006) .

Correlate with disease severity, the degree of oxygen desaturation is related to the diffusing capacity of carbon monoxide (DLCO) as measured at rest (Marin,Carrizo,Gasco & Sanchez, 2001). The right ventricular response to Exercise in patients with ILD is limited by: VE/MVV, the ratio of respiratory muscle pressure to respiratory muscle strength, arterial desaturation, dyspnea, and poor conditioning and motivation. Oxygen therapy has not resulted in improved incremental exercise performance. Oxygen therapy has been shown to improve endurance exercise performance as well as reduce dyspnea and minute ventilation, however. Insufficient data exist to recommend an exercise prescription for patients with ILD. Exercise testing can determine the amount of oxygen required for given exercise intensities. In clinical practice, the recommendations for patients with COPD are applied to patients with ILD.

2.5 Summary

Asthma represents a continuum of disease process, characterized by inflamation of the airways wall. It has been described as a chronic inflammatory condition, characterized by air-way hyper-responsiveness to a variety of stimuli that lead to recurrent episodes of wheezing, breathlessness, chest tightness and coughing. It is manifested by a wide - spread narrowing of the air-ways that change in severity, either spontaneously or as a result of treatment, largely of allergic origin, with reversible air flow limitation. Asthma is a chronic respiratory disease that can have varying effects on the quality of life of sufferers. It is a major cause of impaired quality of life with impact on work, recreational, physical activities and emotions.

Asthma has multiple causes and, indeed, it is a complex disorder with chronic inflammatory processes cause excess mucous production and brochial smooth muscle constriction, which result from a release inflammatory mediators that include histamine, typase, prostaglandi and leukotrienes from mast cells. Airways may also accumulate thick, visious secretions produced by global cells and submucosal glands, with a leakage of plasma proteins and accumulated cellular debries. Although airway narrowing affects the tracheo-brochial tree, small bronchi (2-5 mm in diameter) are mostly affected. Maximal expiratory flow rate is reduced and residual lung volumes are increased as air is trapped behind the blocked airways. As a result, during an asthma attack, the respiratory rate increases to compensate for the increased obstruction of the airways and the inability of the usually elastic lung recoil (dynamic hyperinflation.

Asthmatics must exert great efforts to breath as the thorax becomes over-inflated. With progression of the attack, the diaphragm and intercostal muscles must compensate and contribute more energy during respiration. In a severe attack, muscle efficiency is vetually lost. The increase breathing rate leads to respiratory muscle fatique and physical distress that may result in death. Indeed, as many as 4,200 to 5,000 people die from asthma each year in the United States.

Researchers have discovered two major factors responsible for the aetiology of asthma. They include host factors (factors causing its development) and environmental factors (factors causing triggering its symptoms). The mechanisms that influence the development and expression of these disorders are generally complex and interactive. For example, genetic factors interact with environmental factors to determine asthma susceptibility among individuals.

Common respiratory disorders include chest pain syndromes, cough,. Chronic lung diseases such as asthma, COPD, and interstitial lung disease impact exercise capacity and endurance of asthmatic patients. Exercise training is a vital component of comprehensive pulmonary rehabilitation. For example, with exercise, maximal expiratory flow rate is reduced and residual lung volumes are increased as air is trapped behind the blocked airways. As a result, during an asthmatic attack, the respiratory rate increases to compensate for the increased obstruction of the airways, and the inability of the usually elastic lung recoil. Tidal volume increases in patients with COPD because they will be forced to a more energy conserving mode by reducing their tidal volumes.

The principal purpose of physical exercise for the primary prevention and treatment of lifestyle- related disease is to improve the quality of life of the individual suffering from asthma. The respiratory system rarely limits exercise in the normal subject. In patients with chronic pulmonary processes, the respiratory system may indeed be the limiting factor. The American College of Sports Medicine (ACSM) supports the viewpoint that from light to moderate physical activity (30 minutes a day, on most days of a week) is beneficial for improving the quality of life in persons with COPD. Exercise cannot reverse the physiologic and structural deficits in COPD, but may reduce disability associated with this condition by improving physical endurance and strength. It may also improve breathing efficiency and tolerance, especially in severely impaired patients. Patients with COPD who follow an individualized progressive exercise program may increase their functional capacity from 70 % to 80 % .

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 INTRODUCTION

The purpose of this study was to investigate the effect of aerobic training on forced expiratory volume, forced inspiratory volume,vital capacity, VO_2 max, FEV/FVC ratio and respiratory rate of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria. To achieve this purpose, the researcher adopted the following:

A research design, population, sample and sampling techniques, sequence of testing, instrumentation, training protocols, testing frequency, experimental controls and statistical techniques used in analyzing the data are discussed in this chapter.

3.2 RESEARCH DESIGN

For the purpose of this study, a quasi-experimental of one group repeated trials research design was used as suggested by Kerlinger (1988). In this design, one group was given different treatment at different times. The baseline or pre-training measures served as control, while the 4^{th} week, 8^{th} week and 12^{th} week measures were the experimental manipulations. The design was to maximize the between treatments variance, identify the between units variance and to minimize the error residual variance.

3.3 POPULATION

The population for the study consisted of 42 asthmatic adults, attending the out-patient Respiratory Unit Clinic of Kaduna State College of Education Clinic, Gidan Waya between the ages of 18 and 35 years.

3.4 SAMPLE AND SAMPLING TECHNIQUE

The purposive sampling technique was used to categorise the subjects according to levels of asthmatic attacks as mild, moderate and severe episodes. In this study, 26 volunteered asthmatic adults were drawn from the population, which comprised 13 males and 13 females drawn from the out-patient Respiratory Unit of Kaduna State College of Education, Gidan Waya.

The subjects were classified into three groups according to the severity of the disease. This grading system was modified from the one described by Chaitra & Vijay (2011). The severe group consisted of zero (0) patients with more than 10 acute attacks a year with or without complete clinical recovery between attacks. The moderate group consisted of thirteen (13) those with 5 attacks a year and usually show complete or partial freedom from wheezing between attacks, while the mild group had thirteen (13) with 1 attack a year with complete clinical recovery between attacks.

i. Asthmatics with mild episodes**...............13**

ii. Asthmatics with moderate episodes**........13**

iii. Asthmatics with severe episodes**...........0**

TOTAL.................26

3.4.1 Criteria for inclusion:

All subjects were screened to ensure that they met the following inclusion criteria before they were selected for this study:

i. They were all asthmatic outpatients from the Clinic of Kaduna State College of Education, Gidan Waya, Kaduna State. .

ii. They were all from the mild and moderate groups with complete clinical recovery between attacks.

iii. They were all between the ages of 18 and 35 years for both men and women.

iv. They were all taking inhaled bronchodialator and other medications for asthma (inhaler).

v. They were all able to perform the walking test which was for the purpose of erobic training.

3.4.2 Exclusion criteria were based on the medical records of the subjects, obtained from the Clinic of Kaduna State College of Education Gidan Waya with the following**:**

i. Those with severe left heart failure.

ii. Muscular or skeletal problems inhibiting walking performace.

iii. Pregnant asthmatic patients with a concurrent chest infection.

iv. Those asthmatics with an unstabled frequency of attacks and had not participated in any organized physical activity after hospital treatment.

3.5 INSTRUMENTATION

The following instruments were used in the study for data collection.

i. Treadmills: Trimline 7800 Treadmill, USA was used for aerobic training.

ii. **Spirometer**: A digital Spirometer SP 10, CE0123, manufactured by Contec Medical Systems Co. Ltd China, was used for pulmonary function test.

iii. **Stop watch**: Six stop watches Digital Port-Spring Model 015, manufactured by Jewele Sport Company, Britain were used for monitoring duration of the aerobic training (Baumgartner, Jackson, Mahar & Rowel, 2007).

iv. Lange Skin fold calipers: A standard Vernier outer plastic calipers was used to determine skin folds. The caliper used was calibrated in millimeters (Austrian Health and Fitness Survey, 1985; Heyward, 1998; Dikko, 2003). The lange skin fold calipers is more elastic and expands to a large extent even when in closed position. Values obtained were compared with those obtained from standard verierouter plastic calipers for accuracy and reliability of results.The lange calipers was used for determination of body fat percent. (Heyward, 1998).

iii). ***Weighing scale***:-Weighing scale was used to determine body mas index (BMI). Weighing Scale Model BR-9011, capacity of 120kg made in China was used to measure body weight of the subjects to the nearest kg as suggested by Australian Health and Fitness Survey (1985).

iv). Measuring tape (calibrated):- The Dough fang measuring steel tape brand was used in measuring the height of the subjects (m) as suggested by Wilmore (1999).

3.6 Informed consent:

All subjects for the study were required to fill an informed consent form. Participants involved in the study were adequately briefed on the procedures of the experiment, the likely benefits to be derived from participation, the discomfort to be experienced and the precautions to be taken for hitch-free participation in the training program, before completing and signing the informed consent form.

3.7 TEST PROCEDURES

To be able to conduct the test for this study, ethics approval to use human subjects for the study was granted by the Ahmadu Bello University Committee on Use of Human Subjects for Research (ABUCUHSR) Zaria,(Appendix A), a letter of introduction from the Department of Physical and Health Education, Faculty of Education, Ahmadu Bello University, Zaria to the Provost of Kaduna State College of Education Gidan Waya for approval to use its Clinic for the recruitement of subjects for the study and also for permission to use its gymnasium for the training (Appendix B) and an informed consent form for the participants to fill(Appendix C) were obtained before the tests were conducted.

3.7 TECHNIQUES OF MEASUREMENT

3.7.1 Physical characteristics of subjects

Subject's physical characteristics (height and weight) were assessed in accordance with the protocol of International Working Group on Anthropometry (IWGK) as described by Atlantis, Martins, Haren & Taylor, (2009). Specifically, measurements included standing height and weight**.**

Height: Subject's height was measured, while standing erect looking straight ahead and bare-footed against the stadiometer. Horizontal broad blade wooden ruler was rested on the head of each subject against the instrument to the nearest 0.1cm.

Weight: Subject's weight was measured using a portable bathroom scale with provision for re-calibration while dressed in light dress without footwear. The weight was recorded to the nearest 0.5 kg.

Body Mas Index (BMI): The height and weight measures were used to calculate the body mass index using the Quelled index by dividing weight (kg) by height (m) squared(wt/ht) (Wildman & Miller, 2004; Baumgartner et al, 2007; Williams, 2007; Plowman & Smith, 2008; Ije, Uchechukwu & Chukwunoso, 2010). The BMI values were read off a monogram for BMI (Dorth, Arnt, Eli- Anne, Stian & Tomas, 2010).

3.7.2 Determination of forced expiratory volume (FEV1):

Principle:

Forced expiratory volume in one second (FEV1) is the volume of air expired in the first second of maximal expiration after a maximal inspiration, and is a useful measure of how quickly full lungs can be emptied. It represents the volume of air expired in the first second of a FVC. The estimation of FEV1 is the most commonly used screening test for air-way diseases. Normally, FEV1 usually a range of 75-80% of the FVC (Saey *et al* 2006; Rowel, 2011). It is useful in distinguishing between restrictive and obstructive diseases. Peak expiratory flow rate (PEFR) is the highest flow value measured during forced expiration. It is one of many tests that measure how well the air-ways work. It measures air-way obstructions and it detects moderate or severe disease. Factors which determine FEFR are air-way obsruction, closure and compression of small air-ways, strength of expiratory muscles and the lung and chest mechanics (Desalu, Oluboyo & Salami, 2009; Sports Network, 2010).

Procedure

Each subject was asked to be in a sitting position (upright sitting position) and was expected to wear the spirometer with a noseclip on. They were instructed to take maximum inspiration and blow air forcefully into the mouth piece of the spirometer as rapidly, forcefully and completely as possible. It was ensured that a tight seal was maintained between the lips and mouth piece of the spirometer. The best of three trials was recorded for each subject expressed in liters of body temperature and ambient pressure saturated with water vapour(American Thoracic Society, 2005; Sidiropouou *et al*, 2007; Scott & Edward, 2012).

3.7.3 Determination of Peak expiratory flow (PEF)

Principle

Peak expiratory flow (PEF) is the fastest rate at which air can move through the airways during a forced expiration starting with fully inflated lung. Most adults and children, even as young as 5 years of age, can perform a PEF measurement. The effort required to produce measurement is short maximal blast of air. The peak flow varies according to age, sex and height. PEF monitoring is an important clinical tool at home, in the office emergency department and Hospital (Steinbrook, 2006; Spyros *et al*, 2009; Cris, Joseph & William, 2009) . PEF can be used for diagnosis if the PEF increases more than 15 percent. 15 to 20 minutes after inhalation of rapid acting β2-agonist, or PEF varies more than 20 percent from morning measurement upon arising to measurement 12 hours.

Later (more than 10 percent in patients who are not taking a bronchodilator) or PEF decreases 15 percent after 6 minutes of sustained running or exercise. It is important to establish personal best value and minimum circulation variability.

Procedure

Each subject was made to sit in an upright position, the spirometer worn with the mouth clip piece tightly fixed and took a short maximal blast of air. The best of three trials was recorded for each subject expressed in liters at body temperature and ambient pressure saturated with water vapour.

3.7.4 Determination of forced inspiratory volume (FIV1);

Principle

Forced inspiratory volume (FIV) is the volume of air that can be inspired forcefully following a normal tidal volume of inspiration (WHO, 2003; Riza & Farid, 2005; Welsh, 2006). Forced inspiratory volume of air in one second (FIV1) is the volume of air inspired in the first second of normal tidal volume. It is useful in measuring how quickly lungs can be filled.

Procedure

The subject was requested to sit in an upright position, the spirometer won with the mouth clip piece tightly fixed and took a short maximal blast of air. The best of three trials was recorded for each subject expressed in liters at body temperature and ambient pressure saturated with water vapour (American Thoracic Society, 2005).

iv. **Tidal volume (TV):** The subject was requested to sit in an upright position, the spirometer is won with the mouth clip nose tightly fixed, he took air in and out of lungs in a single quiet respiration to signify the normal dept of breathing. The best of three trials was recorded for each subject expressed in liters at body temperature and ambient pressure saturated with water vapour (American Thoracic Society, 2005).

3.7.5 Determination of Vital capacity (VC)

Principle

Vital capacity (VC) is the sum of the inspiratory reserve volume, tidal volume and the expiratory reserve volume. It is the maximum volume of air that a person can expel from his respiratory tract after a maximum inspiration (Saey *et al*, 2006; Jackson *et al*, 2009; Ibe & Ele, 2012).

Procedure

Each subject was asked to be in a sitting position (upright sitting position) and shall be expected to wear the spirometer with a noseclip on. They were instructed to take maximum inspiration and blow air forcefully into the mouth piece of the spirometer as rapidly, forcefully and completely as possible. It was ensured that a tight seal was maintained between the lips and mouth piece of the spirometer. The best of three trials was recorded for each subject expressed in liters at body temperature and ambient pressure saturated with water vapour(American Thoracic Society, 2005; Heikki, 2007; LaBella *et al*, 2009).

3.7.6 Determination of FEV/ FVC ratio

Forced expiratory vital capacity (FEVC) is the volume of air that can be expired rapidly with a maximum inspiration. Forced expiratory volume in one second(FEVi) is the volume of air expired in the first second of maximal expiration after a maximal inspiration and is a useful measure of how quickly full lungs can be emptied. It represents the volume of air expired in the first second of a FVC. Estimation of FEVi is the most commonly used screening test for airway diseases. Normally, FEV1 is about 80% of the FVC (Cedric & Fain, 2005; Lacasse, 2005; Ishee, 2012). It is useful in distinquishing between restrictive and obstructive diseases. Peak expiratory flow rate (PEFR) is the highest flow value measured during forced expiration. It is one of the many tests that measures how well the airways work. It measures airway obstructions and it will detect moderate or severe disease. Factors which determine PEFR are airway obstruction, closure and compression of small airways, strength of expiratory muscles and the lung and chest mechanics .

Procedure

Each subject was instructed to sit in an upright position with his mouth sealed in the spirometer tube, taking a maximal inspiration, and a forced expiratory flow at mid expiration and forces expiratory flow at mid inspiration. (i.e. FEF 50/FIF 50). The best of three trials was recorded for each subject expressed in liters at body temperature and ambient pressure saturated with water vapour (American Thoracic Society, 2005).

3.7.6 Determination of VO_2 max

Principle

American College of Sports Medecine and American Diabetes Association(2010) stressed that maximal oxgygen uptake (VO_2 max) of an individual increases with the introduction of exercise due to the effects of increase in body temperature and is an indication of oxgygen transport capacity of the heart, lungs and blood circulation. It is also used as a measure of exercise capacity. VO_2 max peak per unit body mass does not change. However, with age, VO_2 max tends to decline in both male and female asthmatics. VO_2 max is the amount of oxygen consumped during physical activity. It is used to determine the aerobic power and pulmonary ventilation. Ventilation of the lungs allows exchange of gas between blood and atmosphere. Aerobic exercise is an important component of pulmonary rehabilitation for patients with chronic obstructive pulmonary disease (Bateman, Hurd & Banes, 2008).

To be able to determine VO_2 max of the participants, establish the following: The age (in years), Weight (Kg), % fat and Subject's rating of physical activity (SRPA) Borg's rating of perceived exertion scale (Reprinted from Borg, 1998)

Procedure

All subjects were asked to jog round a standard 400 meter track of Kaduna State College of Education, Gidan Waya, for 12 minutes. Research assistants were assinged to each group to keep record of each participant's physical activity rating scale. At the expiration of 12 minutes, the participants were asked to stop the exercise or when the subject experienced perceived physical exertion (PPE) which was read as the individual's physical activity rating scale (Schechter, 2009).

To estimate the participant's weight, Subject's weight was measured using a portable bathroom scale with provision for re-calibration while dressed in light dress without footwear. The weight was recorded to the nearest 0.5 kg.(Baumgartner *et al*, 2007).

To determine body fat percent, the trunk skin folds was taken at sites like abdominal, suprailiac and subscapular while the limb skin folds was measured at the triceps, biceps and medial calfs. The researcher and trained research assistants took all skin folds measurement. The lange skin fold calipers, calibrated in millimeters was used to measure folds of skin only. The fat fold of the skin and subcutaneous fat was held firmly between thumb and index finger, pulling it away from the underlying muscular tissue and following the natural contour of the fat fold. Gently Place the caliper on the skin fold as closely as possible (usually about ½ inch or 0.5 cm) and a constant pressure of $10gm/m^2$ exerted by the pincer arms of the calipers at the point of contact with the skin. The measurement of the thick double layer of the fat fold of the skin and subcutaneous fat tissue should be read and recorded in millimeters (mm) within 2 seconds directly from the calipers as applied (Scot & Edward, 2012).

For the measurement of triceps skin fold, the vertical fold was measured at the middle line of the back of the upper arm, halfway between the tip of the shoulder and the tip of the elbow. For medial calf skin fold, the vertical fold was measured at the middle of the gastroenemous muscles and for the biceps skin fold, vertical fold was measured in the mid-line of the front part of the upper arm half-way between the tip of the shoulder and the elbow. In subscapular skin fold, the obligues fold measurement was just below the bottom hip of the subscapular. In suprailiac skin fold, slightly obligue fold was measured just above the tip bone, gently lighting up the fold to follow the natural diagonal line at this point. In the abdominal skin fold, the vertical fold was measured at least two (2) inches to the right of the umbilicus (Wol fang *et al,* 2010).

All skin fold measurements were taken on the right side of the body and calculated in millimeters as suggested by Petit, Hughes & Warpeha (2010). Three measurements per side was made and the average used to determine the fatfold measurement. Body fat percent was estimated by using the sum of skin folds of triceps and calf (i.e. % body fat = 0.735 (∑ Skf) + 1.0 as suggested by Peterson, Rhea & Sen, 2010).

Below is the method that was used in the estimation of subject's VO_2 max.

VO_2 max of the participant (**Male**) was estimated using this formular: VO_2 max (ml.kg-'min-1) = 47.820 - 0.259 (age) - 0.216(% fat) + 3.275(PARS)-0.082(% fat X PARS) in liters.

VO_2 max of the participant (**female**) was calculated thus: VO_2 max (ml.kg-'min-1)

= 45.628 - 0.265(age) - 0.309(% fat) + 2.175(PARS) - 0.044(% fat X PARS) in ml (ACSM ,2006) .

3.7.8 Determination of Respiratory Rate

Principle

Pattern of breathing refers to the respiratory frequency and regularity, the depth of breathing or tidal volume, and the relative amount of time spent during inspiration and expiration. Normal respiratory rate (RR) in adults is between 14 and 18 cycles per minute. Tidal volume of a 70-kg adult is about 500 ml per breath and the ratio of inspiratory to total time 0.4 at rest. Respiratory rate has a linear relationship with oxygen consumption and energy expenditure (Bahadori, Doyle, Waters & Marra, 2009). It is a key element ensuring that the muscles are oxygenated efficiently. Miller et al (2005) stated that the National Athletic Trainers Association(NATA) position statement recommends nose breathing for asthmatic athletes because this technique warms air, therefore decreasing the inflammation response.

Procedure

The subject was made to sit in an upright position, the spirometer worn with the mouth clip piece tightly fixed and took the depth of breathing or tidal volume, and the relative amount of time spent during inspiration and expiration. Normal respiratory rate in adults is between 14 and 18 cycles per minute. Tidal volume of a 70-kg adult is about 500ml per breath. The best of three trials was recorded for each subject expressed in liters at body temperature and ambient pressure saturated with water vapour (American Thoracic Society, 2005).

3.8 TRAINING PROTOCOL

All exercise training sessions were preceded by 10 minutes warm up and exercises including jogging and stretching exercises. 15 minutes was used for interval running in the first 4 weeks, 20 minutes in the second weeks of training and 25 minutes in the last 4 weeks of training which ended with cool- down sessions. The training session for this research lasted 12 weeks and was done between 4.30 pm – 6.00 pm three times a week (that is, Monday, Wednesday and Friday).

Aerobic Exercise.

All subjects were engaged in brisk treadmill walk/ jogging at a speed of one km/h at a gradient of 0% for the fisrt four weeks. The gradient was increased later to 1% due to improved aerobic fitness and to correlate with outdoor walking and to compensate for the lack of air resistance. The speed of the treadmill was gradually increased by 0.5km/hr or 1km/hr depending on the fitness level of the subjects (Oshio, 2011).

The subjects started training at an intensity of 40 – 50% of HRmax from the baseline to the 4^{th} week. It was increased to 51 – 60% intensity in the 5^{th} – 8^{th} week and was increased to an intensity level of 61 – 70% HRmax in 9^{th} – 12^{th} week (Raul, 2010). This gradual increase of training duration was followed in order to allow the subjects to adapt to the stress of training. However, the training period was altered depending on the rate of perceived physical exertion (PPE) of the participants using the modified Borg Scale. The scale rates from 6-20; where 6 stands for ‘‘no exertion at all’’ while 20 stands for ‘’maximal exertion’’ in order to permit optimal adaptation to the aerobic training.

Table 3.1 Borg's rating of perceived exertion scale

6 – 8	9 – 10	11 -12	13 -14	15 – 16	17 -18	19 -20
No exertion at all	**Very light**	**Light**	**Somehow hard**	**Hard (heavy)**	**Very hard**	**Maximal exertion**

(Borg RPE Scale for Perceived exertion Reprinted From Borg , 1998).

Subjects of the aerobic training group were engaged on treadmill (Trimline 7800 Model, USA. After a 10 minute warm–up exercise participants were instructed to perform aerobic training before resistance training, based on maximum heart rate. The estimated maximal heart rate method of predicting maximal heart rate (220-age of subject) was used to determine the training intensity for each subject. To estimate the maximal heart rate; the Karvonen formular was used as suggested by Chado (2011), the age of the individual has to be known. From the result obtained, a target heart rate was determined for each individual. The obtained maximal heart rate was multiplied by 1.15 prediction factor (McArdle, Katch & Katch, 2009) to obtain a 40 % - 50 % HRmax for the aerobic group, ACSM (2004) recommended that for majority of patients especially asthmatics, the training intensity should be between 40 % - 50 % of HRmax. The target HR was calculated thus:

Target HR= 40 % (HRmax) to 60 % (HRmax).The intensity of the main part of the aerobic training was increased progressively with a working HR 40% - 50 % of estimated HRmax (1 - 4 weeks) increase progressively to 51 – 60 % (5 – 8 weeks) and 61 – 70 % (9 - 12 weeks). 15 minutes were given for the first two weeks and increased to 20 minutes from the third week onwards. The subjects started with warm-up (for 10 minutes), at an intensity of 50-60% of HRmax (15 minutes for aerobic in 2 weeks) and resistance training for three weeks (20 minutes) with intensity of 60-85% HRmax (Raul, Manuel, Sean & Ana, 2010).

Table 3.2 Training schedule

Week	Duration	Warm –up	Walking	Jogging	Cool down	Max HR	RPE	Intensity
0 – 1	30 mins.	5mins.	10 mins.	10 mins.	5mins.	1 – 35 %	9 -10	Light
1 – 4	40 mins.	5mins.	15mins.	15mins.	5mins.	35 – 40%	11 -12	Light
5 – 8	45 mins.	5mins.	20mins.	20mins.	5mins.	40 -60 %	13–14	Light
9 -12	50 mins	5Mins.	20mins.	20mins	5mins.	61 -70 %	15-16	Hard

Resistance exercise

The resistance exercises involved those that use the major muscle groups of the body. They comprised of six (6) different exercises; namely leg curl, leg extension, abdominal curl, tricept extension, lattissimus pull and chest press using multi gym weight machine (Vivan fitness, T 602, USA). The 1RM for each subject was determined. Each subject started with a set of exercise using a weight of which atleast 15 repetitions can be achieved. Small amounts of weights were continously added until a certain weight was reached when no repetitions could be achieved. The weight lifted before this weight was recorded as the 1RM for each subject (Barbara & Wolfang, 2010, Faeze & Sirvan, 2011).

The training programme used by Linger, Goodman, Peake, Graham, Have, Jerrums & Selig (2009) was adopted but with slight modifications in the repetition and percent of 1RM for this study. This was because the subjects have been living inactive lifestyles and needed to progress gradually. The intensity started at 40 -50% of 1RM, 12 -15 repetitions for 2(two) sets at baseline, 51 – 60% of 1RM, 10 – 12 repetitions X 2 in the 5^{th} – 8^{th} week, and ended with 61 – 70% of 1RM, 8 – 10 repetitions for 2 sets in the 9^{th} – 12^{th} week.

The pre-start date was regarded as week ‘0’ during which the first test was conducted on the training group. The second test was administered half way through the training duration regarded as ‘week 4’. The third test was administered at the end of the training duration regarded as ‘week’ 8’. The final test was administered at the end of the training duration regarded as week ‘12’.

3.8.1 EXPERIMENTAL CONTROLS

In order to avoid the influence of extraneous variables on the results of this study, the following were used:

1. To avoid intra-tester and inter –tester variability of the results of the tests, all testers were trained till 0.92 to 0.96 reliability was obtained through test-retest methods that was to be conducted.

2. Habituation to testing procedures have been shown to affect test results. Therefore, all subjects were well acquainted with the procedures of the different tests that were to be conducted in the study, which was hoped to serve as a motivation to get maximal co-operation of the subjects participating in the study.

3. As pre-test activities affect the results of the different tests that were to be conducted in the study, all subjects were advised to refrain from eating, exercising and smoking a few hours to the starting of the test.

4. In order to eliminate any possible previous exertion on the test results, all subjects were asked to rest for 10 to 15 minutes before they were tested.

5. To avoid interfering with the training process, all training sessions were arranged to avoid educational lessons and other rehabilitation appointments.

6. The investigator was always present during the training sessions and during the test and all participants advised to stop the exercise as soon as they experienced any discomfort**.**

7.All participants were allowed to carry along with them their inhallers in case of any discomfort.

8. For the safety of the subjects, a trained nurse was present throughout the training sessions in case there was any abnormalities.

3.8.2 RESEARCH ASSISTANTS:

A total of six research assistants comprising of two trained nurses (male and female) and four other persons who assisted in the conduct of the study. The trained nurses and the researcher were involved in measuring the pulmonary function test. The other two assistants assisted in monitoring the training session and the last two assistants supervised the pace of training of the participants according to pre-set standards, gave encouraging words and in some instances stop the activity when the need arose.

3.9 STATISTICAL TECHNIQUES

For the purpose of this study, the following statistical analyses were applied on the data collected. The data obtained from the training program were analyzed using the Statistical Package of the Social Science (SPSS) version 20.

1. Descriptive Statistics: This was used to determine the central tendency and variability values of the collected data (means, standard deviation and standard error) and were considered statistically significant when value of $P < 0.05$

2 Repeated measures analysis of variance (ANOVA II) statistics was used to determine significant difference among tests in each of the selected variables (FEV,FIV, VC, aerobic fitness **(** VO_2 max**)** FEV/FVC and RR) at a significant level of 0.05.

3. Post-hoc Scheffe's test was used to determine where significant difference occurred.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

The purpose of this study was to examine the effect of aerobic training on pulmonary functions of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria. To achieve this purpose, the data collected in this study were statistically analyzed, the results of which are presented and discussed in this chapter.

4: 2: Results

The physical characteristics of subjects at baseline, immediately after 4th week, 8th week and 12th week of training is presented in Table 4:2:1

Table 4.2.1 Mean, SD, and SEE values of physical characteristics ofsubject'sheight (m) and weight (kg) at baseline, immediately after4thweek,8th week and 12th weeks of training is presented in Table 4.2.1 (n= 26)

Duration training	Variable	Mean	SD	SE
Baseline	Age(years)	24.615	6.568	2.34123
	Weight (kg)	75.342	5.5692	2.5632
	Height(m)	1.682	0.783211	0.21345
	BMI(kg/m^2)	26.54612	1.987621	0.441689
4th week	Weight(kg)	74.2346	4.5642	1.3342
	BMI(kg/m^2)	26.24612	2.2346	0.8743
8th week	Weight(kg)	71.3342	1.4230	1.6743
	BMI(kg/m^2)	26.0241	1.679212	.68231
12th week	Weight(kg)	70.552	4.4531	1.5432
	BMI(kg/m^2)	25.426	1.9924	.446781

BMI = Body mass index, kg = 70.552, kg/m^2 = 25.426

Table 4:2:1 shows the means, standard deviation(SD) and standard error(SE) of the physical characteristics of the subjects used 24.615 ± 6.568, 75.342 ± 5.5692, 1.682 ± 0.783211 and 26.54612 ± 1.987621 kg/m2 respectively.The result of the BMI at baseline showed that the subjects were overweight. As training progressed, the mean weight and BMI of the subjects reduced after 8th week 71.3342 ± 4.4230 and 26.0241 26.54612 ± 1.679212 respectively. Further decrease was observed also after 12th week in weight and BMI,(70.552 ± 4.4531 and 25.426 ± 2.0 kg/m^2) for this study. An observation of the baseline data showed that average age, weight, height and body mass index (BMI) of the subjects were respectively due to aerobic training.

The purpose of this study was to investigate the effect of aerobic training on pulmonary functions of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria. For the purpose of this study, twenty-six (26) asthmatic adults of mean age 24.62 years, mean height 1.68 m, mean weight 75.34 kg and mean BMI 26.54612 kg/m^2 at baseline were adjudged to meet the criteria for asthmatic adults required for the study.

TEST OF HYPOTHESES

Major hypotheses

There are no significant effects of aerobic training on forced expiratory volume,forced inspiratory volume, vital capacity, aerobic fitness (VO_2 max), FEV/ VC ratio and respiratory rates of asthmatic adults in Kaduna State Colege of Education, Gidan Waya, Nigeria.

In order to find out if aerobic training of 12 weeks duration had any statistical effect on the variables listed in the major hypothesis, the data collected were analyzed ccording to the sub-hypotheses raised for the study.

Sub-hypothesis 1

There is no significant effect of aerobic training on FEVI of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria.

To test this sub-hypothesis, information regarding the effect of aerobic training on FEVI at baseline, 4th week, 8th week, and 12th week is presented in the descriptive statistical Table 4. 2. 2a

Table 4.2.2a: Descriptive statistics of mean, standard deviation(SD) and Standard error (SE) of Forced Expiratory Volumes (FEVI) of asthmatic subjects before, during and after training.

Variable	Duration training	Mean	SD	SE	% Change
FEVI	Baseline	1.8962	.23745	.04657	
	4th week	2.2346	.18098	.03549	
	8th week	2.9038	.29730	.05830	1.01= 53.14 %
	12th week	3.2946	.27032	.05301	1.40=73.75%

Table 4.2.2a shows the means, SD and SE of Forced Expiratory Volume (FEVI) of asthmatic adults in Kaduna State College of Education, Gidan Waya at 0 week (baseline), immediately after 4th week, 8th week and 12th week of training. An observation of the baseline data (0 week) showed that the participants had mean values of FEV of 1.8962±.23745 liters. Observation of the table also revealed that FEVi mean values after 4th week were 2.2346±.18098 liters. Further more, an observation of the table after 8th week and 12th week values were 2.9038±.29730 and 3.2946 ±.27032 liters respectively.

In order to find out whether the increases were statistically significant, the data were analyzed using repeated measures analysis ANOVA, the result of which is presented in table 4.2.2b

Table 4.2.2b Repeated Measures Analysis of Variance (ANOVA) on Forced Expiratory Volume (FEVI) of asthmatic Adults by weeks of training

Source	SS	Df	MS	F	Sig.
Corrected Model	31.271	3	10.424	166.858	.000
Intercept	693.556	1	693.558	1.1104 *	.053
Training	31.271	3	10.424	166.858 *	.000
Error	6.247	100	.062		
Total	731.074	104			
Corrected Total	37.517	103			

$F (3, 104) = 2.00$ $P < 0.05$ * Significant

Table 4.2.2b shows repeated measures ANOVA on forced expiratory volume (FEVI) of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria before, during and after 12 weeks of aerobic training. Observation of the analysis revealed that training had significant effect on forced expiratory volumes of the subjects. However, a comparison of baseline and 12th week values showed significant effect of intercept (P. 000). Therefore, the null hypothesis which states that there is no significant effect of aerobic training on forced expiratory volume (FEV) of asthmatic adults in Kaduna State College of Education Gidan Waya is hereby rejected.

To establish which phase of training was responsible for the significant difference, post- hoc Scheffe's tests was applied on the means at baseline, 4th week, 8th week and 12th week and the result is presented in Table 4.2.2c

Table 4.2.2c: Results of Scheffe's post - hoc tests on the mean scores of Forced Expiratory Volume (FEVI) of the subjects before, during and after training

(I) Week	(J) Week	Mean difference (I-J)	Std. Error	Sign.	95% confidence Interval	
					Lower Bou	Upper Bound
Baseline	4th week	-.33846	.06942	.000	-.5359	-.1411
	8th week	-1.00769	.06942	.010	-1.2051	-.8103
	12 week	-1.39846	.06942	.000	-1.5959	.20071.
4th week	Baseline	.33846	.05923	.000	.1411	1-.2011
	8th week	-.66923	.05923	.002	-.8666	.5359
	12th week	-1.06000	.05923	.000	-1.2574	-.4718
8th week	Baseline	1.00769**	.07592	.023	.8103	-.8626
	8th week	.66923	.07592	.000	.4718	1.2051
	12th week	.66923	.07592	.032	-.5882	.8666
12th week	Baseline	1.39846**	.05926	.036	1.2011	-.1934
	4th week	1.06000	.05926	.000	.8626	1.5959
	8th week	.39077	.05926	.042	.1934	1.2574
	12th week	-1.39846	.05926	.420	-.4762	.5882

** Significant at week 8h and week 12th

Table 4:2:2c shows that the significant difference was at the 8th and 12th week of training (sig .000) $p < 0.05$.

Sub-hypothesis II:

There is no significant effect of aerobic training on FIVI of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria.

To test this sub-hypothesis, information regarding the effect of aerobic training on FIVI of asthmatic adults in Kaduna State College of Education, Gidan Waya at baseline, 4^{th} week, 8^{th} week and 12^{th} week is presented in the descriptive statistic in table 4.2.3a

Table 4.2.3a Descriptive statistics of Means, SD and SE of forced inspiratory volumes (FIVI) of asthmatic adults before, during and after training.

Variable	Duration training	Mean	SD	SE	% Change
FIVI	Baseline	1.7904	.29401	.05766	
	4^{th} week	2.0592	.27514	.05396	
	8^{th} week	2.2996	.30158	.05914	0.51=28.44%
	12^{th} week	2.6269	.29505	.05786	0.84=46.72%

Table 4:2:3a shows the means, SD and SE of forced inspiratory volume (FIVI) at baseline, immediately after 4^{th} week, 8^{th} week and 12^{th} week of aerobic training. An observation of baseline data (0 week) showed that the participants had mean forced inspiratory volume (FIV) value of 1.7904±.29410. Further observation of the table also revealed mean values of FIVi of 2.0592 ±.27514, 2.2996 ±.30158 and 2.6269 ±.29505 liters after 4th week, 8^{th} week and 12^{th} week respectively.

In order to find out whether these values were statistically significant, the data was analyzed using repeated measures analysis ANOVA, the result of which is presented in table 4.2.3b

Table 4:2:3b: Repeated measures analysis of variance for differences on forced inspiratory volume (FEVI) of asthmatic adults before, during and after training.

Source	SS	Df	MS	F	Sig.
Corrected Model	9.871	3	3.290	38.692	.000
Intercept	500.636	1	500.636	5.8873**	.063
Training	9.871	3	3.290	38.692 **	.056
Error	8.504	100	.085		
Total	519.010	104			
Corrected Total	18.375	103			

F (3, 104) = 2.00 P < 0.05 ** Significant

Table 4.2.3b shows the results of repeated measures ANOVA on forced inspiratory Volume (FIVI) of asthmatic adults in Kaduna State College of Education Gidan Waya at baseline, 4^{th} week, 8^{th} week and 12^{th} week of aerobic training. The result revealed statistical significant effect of aerobic training after 8^{th} week and 12^{th} week of aerobic training (P < 0.05). Therefore, the null hypothesis which states that there is no significant effect of aerobic training on forced inspiratory volume (FIV) of asthmatic adults in Kaduna State Collecge, of Education is hereby rejected.

To establish which phase of training was responsible for the significant difference between the means in the 4 phases of data collected, Post hoc Scheffe’s test was applied and the result of which is presented in table 4:2:3c

Table 4:2:3c: Results of Scheffe's post hoc tests on the mean scores of forced inspiratory volume (FIVI) of the subjects before, during and after training periods

(I) Week	(J) Week	Mean difference (I-J)	Std. Error	Sign	95% confidence Interval. Lower Bound	Upper Bound
Baseline	4th week	-.26885**	.08088	.015	-.4988	-.0389
	8th week	-.50923	.08088	.000	-.7392	-.2792
	12 week	-.83654	.08088	.000	-1.0665	-.6065
4th week	Baseline	.26885**	.06547	.015	.0389	.4988
	8th week	-.24038	.06547	.037	-.4704	-.0104
	12th week	-.56769	.06547	.000	-.7977	-.3377
8th week	Baseline	.50923**	.07235	.000	.2792	.7392
	4th week	.24038	.07235	.037	.0104	.4704
	12th week	-.32731	.07235	.002	-.5573	-.0973
12th week	Baseline	.83654**	.07249	.000	.6065	1.0665
	4th week	.56769	.07249	.000	.3377	.7977
	8th week	.32731	.07249	.002	.0973	.5573
	12th week	-.26885	.07249	.001	-.4293	-.1084

** Significant at week 8th and week 12th.

Table 4.2.3c shows that the significant differnce in the means of forced inspiratory volumes of asthmatic adults was due to the mean differnce at baseline vs 4th week, baseline vs 8th week and baseline vs 12th week (sig .037) less than P < 0.05.

Sub-hypotheses III:

There is no significant effect of aerobic training on vita capacity (VC) of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria

To test this sub-hypothesis, information regarding the effect of aerobic training on Vital Capacity (VC) of asthmatic adults in Kaduna State College of Education, Gidan Waya at baseline, 4^{th} week, 8^{th} week and 12^{th} week is presented in the descriptive statistical table 4:2:4a

Table 4.2.4a Descriptive statistic of means, SD and SE of Vital Capacity (VC) of asthmatic adults over the duration of the training

Variable	Duration training	Mean	SD	SEE	% Change
Vital Capacity	Baseline	2.3427	.46582	.09135	
	4^{th} week	2.4988	.47252	.09267	
	8^{th} week	2.8019	.39605	.07767	0.46=19.60 %
	12^{th} week	3.1808	.32628	.06399	0.84= 35.77%

Table 4:2:4a shows the means, SD and SE of vital capacity (VC) at baseline, immediately after 4^{th} week, 8^{th} week and 12^{th} week of aerobic training of asthmatic adults in Kaduna State College of Education, Gidan Waya. An observation of the baseline data showed that the participants had mean value of vital capacity (VC) of 2.3427 ±.46582. Further observation of the table also revealed that the mean values of VC of asthmatic

adults were 2.4988 ±.47252, 2.8019 ± .39605 and 3.1808 ±.32628 liters in their 4th week, 8th week, 9th week and 12th week respectively.

In order to find out whether these values were statistcally significant, data was analyzed using repeated measures ANOVA, the result of which is shown in table 4.2.4b

Table 4.2.4b: Repeated measures analysis of variance on vital capacity (VC) of asthmatic adults for differences before, during and after training

Source	SS	Df	MS	F-Value	Sig.
Corrected Model	10.865	3	3.622	20.520	.000
Intercept	760.213	1	760.213	4.3073 **	.000
Training	10.865	3	3.622	20.520**	.000
Error	17.649	100	.176		
Total	788.727	104			
Corrected Total	28.514	103			

F (3, 104) = 2.00 P< 0.05 * * Significant

Table 4.2.4b shows the results of repeated measures ANOVA of aerobic training on vital capacity (VC) of asthmatic adults in Kaduna State College of Education, Gidan Waya. The result revealed statistical significance after 8th week and 12th week of aerobic training ($p < 0.05$). Therefore, the null hypothesis which states that there is no significant effect in the mean vital capacity (VC) of asthmatic adults in Kaduna State College of Education, Gidan Waya on account of the period of training is hereby rejected.

To establish tha phase of training that was responsible for the significant difference, post hoc Scheffe's test was applied on the means at baseline, 4th week, 8th week and 12th week, the result of which is presented in table 4.2.4c

Table 4:2:4c: Results of Scheffe's post hoc tests on the means of Vital Capacity (VC) of the subjects before, during and after training.

(I) Training	(J) Training	Mean difference (I-J)	Std. Error	Sign.	95% confidence interval	
					Lower Bound	Upper Bound
Baseline	4th week	- .15615	.11632	.616	-.4869	.1746
	8th week	- .45923**	.11632	.002	-.7900	-.285
	12 week	- .83808	.11632	.000	-1.1689	-.5073
4th week	Baseline	.15615	.13632	.616	-.1746	.4869
	8th week	- . 30308	. 13632	. 086	-.6339	.0277
	12th week	- .68192	.13632	.000	-1.0127	-.3511
8th week	Baseline	.45932**	.12632	.002	.1285	.7900
	4th week	.30308	.12632	.086	-.0277	.6339
	12th week	- . 37885	. 12632	.017	-.7096	-.0481
12th week	Baseline	.83808**	.14632	.000	.5073	1.1689
	4th week	.68192	.14632	.000	.3511	1.0127
	8th week	.37885	.14632	.182	.0481	.7096
	12th week	- . 15615	. 14632	.000	-.3869	.0746

Baseline Vs 4th week, 8th week and 12th week

** Significant at week 8th and week 12th.

Table 4:2:4c shows that the significant differnce in the means of Vital Capacity (VC) of asthmatic adults was due to the mean differnce of baseline Vs 12th week (sig. .000), less than $P < 0.05$.

Sub- hypothesis IV: There is no significant effect of aerobic training on VO_2 max of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria

To test this sub-hypothesis, information regarding the effect of aerobic training on VO_2 max of asthmatic adults in Kaduna State Collge of Education, Gidan Waya before, during and after training is presented in the descriptive statistical Table 4.2.5a

Table 4.2.5a: The mean scores of Aerobic fitness (VO_2 max) of asthmatic adults over the duration of the training.

Variable	Duration of traini	Mean	SD	SEE	% Change
VO_2 max)	Baseline	17.7673	2.87369	.56358	
	4th week	18.3523	2.40703	.47206	
	8th week	19.6973	2.44352	.47921	1.93=10.86 %
	12th wek	20.8312	1.66058	.32567	3.06=17.24 %

Table 4.2.5a shows the means, SD and SE of Aerobic Fitness (VO_2 max) at baseline, immediately after 4th week, 8th week and 12th week of aerobic training of asthmatic adults in Kaduna State College of Education, Gidan Waya. An observation of baseline data showed that the participants had mean of aerobic fitness(VO_2 max) values of 17.7673±2.87369 liters.Further observation of the table also revealed that mean (Vo_2 max) values were 18.3523 ±2.40703,19.6973±2.44352 and 20. 8312±1.66058 ml/kg/min in their 4th week, 8thweek, and 12th week respectively.

In order to find out whether these increase were statistically significant, the data were analyzed using repeated measures ANOVA, the result of which is presented in table 4.2.5b

Table 4.2.5b: Repeated measures analysis of variance (ANOVA) for differnces on Aerobic Fitness (Vo_2 max**) of asthmatic adults before, during and after training.**

Source	SS	DF	MS	F	Sig.
Corrected Model	147.508	3	49.169	8.634	.000
Intercept	38187.030	1	3817.030	6.703 **	.000
Training	147.508	3	49.169	8.643 **	.000
Error	569.506	100			
Total	38904.044	104			
Corrected Total	717.014	103			

$F (3, 104) = 2.00$ $P < 0.05$ ** Significant

Table 4.2.5b shows repeated measure ANOVA on aerobic training (VO_2 max) of asthmatic adults in Kaduna State College of Education Gidan Waya before, during and after 12 weeks of aerobic training. An observation of the analysis revealed that training had significant effect on aerobic training (VO_2 max). Therefore, the null hypothesis which states that there is no significant effect of aerobic training on VO_2 max of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria is hereby rejected.

To establish the phase of training that was responsible for the significant differnce, post-hoc Scheffe's test was applied on the means at baseline, 4th week, 8th week and 12th week, the result of which is presented in table 4.2.5c

Table 4.2.5c Results of Scheffe's post hoc tests on the means of aerobic fitness (VO_2 max) of asthmatic adults before, during and after training

(I) Training	(J) Training	Mean difference (I-J	Std. Error	Sign	95% confidence interval . Lower Bound	Upper Bound
Baseline	4th week	- .58500	.65188	.854	-2.4672	1.2972
	8th week	-1.9300**	.65188	.042	-3.8122	-.0478
	12 week	-3.06385	.65188	.000	-4.9460	-1.1817
4th week	Baseline	. 58500	.74873	.854	-1.2972	2.4672
	8th week	-. 34500	.74873	.254	-3.2272	.5372
	12th week	-2.47885	.74873	.004	-4.3610	-.5967
8th week	Baseline	1.93000**	.46534	.042	.0478	3.8122
	4th week	1.34500	.46534	.254	-.5372	3.2272
	12th week	-1.13385	.46534	.406	-3.0160	.7483
12th week	Baseline	3.06385**	.85579	.000	1.1817	4.9460
	4th week	2.47885	.85579	.004	.5967	4.3610
	8th week	1.13385	.85579	.406	-.7483	3.0160

	12^{th} week	- .58500	.85579	.379	-1.8981	.7281

Baseline Vs 8^{th} week, Baseline Vs 12^{th} week. ** Significant

Table 4.2.5c shows that the significant differnce in the means of aerobic Fitness (VO_2 max) was due to mean difernce of baseline Vs 8^{th} week, baseline Vs 12^{th} week (sig 0.042) less than $p > 0.05$.

Sub-hypothesis V : **There is no significant effect of aerobic training on FEV/ FVC ratio of asthmatic adults in Kaduna State College of Education, Waya, Nigeria**

To test this sub-hypothesis, information regarding the effect of aerobic training on FEV / FVC of asthmatic adults in Kaduna State College of Education, Gidan Waya before, during and after training is presented in the descriptive statistical Table 4.2.6a

Table 4:2:6a **Descriptive statistics of means, SD and SE of FEV/ FVC Ratio of asthmatic adults before, during and after training.**

Variable	Duration of training	Mean	SD	SE	% Change
FEV/FVC Ratio	Baseline	2.4623	.13073	.02564	
	4^{th} week	1.6996	.39174	.07683	
	8^{th} week	1.1523	.47474	.09310	1.31=53.20 %
	12^{th} week	.9423	.54129	.10616	1.52=61.73 %

Table 4.2.6a shows the means, SD and SE of FEV/ FVC Ratio at baseline, immediately after 4^{th} week, 8^{th} week and 12^{th} week of aerobic training of asthmatic adults in Kaduna State College of Education, Gidan Waya. An observation of baseline data

showed that the participants had mean value FEV/ FVC Ratio of 2.4623 ± 0.13073.Further observation of the table revealed that the means of FEV/ FVC Ratio were 1.6996 ± .39174, 1.1523 ± .47474 and .9423 ± .54129 liters after 4th week, 8th week, and 12th week respectively.

In order to find out whether these increase were statistically significant, the data was analyzed using repeated measures ANOVA, the result of which is presented in table 4:2:6b

Table 4.2.6b: Repeated measures analysis of variance (ANOVA) on FEV/FVC ratio **of asthmatic adults by weeks of training**

Source	SS	DF	MS	F	Sig.
Corrected Model	36.674	3	12.225	71.189	.000
Intercept	255.753	1	255.753	1.4893*	.000
Training	36.674	3	12.225	71.189**	.000
Error	17.172	100	.172		
Total	309.600	104			
Corrected Total	53.847	103			

F (3, 104) = 2.00 P < 0.05 * * Significant * Not significant

Table 4:2:6b shows the result of repeated measure of ANOVA on values of FEV/ FVC Ratio of asthmatic adults in Kaduna State College of Education Gidan Waya before, during and after 12 weeks of aerobic training. An observation of the analysis revealed that the training had statistical effect on FEV/ VC ratio. However, a comparison of baseline and12th week values showed no significant effect on intercept (P.000). Therefore, the null hypothesis which states that there is no significant effect on FEV/ VC ratio of asthmatic adults in Kaduna State College of Education, Gidan Waya is hereby rejected.

To establish the phase of training that was responsible for the significant differnce, pot-hoc Scheffe's test was applied on the means at baseline, 4th week, 8th week and 12th week of which is presented in Table 4.2.6c

Table 4.2.6c: Results of Scheffe's post hoc tests on the means of FEV/ **FVC ratio of the subjects before, during and after training.**

(I) Training	(J) Training	Mean difference (I-J)	Std. Error	Sig.	95% confidence Interval	
					Lower bound	Upper Bound
Baseline	4th week	.76269	.22511	.000	.4354	1.0900
	8th week	1.31000**	.22511	.010	.9827	1.6373
	12 week	1.52000	.22511	.000	1.1927	1.8473
4th week	Baseline	- .76269	.32510	.014	-1.0900	-.4354
	8th week	. 54731	.32510	.000	.2200	.8746
	12th week	.75731	.32510	.022	.4300	1.0846
8th week	Baseline	-1.31000**	.43512	.024	-1.6373	-.9827
	4th week	-.54731	.43512	.000	-.8746	-.2200
	12th week	.21000	.43512	.349	-1.173	.5373
12th week	Baseline	-1.52000**	.11527	.000	-1.8473	-1.1927
	4th week	-.75731	.11527	.000	-1.0846	-.4300
	8th week	-.21000	.11527	.349	-.5373	.1173
	12th week	.76269	.11527	.000	.5343	.9911

** Significant

Baseline vs 4th week, Baseline vs 8th week and Baseline vs 12th week.

Table 4.2.6c shows that the significant differnce in the means of FEV/ FVC ratio of asthmatic adults was due to the means differnce at baseline Vs 4th week, baseline Vs 8th week baseline Vs 12th week (sig .000), less than P > 0.05.

Sub-hypothesis VI: There is no significant effect of aerobic training on Respiratory Rate (RR) of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria

To test this sub-hypothesis, information regarding the effect of aerobic training on RR of asthmatic adults in Kaduna State College of Education, Gidan Waya before during and after training is presented in Table 4.2.7a

Table 4.2.7a**: Descriptive statistics of means, SD and SE of Respiratory Rate (RR) of asthmatic adults before, during and after training**

Variable	Duration training	Mean	SD	SE	% Change
RespiratoryRate (RR)	Baseline	35.3846	1.85638	.36407	
	4th week	39.5385	1.44881	.28410	
	8th week	45.5385	3.02299	.59286	10.15=28.68%
	12th week	53.1923	3.54423	.69508	17.81=50.33%

Table 4.2.7a shows the Means, SD and SE of Respiratory Rate (RR) at baseline, immediately after 4th week, 8th week and 12th week of aerobic training on respiratory rateof asthmatic adults in Kaduna State College of Education, Gidan Waya. An observation of the baseline data showed that the participants had mean RR value of

35.3846 ±1.85638liters. Further observation of the table also revealed that the means of RR were 39.5385 ± 1.44881, 45.5385± 3.02299 and 53.1923±3.54423 liters after 4th week, 8th week and 12th week respectively.

In order to find out whether these increases were statistically significant, data were analyzed using repeated measures ANOVA, the results of which are shown in Table 4.2.7b

Table 4.2.7b: Repeated measures analysis of variance (ANOVA) for difference in Respiratory Rate (RR) of asthmatic adults before, during and after training

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4674.385	3	1558.128	228.800	.000
Intercept	196098.615	1	196098.615	2.8804**	.000
Training	4674.385	3	1558.128	6.810 **	.000
Error	681.000	100			
Total	201454.000	104			
Corrected Total	5355.385	103			

$F (3, 104) = 2.00$, $P< 0.05$ ** Significant

Table 4.2.7b shows repeated measures ANOVA on respiratory rate (RR) of the subjects before during and after aerobic training.The result revealed statistical differnce ($P = 0.000$) after 8th and 12th week of aerobic training on respiratory rate of asthmatic adults in Kaduna State College of Education, Gidan Waya ($P < 0.05$). The hypothesis of no significant difference is hereby rejected.

To establish which phase of training was responsible for the significant difference, Post hoc Scheffe's tests was applied on the means at baseline, 4^{th} week, 8^{th} week and 12^{th} week and the result is presented in Table 4. 2. 7c

Table 4.2.7c: Results of Scheffe's Post hoc tests on the means of respiratory rate (RR**) before, during and after training.**

(I) Training	(J) Training	Mean difference (I-J)	Std. Error	Sig.	95% confidence Interval	
					Lower bound	Upper Bou
Baseline	4^{th} week	-4.15385	.42383	.000	-6.2122	2.0955
	8^{th} week	- 10.15385 **	.42383	.000	-12.2122	8.0955
	12 week	- 17.80769	.42383	.000	-19.8661	15.7493
4^{th} week	Baseline	4.15385	.53383	.000	2.0955	6.2122
	8^{th} week	- 6.00000	.53383	.000	-8.0584	3.9416
	12^{th} week	- 13.65385	.53383	.000	-15.7122	11.5955
8^{th} week	Baseline	10.15385**	.88383	.000	8.0955	12.2122
	4^{th} week	6.00000	.88383	.000	3.9416	8.0584
	12^{th} week	-7.65385	.88383	.000	-9.7122	5.5955
12^{th} week	Baseline	17.80769**	.66383	.000	15.7493	19.8661
	4^{th} week	13.65385	.66383	.000	11.5955	15.7122
	8^{th} week	7.65385	.66383	.000	5.5955	9.7122
	12^{th} week	- 4.15385	.66383	.000	-5.5899	2.7178

** Significant at baseline, 8^{th} week and 12^{th} week.

Table 4.2.7c shows that the significant differnce in the means of respiratory rate (RR) was due to the mean difference between baseline, 8th week and 12th week of training(sig .000) $P < 0.05$.

4.3: DISCUSSION

Pulmonary functions tests included in this study were forced expiratory volumes, forced inspiratory volumes, vital capacity, aerobic fitness which was determined by (VO_2 max) that was inferred from 12 - minute run test, forced expiratory volume/ forced vital capacity ratio and respiratory rate.

Results of this study showed that significant difference existed in the mean values of forced expiratory volume (FEV) of astmatic adults in Kaduna State College of Education Gidan Waya on the account of the period of training. The mean (FEV) were 1.8962, 2.2346, 2.9038 and 3.2946 in their week 0, 4th week, 8th week and 12th weeks respectively. This shows that the higher the period of training, the higher the increase of the forced expiratory volume of the asthmatic adults. This is in agreement with the findings of Cooper (2009), Terranova and Henning (2011), Global Initiative for Chronic Obstructive Lung Disease (2010) and CDCP (2011) who demonstrated that with exercise, patients with chronic obstructive pulmonary disease gained good bronchodilator reversibility (BDR), FEVI is increased by 200 ml and > 12 percent, and both occur after a dose of exercise. This finding may be attributed to the regular physical activity especially the observation that aerobics strengthen respiratory muscles, thereby resulting in an increase in lung capacity. However, this is opposed by the findings of Reynolds (2008) and Fanci (2008) who found out that exercise exposed individuals suffering from chronic obstructive pulmonary diseases are proned to psychological problems including anxiety and depression due to decrease in their ability to inhale air because of narrowed airways. The changes in the psychological variables are very important in the long run given that the person's willingness to continue the exercise program is a major factor determining the rate of decline during the course of the disease. It is reported by Dikki (2009) that as one ages however, structural changes occur that impede the ventilatory response which include a loss of elastic recoil, chest wall become stiffer resulting to reduced lung capacity. Since breathlessness is usually a transient symptom during exercise, patients should slow down rather than stop the exercise suddenly.

The result of this study revealed that exercise enabled asthmatic patients to have a more powerful and more effective inspiration as opposed to what they have been able to before participating in such aerobic exercise. This result agrees with the findings of Corbridge (2010), Verity (2010), Kolawole, Oayemi & Erhabor (2011) who maintained that patients with airflow obstruction will gain a more energy conservating mode by reducing their tidal volumes. These patients will achieve minute ventilation equivalent to maximum minute ventilation (MVV) levels exceeding 0.75, which is distincly unusual for normal subjects and have minimal breathing rate available. However, Douglas (2010) demonstrated in a study that patients with chronic obstructive lung disease will face the challenge of responding to exercise by increasing their tidal volumes and to maintain this relatively high tidal volume is quite high.

The present study also revealed that aerobic exercise caused an increase in FEVI and PEFR. This is in agreement with the findings of Reza Farid (2005), David & Rob (2007) and Christopher (2007) who demonstrated that there was improvement in the pulmonary functions of asthmatic patients. However, in a study conducted by Alexander, Oni, Erhabor & Egbagbe (2010) showed that asthma restrict patients from engaging in sports and physical activity. It was also found to disturb sleep and was responsible for recurrent hospitalization in 50 % of the patients. The reason for this may be because the majority of the patients studied in this study preferred the use of aerosol bronchodilator for treatment of asthma, instead of combining it with exercise.

This study revealed an increase in Vo_2max of the patients. This is in agreement with the findings of Andersen, Harro & Sardinha (2006), Heikki (2007), Boyden, Rubenfire & Franklin (2010) who found that in a wide range of exercises (e.g walking, cycling games and resistance training), patients with chronic obstructive pulmonary lung diesease VO_2 max as well as a workload is increased by 8 % - 15 % primarily, by increasing maximal cardiac output and arterial- venous gradient. Training results in an increase capacity for aerobic exercise as oxygen delivery and skeletal muscle utilization are enhanced (Hanes, Issa, Proud & Togias (2006). Contrary to this finding, Wasserman (2005), Barhadori, Doyle-Waters & Marra(2009 in their studies demonstrated that patients with chronic obstructive pulmonary disease exercising at levels equal to 30 % of VO_2 max do not derive any benefit of training. The level of exercise in this study which was at 40 % - 50 % of VO_2 max or HRmax may be responsible for the difference as this study began its training with a HRmax at 40% - 50% HRmax. The training benefit reached its maximum in 8 to 12 weeks.

As revealed by this study, FEVI / FVC ratio increased with exercise. This result agrees with the findings of the study carried out by levy, Fletcher, Price Hausen Halbert & Yawn (2006) and Christopher (2007) who observed a significant change in FEVI/ FVC ratio following exercise administration in asthmatic patients**.** Contrary to the study of Riza & Farid (2005) who demonstrated that there was no significant change in FEVI/ FVC ratio of subjects suffering from asthma. The difference in their results may be attributed to the fact that airway disorders such as asthma, chronic obstructive pulmonary disease and bronchitis cause obstructive type of lung function abnormality. This is diagnosed by reduced FEVI > FVC percent less than 75 % and FEVI % predicted less than 80 %.

Regarding respiratory rate, this study revealed that with the introduction of exercise, respiratory rate increased. This is in agreement with the study of Bateman, Hurd, Barnes, Bousquet, Drazen & FitzGerald (2008), Fajt & Wenzel (2009), who demonstrated that patients with chronic obstructive pulmonary disease assumed a breathing pattern similar to normal subjects, with tidal volume and frequency increasing in response to demand until tidal volume reaches 50 % - 60 % of vital capacity. At that point, additional increments in VE are primarily achieved through changes in respiratory frequency. Contrary to the work of Levy, Fletcher, price, Hausen, Halbert & Yawn (2006) who demonstrated that patients with chronic obstructive pulmonary disease will generate higher inspiratory pressures than normal subjects, occurring at similar work rates due to reduced inspiratory muscle strength in patients with COPD. The increased pressure requirements may result in fatigue more rapidly. It should be noted, therefore, that patients with COPD response pattern and capabilities are governed by their disease states.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5:1 Introduction

This chapter presents the summary, conclusion of the findings of the effect of aerobic training on forced expiratory volumes, Forced inspiratory volumes,Vital capacity, aerobic fitness (Peak VO_2 max), FEVi/FVC Ratio and Respiratory rate of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria. Recommendations on the use of aerobic training to improve the pulmonary functions of asthmatic adults are made.

5.2 Summary

This study was undertaken to examine the effect of aerobic training on pulmonary functions of asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria. Experimental research design was used. 26 subjects from the ages of 18-35, who met the inclusion criteria participated in the 12 week training. There was no control group but the first four (4) weeks served as baseline. The specific pulmonary functions test assessed included FEVI, FIVI, VC, Peak VO_2 max, FEVi/FIV Ratio and Respiratory rate of asthmatic adults.

Spirometry test was used to determine FIVI, FEVI, VC, FEV/FVC Ratio. A 12 minute run test was used to determine aerobic fitness (Peak VO_2 max) and informed consent form was completed by participants to show their readiness to participate in the study. A written permission was also obtained from Ahmadu Bello University Zaria, ethical commitee to use human subjects for the study.

All exercise training sessions were preceded by 10 minutes warm up and exercises included jogging and stretching exercises. 15 minutes was used for interval running in the first 4 weeks, 20 minutes in the second weeks of training and 25 minutes in the last 4 weeks of training which ended with cool down sessions. The training session for this research lasted 12 weeks and was done between 4.30 pm – 6.00 p.m three times a week (that is, Monday, Wednesday and Fridays). All subjects were engaged in brisk treadmill walk/jogging at a speed of 1km/hr at a gradient of 0% for the fisrt four weeks. The gradient was increased later to 1% due to improved aerobic fitness and to correlate with outdoor walking and to compensate for the lack of air resistance. The speed of the treadmill was gradually increased by 0.5km/hr or 1km/hr depending on the fitness level of the subjects. The subjects started training at an intensity of 40 – 50% of HRmax from the baseline to the 4^{th} week. It was increased to 51 – 60% intensity in the 5^{th} – 8^{th} week and was increased to an intensity level of 61 – 70% HRmax in 9^{th} – 12^{th} week. This gradual increase of training duration was followed in order to allow the subjects to adapt to the stress of training. However, the training period was altered depending on the rate of perceived physical exertion (PPE) of the participants using the modified Borg Scale. The scale rates from 6-20; where 6 stands for ‘‘no exertion at all’’ While 20 stands for ‘’maximal exertion’’ inorder to permit optimal adaptation to the aerobic training.The intensity of the main part of the aerobic training was increased progressively with a working HR 40% - 50 % of estimated HRmax (1 - 4 weeks) increase progressively to 51 – 60 % (5 – 8 weeks) and 61 – 70 % (9 - 12 weeks). 15 minutes were given for the first two weeks and increased to 20 minutes from the third week onwards. The subjects started with warm-up (for 10 minutes), at an intensity of 50 - 60% of HRmax (15 minutes for aerobic in 2 weeks), resistance training for 3 weeks (20 minutes) with intensity of 60-85% HRmax.

The data collected were statistically analyzed using descriptive and repeated measues analysis of variance (ANOVA). When a significant F-ratio was obtained, Scheffe's post-hoc test was performed to determine which pulmonary function differs significantly from one another. All statistical analyses were done using statistical package for social science (SPSS) package. The hypotheses were tested at 0.05 alpha- level of significance under relevant degrees of freedom.

Findings indicated that there was a significant increase in FEVI, FIVI, VC, VO_2 max of asthmatic patient FEVi/ FVC Ratio and RR of asthmatic patients following a 12-week of aerobic training.

5:3 Conclusion

In view of the limitations and on the basis of the results of this study, the following conclusions were made:

1. Aerobic training significantly increased FIV1 of asthmatic patients.
2. Aerobic training significantly increased FEV1 of asthmatic patients.
3. Aerobic training significanlty increased VC of asthmatic patients.
4. Aerobic training significantly increased VO_2 max of asthmatic patients.
5. Aerobic training significanlty increased FIV1/ FEV1 ratio of asthmatic patients.
6. Aerobic training significantly increased respiratory rate of asthmatic patients.

5: 4 Recommendations

On the basis of the findings of this study, the following recommendations are made to improve the quality of life of young asthmatic adults in Kaduna State College of Education, Gidan Waya, Nigeria:

1. Participation in aerobic training has been shown to increase functional capacity of asthmatic adults. Therefore, asthmatic adults should be enlightened through seminars and workshops to combine both pharmachological treatments with exercise.
2. Since aerobic training was found to improve pulmonary functions of asthmatic patients, it is suggested that health professionals and fitness centers should use this method of training for asthmatic patients and they should be encouraged to exercise themselves for at least 20-40 minutes only in a week to improve their quality of life..
3. In view of the beneficial role of exercise training for health in the asthmatic patients, it is recommended that asthmatic adults should personally engage in regular walking/jogging as a prophylactic measure against pulmonar dysfunction.

5:5 Recommendations for Further Research

In the course of this investigation, the researcher came across a number of issues related to pulmonary risk factors which are rcommended below for further research:

1.If this study was to be replicated, modifications should be made to gain a better representation of the asthmatic patients. The study should address both gender and race/ethnicity of the participants.

2. This study only used spirometry to determine effect of aerobic training on pulmonary functions. However, it has failed to administer a bronchodilator prior to performing spirometry. The researcher, therefore, is suggesting that asthmatic patients be administered bronchodilator prior to performing spirometry in a further study to determine its influence on pulmonary functions test.

3. This study only examined the effect of aerobic training on the pulmonary functions of asthmatic adults. It did not study the influence of asthma on physical activity over the range of early childhood into adulthood. The researcher is therefore, suggesting that a study be carried out to examine the influence of aerobic fitness on asthma severity in children and adolescents.

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