EFFECT OF FUNCTIONAL EXERCISE (6 MINUTES WALK TEST) ON LUNG FUNCTION LEVEL IN HEALTHY ADULT MALES.

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A PROJECT WRITTEN IN THE DEPARTMENT OF PHYSIOLOGY AND SUBMITTED TO THE SCHOOL OF BASIC MEDICAL SCIENCES, COLLEGE OF MEDICAL SCIENCES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (B.Sc.) DEGREE OF THE UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA.

NOVEMBER, 2025

CERTIFICATION

This is to certify this project on "**EFFECT OF FUNCTIONAL EXERCISE (6 MINUTES WALK TEST) ON LUNG FUNCTION LEVEL IN HEALTHY ADULT MALES**" was carried out by **OSA-IGHARO NOSAKHARE MIEBAKA**, with the matriculation number **BMS2101668** in partial fulfillment of the requirement of the award of Bachelor of Science Degree (B.Sc) in the Department of Physiology, School of Basic Medical Sciences, College of Medical Sciences, University of Benin, Benin City, Edo State, Nigeria.

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DEDICATION

I dedicate this work to God Almighty, my Creator, my constant source of strength, and the wellspring of my inspiration, wisdom, and understanding. It is by His grace alone that I have been able to embark on and complete this journey. Through His guidance, I have found direction; on His wings, I have soared.

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ABSTRACT

One important measure of cardiopulmonary fitness is functional exercise capacity. A popular and standardized method for evaluating this ability is the Six-Minute Walk Test (6MWT), which measures how various physiological systems react to submaximal effort. While its impact on cardiovascular parameters is well-documented, the specific, acute effects of a self-paced functional exercise like the 6MWT on spirometric lung function levels in healthy individuals remain less characterized. Establishing this baseline response is crucial for the accurate interpretation of tests in clinical populations. This study sought to evaluate the acute effect of the Six-Minute Walk Test (6MWT) on lung function levels in healthy adult male subjects. A pre-post intervention study design was employed. A cohort of healthy adult male students from the University of Benin, aged 18-29 years, was recruited. Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV1), FEV1/FVC ratio, and Peak Expiratory Flow (PEF) were measured using baseline spirometry. Each participant then completed the 6MWT on a standardized 30-meter track in compliance with the American Thoracic Society's (ATS) recommendations. Spirometry was repeated immediately post-exercise to capture acute changes in lung function parameters. Results showed a significant post-exercise reduction in FEV1 and the FEV1/FVC ratio. In contrast, no significant changes were observed in FEF25, FEF75, or PEF. The significant decrease in FEV1 and FEV1/FVC suggests mild, exercise-induced bronchoconstriction predominantly in the large, central airways. The stability of small airway parameters (FEF25, FEF75) and PEF indicates this response is localized, not affecting peripheral airway function or maximal expiratory effort. This pattern aligns with known physiological responses to exercise, where increased ventilation can trigger airway reactivity. The 6MWT induces an acute, measurable reduction in large airway function in healthy males. This finding establishes that a degree of airway reactivity is a normal physiological response to submaximal exercise. Recognizing this baseline is essential for accurately differentiating normal post-exercise dynamics from pathological bronchoconstriction in clinical assessments.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

As a vital indicator of a person's general health and ability to engage in physical activity, the examination of respiratory health is an essential part of a thorough physiological evaluation (Blake *et al*., 2017). The lungs, through the intricate processes of ventilation and gas exchange, supply the oxygen necessary for aerobic metabolism and remove the resultant carbon dioxide, thereby sustaining cellular function throughout the body (Ionescu, 2013). Pulmonary Function Tests (PFTs), a group of noninvasive techniques intended to gauge how effectively the lungs are functioning, are used to objectively quantify the effectiveness of this system (Ranu *et al*., 2011). These tests are indispensable in clinical settings for diagnosing, monitoring, and managing a wide spectrum of respiratory diseases, including asthma, chronic obstructive pulmonary disease (COPD), and pulmonary fibrosis (Ranu *et al*., 2011). Beyond their diagnostic utility in pathology, PFTs are also routinely employed in healthy populations as part of routine physical examinations, for preoperative risk assessment, and to monitor the potential impact of occupational or environmental exposures on lung health.

Functional capacity is defined as the integrated ability of the cardiopulmonary, cardiovascular, and musculoskeletal systems to perform sustained aerobic work, a capability that underpins the performance of essential activities of daily living (Arena *et al*., 2007). A robust functional capacity is associated with an active lifestyle, a reduced risk of chronic disease, and enhanced quality of life. The evaluation of this capacity, therefore, offers profound diagnostic and prognostic insights across diverse clinical and research domains (Cossio-Bolaños *et al*., 2024).

The 6-Minute Walk Test (6MWT) has become a particularly useful instrument among the many approaches for evaluating functional ability (Agarwala & Salzman, 2020). The distance a person can walk on a level, hard surface in six minutes is measured by this straightforward, safe, affordable, and well standardized submaximal field test (American Thoracic Society, 2002). The test's self-paced nature accurately reflects the physiological demands of everyday activities, making it a more practical measure of functional status than maximal exercise tests for many individuals. While extensively validated and utilized in clinical populations with cardiopulmonary limitations (Arena *et al*., 2007), the 6MWT is also an effective instrument for evaluating aerobic capacity and endurance in healthy individuals. Its widespread adoption, guided by standardized protocols established by the American Thoracic Society (ATS), ensures its reliability and the comparability of results across different settings (Melliti et al., 2021a).

1.2 Statement of the Problem

The physiological response of the human respiratory system to physical exercise is a subject of extensive scientific inquiry. A large body of literature has characterized the changes in ventilation, gas exchange, and airway mechanics that occur during and after physical exertion. However, this research has predominantly focused on two distinct areas: the effects of maximal or near-maximal exercise protocols, or the respiratory responses within clinical populations suffering from cardiopulmonary diseases. While valuable, these areas of focus leave a significant gap in the understanding of respiratory physiology as it pertains to everyday life. Maximal exercise tests, by design, push physiological systems to their limits and do not represent the intensity of typical daily activities. Conversely, studies in clinical populations reveal responses that are modulated, and often confounded, by underlying pathophysiology.

A critical gap exists in the literature concerning the precise, acute effects of a standardized, submaximal exercise bout, one that is representative of common activities such as brisk walking, on a comprehensive panel of spirometric parameters in a healthy, asymptomatic adult male population. The 6-Minute Walk Test (6MWT) is widely employed as a tool to measure the *distance* an individual can walk, using this outcome as a proxy for functional capacity. However, its potential utility as a standardized physiological *stressor* to provoke and quantify immediate, measurable changes in lung function itself has been significantly underexplored. Without a clear understanding of the normative spirometric response to such a common and standardized test, the interpretation of post-exercise lung function changes in both research and clinical contexts remains incomplete.

1.3 Justification of the Study

A popular, straightforward method for determining functional exercise capacity is the 6-Minute Walk Test (6MWT). However, a critical gap exists in our understanding of its direct, acute impact on lung function itself, especially in healthy individuals.

While extensive research has focused on how maximal exercise or disease affects breathing, the response to a common, submaximal activity like brisk walking remains poorly documented. This study is justified by the urgent need to establish a normal physiological baseline. Currently, when clinicians and researchers see changes in lung function after a 6MWT in patients, they cannot easily distinguish between a sign of disease and a normal, temporary reaction to the exercise. By meticulously documenting how the lungs of healthy individuals respond, this study provides an essential reference point. This work is crucial for improving the accuracy of diagnoses and the validity of research in patients with heart and lung conditions, ensuring that a normal exercise response is not mistaken for a pathological one.

1.4 Research Questions

1. What is the baseline FVC, FEV1, FEV1/FVC ratio, and PEF in healthy adult male subjects?
2. What is the effect of the 6MWT on FVC, FEV1, FEV1/FVC ratio, and PEF immediately post-exercise?
3. Does the 6MWD and the percentage change in spirometric readings significantly correlate?

1.5 Objectives of the Study

The objectives of this study are to:

1. To determine the baseline lung function parameters (FVC, FEV1, FEV1/FVC ratio, PEF) in healthy adult males.
2. To assess the acute change in lung function parameters immediately following the 6MWT.
3. To evaluate the relationship between the Six-Minute Walk Distance (6MWD) and the magnitude of change in lung function parameters.

1.6 Scope of the Study

This investigation's scope is focused to ensure methodological rigor and clarity of results. The study will be limited to a cohort of healthy, non-smoking adult males aged 18 - 35 years. The primary experimental intervention will consist of a single, standardized 6MWT. The primary outcome measures are the core spirometric variables: FVC, FEV1, the FEV1/FVC ratio, and FEF25-75%. Secondary outcome measures will include the 6MWD, as well as pre- and post-test measurements of heart rate and SpO2.

1.7 Significance of the Study

The findings of this research are anticipated to hold significant value for both basic science and clinical application. Primarily, this study will generate crucial normative data on the acute respiratory response to a common and highly standardized form of submaximal exercise. By meticulously documenting the changes in lung function following a 6MWT in a healthy population, this work will establish a vital physiological baseline that is currently lacking in the scientific literature.

The significance of this research, however, extends beyond the simple cataloging of normative data; it aims to provide an essential "control" dataset that can directly inform and improve the interpretation of clinical research. Clinicians and researchers frequently utilize the 6MWT to assess functional capacity and treatment efficacy in patients with a wide range of cardiopulmonary diseases, such as COPD, pulmonary fibrosis, and heart failure (AgarwalaandSalzman, 2020). In many of these clinical trials and assessments, PFTs are performed before and after the 6MWT to evaluate disease progression or the impact of a therapeutic intervention. A fundamental challenge in interpreting these results is the inability to distinguish between changes caused by the underlying pathology and changes that represent a normal physiological adaptation to the exercise itself. Without a clear understanding of how a healthy respiratory system responds to the 6MWT stimulus, there is a significant risk of misattributing normal, transient exercise-induced physiological changes to a pathological process or a treatment effect. This study provides the essential reference point needed to make this distinction, thereby enhancing the accuracy of clinical assessments and the validity of research findings in patient populations. By defining the healthy response, this work will allow for a more nuanced and accurate interpretation of post-exercise spirometry across the entire spectrum of health and disease.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Respiratory System

The human respiratory system is a complex and highly efficient biological engine, fundamentally responsible for gas exchange, the process of supplying oxygen (O_2) to the bloodstream for distribution to the tissues of the body and removing metabolic waste product, carbon dioxide (CO_2) (Ionescu, 2013). Its function is so vital that even brief interruptions can have catastrophic consequences. A comprehensive understanding of its anatomy, the mechanics of breathing, and the principles of gas exchange provides the necessary foundation for interpreting measures of its function, such as those obtained through spirometry.

The upper and lower airways make to the structural division of the respiratory system (Ionescu, 2013). The nasal passages, pharynx, and larynx make up the upper airways, which filter, warm, and humidify incoming air (Mallik *et al*., 2020). The trachea, a membranous tube protected from collapse by C-shaped cartilaginous rings, is where the lower airways start (Ionescu, 2013). The right and left major bronchi, which enter the corresponding lungs, split off from the trachea at the carina level (Ionescu, 2013). Lobar bronchi, segmental bronchi, and eventually several million terminal bronchioles are the progressively smaller tubes that result from the bronchi's considerable branching throughout the lungs (Ranu *et al*., 2011). This intricate, tree-like structure, known as the bronchial tree, functions as a conductive pathway, moving air to the sites of gas exchange. The terminal bronchioles lead into the respiratory zone of the lungs, which consists of respiratory bronchioles, alveolar ducts, and finally, the alveoli, tiny, thin-walled air sacs that are the primary sites of gas exchange (Lamb *et al*., 2023).

The process of breathing, or ventilation, is a mechanical act driven by the muscles of respiration. The diaphragm, a big, dome-shaped muscle that divides the abdominal and thoracic chambers, is the main inspiration muscle (Ivanov, 2022). The diaphragm flattens and contracts during a quiet inspiration, expanding the thoracic cavity's vertical dimension (Ionescu, 2013). The anteroposterior and lateral dimensions of the chest are increased when the external intercostal muscles contract simultaneously, raising the rib cage up and out (Mallik *et al*., 2020). The lungs expand as a result of the thoracic cavity's expansion, which lowers intrapleural pressure (Ionescu, 2013). The resulting decrease in intrapulmonary pressure relative to atmospheric pressure creates a pressure gradient that drives air into the lungs (Lamb *et al*., 2023).

2.1.1 Lung Volumes and Capacities

Physiologists have established a number of standard volumes and capacities to measure the mechanical function of the lungs. These values are crucial for interpreting pulmonary function tests because they describe the volume of air in the lungs at various stages of the respiratory cycle. There are four primary lung volumes, which are discrete and do not overlap (Lamb *et al*., 2023):

Tidal Volume (TV or V_T): The volume of air inhaled or exhaled during a single, normal breath at rest. In a healthy adult, this is typically around 500 mL (Melliti *et al*., 2021).

Inspiratory Reserve Volume (IRV): The maximum additional volume of air that can be forcibly inhaled after the end of a normal tidal inspiration (Melliti *et al*., 2021).

Expiratory Reserve Volume (ERV): The maximum additional volume of air that can be forcibly exhaled after the end of a normal tidal expiration (Melliti *et al*., 2021).

Residual Volume (RV): The volume of air that remains in the lungs even after a maximal, forceful exhalation (Melliti *et al*., 2021). This volume is crucial as it prevents the complete collapse of the alveoli (Mallik *et al*., 2020).

From these four primary volumes, four lung capacities are derived. A capacity is the sum of two or more volumes:

Inspiratory Capacity (IC): The maximum volume of air that can be inhaled starting from the normal end-expiratory level (Mallik *et al*., 2020). It is the sum of Tidal Volume and Inspiratory Reserve Volume (IC = TV + IRV) (Mallik *et al*., 2020).

Functional Residual Capacity (FRC): The amount of air that is still in the lungs after a typical tidal expiration (Arena *et al*., 2007). It symbolizes the respiratory system's equilibrium point, where the lungs' inward recoil balances the chest wall's outward pull (Arena *et al*., 2007). It is the total of Residual Volume and Expiratory Reserve Volume (FRC = ERV + RV).

Vital Capacity (VC): The maximum volume of air that can be exhaled after a maximal inhalation. It represents the total usable volume of the lungs and is a critical measure of ventilatory capacity (Arena *et al*., 2007). It is the sum of Inspiratory Reserve Volume, Tidal Volume, and Expiratory Reserve Volume (VC = IRV + TV + ERV) (Arena *et al*., 2007).

Total Lung Capacity (TLC): The total volume of air the lungs can hold after a maximal inspiration (Mallik *et al*., 2020). It is the sum of all four lung volumes (TLC = RV + ERV + TV + IRV) or the sum of Vital Capacity and Residual Volume (TLC = VC + RV) (Mallik *et al*., 2020).

It is fundamentally important to recognize the limitations of different measurement techniques in assessing these volumes and capacities. Standard spirometry, which measures the flow and volume of air moving in and out of the lungs, can directly measure TV, IRV, ERV, IC, and VC (Arena *et al*., 2007). However, because it is impossible to voluntarily exhale the Residual Volume, spirometry cannot measure RV directly. Consequently, any capacity that includes RV, namely, FRC and TLC, cannot be determined by spirometry alone. The measurement of these specific volumes requires more advanced techniques, most commonly whole-body plethysmography or gas dilution methods (MedlinePlus, 2025).

2.1.2 Principles of Gas Exchange

The ultimate purpose of ventilation is to facilitate gas exchange between the air in the alveoli and the blood in the pulmonary capillaries (Melliti *et al*., 2021). This process occurs across the respiratory membrane (or alveolar-capillary membrane), an extremely thin barrier, approximately 0.5 micrometers thick, composed of the alveolar epithelial cells, the capillary endothelial cells, and their fused basement membranes (Ionescu, 2013). The vast surface area of this membrane, estimated to be around 70 square meters in a healthy adult, combined with its minimal thickness, creates ideal conditions for rapid diffusion (Ionescu, 2013).

Gas exchange is governed by the principles of partial pressures, as described by Dalton's Law and Henry's Law (Ionescu, 2013). The movement of each gas (O_2 and C O_2) occurs independently down its own partial pressure gradient (Mairbäurl, 2013). In the alveoli, the partial pressure of oxygen (P_aO_2) is high (around 104 mmHg), while in the deoxygenated blood arriving from the tissues via the pulmonary artery, the partial pressure of oxygen (P_vO_2) is low (around 40 mmHg) (MedlinePlus, 2025). This steep gradient drives the rapid diffusion of oxygen from the alveoli into the blood, where it binds to hemoglobin in red blood cells (Mairbäurl, 2013). Simultaneously, the partial pressure of carbon dioxide (P_v CO_2) in the venous blood is high (around 45 mmHg), while the alveolar partial pressure of carbon dioxide (P_aCO_2) is low (around 40 mmHg) (Ionescu, 2013). This gradient facilitates the diffusion of CO_2 from the blood into the alveoli, from where it is removed from the body during exhalation (Melliti *et al*., 2021).

The efficiency of this entire process can be quantified by measuring the diffusing capacity of the lung for carbon monoxide (DLCO) (Melliti *et al*., 2021). In this test, a patient inhales a small, harmless amount of carbon monoxide, and the amount exhaled is measured. The difference indicates how effectively gas is transferred from the lungs into the bloodstream (Ponce *et al*., 2025). A reduced DLCO can indicate damage to the alveolar-capillary membrane, as seen in diseases like pulmonary fibrosis, or a loss of surface area for gas exchange, as occurs in emphysema. While DLCO is not a primary measure in the current study, understanding its role provides a more complete picture of the multifaceted nature of pulmonary function.

2.2 Methodologies for Assessing Pulmonary Function

The evaluation of respiratory health relies on a list of objective, standardized procedures collectively known as Pulmonary Function Tests (PFTs). These tests provide quantitative data on the mechanical and gas-exchanging properties of the lungs, which are essential for diagnosing disease, monitoring its progression, and assessing therapeutic responses (Ranu *et al*., 2011). The main categories of PFTs include spirometry, which measures airflow and dynamic lung volumes; lung volume tests (e.g., body plethysmography), which measure static lung volumes including residual volume; and diffusion capacity tests (DLCO), which assess the efficiency of gas transfer into the blood (Ponce *et al*., 2025). Among these, spirometry is by far the most common, accessible, and widely utilized test, serving as the cornerstone of pulmonary function assessment in both clinical and research settings.

2.2.1 Spirometry: Principles and Standardized Procedure

Spirometry is a physiological test that measures the volume of air an individual can inhale and exhale as a function of time (Ponce *et al*., 2025). It is a noninvasive, effort-dependent test that provides critical information about the presence and severity of both obstructive and restrictive ventilatory defects. The primary maneuver in spirometry involves the patient taking a maximal, deep inhalation followed immediately by a forced, rapid, and complete exhalation that continues for as long as possible, typically for at least six seconds in adults (Lamb *et al*., 2023)

The validity and reproducibility of spirometry results are critically dependent on strict adherence to standardized procedures, as outlined by joint guidelines from the American Thoracic Society (ATS) and the European Respiratory Society (ERS). The quality of the data hinges on three key factors: patient cooperation, effective coaching by the test administrator, and proper equipment calibration. Before the test, the procedure must be clearly explained and demonstrated to the patient (Lamb *et al*., 2023). During the maneuver, the patient is vigorously coached to ensure a maximal effort is exerted from the very beginning and sustained throughout the exhalation. To prevent air leakage through the nose, the use of a nose clip is standard practice.

To ensure the results are reliable, the ATS/ERS guidelines mandate specific criteria for acceptability and reproducibility. An acceptable maneuver must show a rapid start (i.e., minimal hesitation), be free from artifacts such as coughing or glottic closure, and demonstrate a clear end-of-test plateau on the volume-time curve. For a test session to be considered valid, the patient must perform a minimum of three acceptable maneuvers. Furthermore, these maneuvers must be reproducible: the difference between the two largest Forced Vital Capacity (FVC) values and the two largest Forced Expiratory Volume in one second (FEV1) values must each be within 150 mL (or 100 mL if the FVC is less than 1.0 L) (Moore, 2012).

2.2.2 Key Spirometric Parameters and Their Interpretation

Spirometry yields several key parameters that, when interpreted together, provide a detailed picture of an individual's ventilatory function.

Forced Vital Capacity (FVC): This is the total volume of air, measured in liters, that can be forcibly and completely exhaled after a maximal inspiration (Ponce *et al*., 2025). The FVC is a fundamental measure of lung size or volume (Cossio-Bolaños *et al*., 2024). A reduced FVC (typically defined as less than 80% of the predicted value for an individual) is the hallmark of a restrictive ventilatory defect. Restrictive defects are conditions that limit lung expansion, such as pulmonary fibrosis (scarring of lung tissue), diseases of the chest wall (e.g., scoliosis), or neuromuscular weakness affecting the respiratory muscles (Ponce *et al*., 2025).

Forced Expiratory Volume in 1 Second (FEV1): This is the volume of air, also in liters, that is exhaled during the first second of the FVC maneuver. The FEV1 is a critical measure of airflow and reflects the caliber of the larger and medium-sized airways. A reduced FEV1 is the primary indicator of an obstructive ventilatory defect. Obstructive diseases, such as asthma, chronic bronchitis, and emphysema, are characterized by increased airway resistance, which slows the rate of expiratory airflow.

FEV1/FVC Ratio: This is the ratio of FEV1 to FVC, expressed as a percentage (FEV1/FVC \times 100). This ratio is the most important parameter for distinguishing between obstructive and restrictive patterns. In a healthy adult, the FEV1/FVC ratio is typically between 70% and 85%, declining slightly with age (Melliti *et al*., 2021).

An **obstructive pattern** is defined by a disproportionate reduction in FEV1 relative to FVC, resulting in a *low* FEV1/FVC ratio (e.g., < 70%). This indicates that airflow is limited.

In a **restrictive pattern**, both FEV1 and FVC are reduced proportionally due to the smaller lung volume. Consequently, the FEV1/FVC ratio is typically normal or even elevated (> 80%).

Forced Expiratory Flow (FEF25-75%): This parameter, also known as the mid-expiratory flow rate, measures the average rate of airflow during the middle half of the FVC maneuver (i.e., from the point where 25% of the FVC has been exhaled to the point where 75% has been exhaled). The FEF25-75% is considered to be a more sensitive indicator of obstruction in the smaller, peripheral airways than the FEV1. A reduced FEF25-75% can be an early sign of small airway disease, sometimes appearing before a significant reduction in FEV1 is detectable (Kwon *et al*., 2020).

Table 2. 1: Key Spirometric Parameters and Their Physiological Significance

Parameter	**Definition**	**Physiological Significance**

Parameter	Definition	Physiological Significance
FVC	Forced Vital Capacity: The total volume of air that can be forcibly exhaled after a maximal inspiration (American Thoracic Society, 2002).	Represents the usable volume of the lungs; a measure of lung size. Reduced in restrictive diseases.
FEV1	Forced Expiratory Volume in 1 Second: The volume of air forcibly exhaled in the first second of the FVC maneuver (American Thoracic Society, 2002).	Reflects the caliber of the large and medium-sized airways. Reduced in obstructive diseases.[4]
FEV1/FVC Ratio	The ratio of FEV1 to FVC, expressed as a percentage (American Thoracic Society, 2002).	The primary indicator for differentiating obstructive (<70-80%) from restrictive (normal or high) patterns.
FEF25-75%	Forced Expiratory Flow 25-75%: The average rate of airflow during the middle portion of the FVC (American Thoracic Society, 2002).	Considered a sensitive measure of airflow in the small peripheral airways. May indicate early obstruction.
PEF	Peak Expiratory Flow: The maximum speed of expiration achieved during the FVC maneuver (American Thoracic Society, 2002).	Reflects large airway function and expiratory muscle strength. Useful in monitoring conditions like asthma.

2.3 SIX MINUTE WALK TEST: CONCEPT AND PROTOCOL

The six-minute walk test (6MWT) is a widely-used submaximal field walking test to evaluate functional exercise capacity (Cox *et al.*, 2017). The 6MWT is a safe, inexpensive, and straightforward test commonly used for assessment and as an outcome measure, using the distance walked (6MWD) as the primary outcome (Baillot *et al*., 2015). The test gained significant prominence and widespread acceptance following the publication of standardized guidelines by the American Thoracic Society (ATS) in 2002 (Kammin, 2022). These comprehensive guidelines provided a consistent methodology for administering the 6MWT, which was crucial for ensuring the reproducibility and comparability of results across different clinical sites and research studies (Du *et al*., 2009). Prior to this standardization, variations in test protocols often led to inconsistent findings, making it challenging to synthesize data and establish reliable reference values. The ATS guidelines thus transformed the 6MWT into a robust and dependable tool for both clinical assessment and scientific inquiry. These standardized protocols ensure consistency in test administration across different settings and populations, enabling meaningful comparison of results and facilitating the development of normative values (Kammin, 2022).

The European Respiratory Society (ERS) later formalized its place in clinical practice by issuing guidelines for standardized administration, reinforcing its legitimacy (Holland *et al.,* 2014). It is valid and reliable in young and adult, healthy and diseased populations such as chronic obstructive pulmonary disease, pulmonary fibrosis, heart failure, and amputees (Cox *et al.,* 2017; Mänttäri *et al.,* 2018). As the test is self-paced and rests are allowed, it is considered an appropriate assessment of exercise capacity for individuals suffering from respiratory-related symptoms and the general geriatric population (Yohannes and Connolly, 2004). Further, a study by Kervio *et al.* (2005) explored the test's applicability in cardiac rehabilitation, confirming its reliability in measuring submaximal exercise capacity.

The methodology of the 6MWT is well-defined in the American Thoracic Society (ATS) guidelines, which recommend a 30-meter flat corridor, continuous timing, and standardized encouragement (ATS, 2002). A study by Beekman *et al.,* (2013) emphasized the importance of standardized instructions and consistent encouragement, as variability here can impact test outcomes. Key aspects of this standardization include:

Testing Environment: The ATS guidelines strongly recommend performing the 6MWT indoors, along a flat, straight, hard-surfaced, and minimally trafficked corridor. The ideal corridor length is 30 meters (approximately 100 feet). Clear markings should be placed every 3 meters along the corridor, and turnaround points at each end must be distinctly indicated, typically with bright orange traffic cones (Kammin, 2022). The rationale for a 30-meter corridor is critical: shorter corridors necessitate more frequent turns, which can reduce the total 6MWD due to the time and effort expended in changing direction (Agarwala and Salzman, 2020). Studies have shown that continuous (oval) tracks can result in longer walk distances compared to straight tracks, further emphasizing the impact of track layout (Kammin, 2022). The use of a treadmill is explicitly not recommended, as it prevents patients from self-pacing, leading to shorter and non-interchangeable distances compared to corridor tests (American Thoracic Society, 2002).

Equipment: Essential equipment for a standardized 6MWT includes a stopwatch or countdown timer, a mechanical lap counter to accurately track completed laps, two small cones for turnaround points, a movable chair (for resting if needed), and worksheets on a clipboard for recording data (AgarwalaandSalzman, 2020). Additionally, a sphygmomanometer for blood pressure measurement, a source of oxygen for emergency use, and a telephone for rapid emergency response are crucial safety provisions. A pulse oximeter for measuring heart rate (HR) and oxygen saturation (SpO2) is highly recommended, as is the Borg Breathlessness Scale for assessing perceived exertion (RPE) (American Thoracic Society, 2002).

Patient Preparation: Prior to the test, participants should be instructed to wear comfortable clothing and appropriate walking shoes (American Thoracic Society, 2002). They should continue their usual medical regimen, and any regular walking aids (e.g., cane, walker) must be used during the test and documented (American Thoracic Society, 2002). To ensure consistent effort and avoid acute fatigue, vigorous exercise should be avoided within two hours preceding the test (American Thoracic Society, 2002). A light meal is generally acceptable before morning or early afternoon tests. Resting vital signs, including heart rate, blood pressure (systolic and diastolic), oxygen saturation, and perceived exertion (using the Borg scale), should be accurately recorded before the test commences (Agarwala and Salzman, 2020).

Instructions and Encouragement: Standardized instructions are paramount to ensure that all participants understand the test's objective and perform with consistent effort. The patient is clearly told, "The object of this test is to walk as far as possible for 6 minutes. You will walk back and forth in this hallway." They are also informed that they may get out of breath or tired and are permitted to slow down, stop, or rest as necessary, but should resume walking as soon as they are able (American Thoracic Society, 2002). Running or jogging is explicitly prohibited. Crucially, standardized verbal encouragement must be provided at specific intervals (e.g., every minute) to optimize effort and minimize variability in performance due to motivational factors. This consistent encouragement helps to standardize the intensity of effort across different individuals and studies, which has been identified as a significant factor influencing 6MWD (Agarwala and Salzman, 2020; American Thoracic Society, 2002; Kammin, 2022).

Endpoints and Safety Considerations: The test concludes precisely at the six-minute mark, at which point the total distance walked is measured to the nearest meter (American Thoracic Society, 2002). Immediately following the test, post-test physiological parameters (heart rate, blood pressure, oxygen saturation, and perceived exertion) are recorded again (American Thoracic Society, 2002). If a patient stops during the test, the timer is not paused; the time of stopping and restarting, along with the reason for cessation, must be documented (American Thoracic Society, 2002). Reasons for immediate test termination include intolerable dyspnea, chest pain, leg cramps, staggering, diaphoresis, or a pale/ashen appearance. A persistent drop in SpO2 below 80% is also a critical stopping criterion. Test administrators must be certified in basic life support and cardiopulmonary resuscitation to manage potential complications, although the 6MWT is generally considered a safe test with rare complications (American Thoracic Society, 2002; Kammin, 2022; Shabbir *et al*., 2021).

The ATS guidelines also address factors affecting reproducibility and reliability (American Thoracic Society, 2002). A "learning effect" is commonly observed, where individuals tend to walk slightly farther in a second test compared to the first, often showing a 2-8% improvement (Agarwala and Salzman, 2020). To account for this, it is recommended to perform at least two tests, with the best distance recorded, and to allow adequate rest (a minimum of 30 minutes) between tests if conducted on the same day. Inconsistent verbal encouragement or variations in track layout and length can also significantly influence results, further underscoring the need for strict adherence to the standardized protocol (American Thoracic Society, 2002; Pepera *et al*., 2023).

The following table summarizes key methodological guidelines, normative data, and influential factors for the 6MWT, providing a comprehensive overview for context and comparison.

Table 2. 2: Key ATS Guidelines for 6MWT Administration

Aspect	Guideline/Recommendation
Test Environment	Indoors, flat, straight, hard surface, minimally trafficked corridor.
Corridor Length	Recommended 30 meters (100 feet). Shorter corridors reduce 6MWD due to more turns.
Markings	Every 3 meters, cones at turnaround points. Starting line clearly demarcated.
Equipment	Stopwatch/countdown timer, mechanical lap counter, 2 cones, movable chair, worksheets, sphygmomanometer. Optional: Pulse oximeter, Borg scale.
Patient Preparation	Comfortable clothing, appropriate shoes, use usual walking aids (document). No vigorous exercise within 2 hours prior. Light meal acceptable.
Pre-test	Resting Heart Rate (HR), Blood Pressure (Systolic and Diastolic),

Measurements	Oxygen Saturation (SpO2), Perceived Exertion (Borg scale).
Instructions	"Walk as far as possible for 6 minutes." Permission to slow down/stop/rest. No running/jogging. Demonstrate turning.
Encouragement	Standardized phrases at specific time intervals (e.g., every minute).
During Test	If the patient stops during testing, the timer is not stopped, but a notation on the time of stopping and restarting should be noted (American Thoracic Society, 2002). Reason for premature cessation of testing by patient documented (e.g., chest pain, intolerable dyspnea, joint, or back or leg pain) (American Thoracic Society, 2002). Assessor can terminate testing based on patient appearance or if oxygen saturation is <80% (American Thoracic Society, 2002).
Post-test Measurements	Immediate HR, BP, SpO2, Perceived Exertion.
Safety Considerations	Assessors should be certified in basic life support and cardiopulmonary resuscitation. Reasons for immediate test termination (e.g., chest pain, intolerable dyspnea, SpO2 < 80%)

	(American Thoracic Society, 2002). Access to emergency equipment should be available. This can include a crash cart, sublingual nitroglycerin, and bronchodilators(American Thoracic Society, 2002).

Table 2.1 provides a summary of the 6MWT procedural guidelines by the American Thoracic Society (ATS) (American Thoracic Society, 2002; Kammin, 2022).

The primary test outcome is the final distance walked (6MWD). Among healthy individuals, the average 6MWD is between 400 and 700 meters (Enright, 2003). This range overlaps with data reported in other populations (Britto *et al.,* 2013). Factors associated with variability in test performance among healthy subjects include weight and age (Chetta *et al.,* 2006). The longest distance walked by the patient should be taken as the actual result since there is a learning effect associated with improved walking distance when at least two tests are conducted (Enright, 2003). Other factors that may affect the 6MWD in healthy adults include the methodology for 6MWT and the percentage of peak heart rate achieved (Holland *et al.,* 2014).

The contraindications to the 6MWT is having a history of an acute coronary syndrome (either unstable angina or myocardial infarction) within 30 days prior to the test as well as severe, uncontrolled hypertension and a resting heart rate greater than 120 beats per minute (ATS, 2002).

CHAPTER THREE

3.0 METHODOLOGY

3.1 AREA OF STUDY

This study was carried out within the University of Benin, Benin City, Edo State.

3.2 STUDY DESIGN

This study was a sustained-experiment (Pre-Post intervention/experiment) design aimed at assessing the effects of the 6 Minutes' Walk Test (6MWT) on pulmonary parameters in healthy male adults.

3.3 STUDY POPULATION

The study population consisted of a total number of Eighty-nine (89) healthy adult male undergraduate subjects attending the University of Benin. The age range for this study population is between 18-29 years.

Criteria for inclusion includes:

a) Healthy male aged 18-29 years

b) Ability to perform physical activity.

c) Good Body Mass Index (BMI).

d) Informed consent provided.

Criteria for exclusion includes:

a) Acute Illness or recent vaso-occlusive crisis.

b) Low/Poor body mass index (BMI<16).

c) Acute illness within the last 4 weeks.

d) History of asthma or other chronic respiratory conditions.

e) Inability to perform the 6MWT or spirometry.

3.3 SAMPLING PROCEDURE AND SAMPLING SIZE

The sampling procedure involved a baseline assessment in which patients rested in a seated position for 5-10 minutes.

1. Baseline measurements that were taken Pre 6MWT includes:

(a) Cardiopulmonary Parameters: Heart Rate (HR) via Digital sphygmomanometer, Respiratory Rate (RR) via the spirometer, Blood Pressure (BP) via Digital sphygmomanometer, and Oxygen Saturation (SpO_2) via the Pulse Oximeter.

(b) Hematological Indices: Blood samples (3-5mL) was collected to measure the Full Blood cell count using standard laboratory methods.

2. The 6 minute walk test (6WMT): This Walk test was carried out/conducted according to the American Thoracic Society (ATS) guidelines (American Thoracic Society, 2002):

    - Participants walked on a flat straight, 30-meters track.
    - Instructions were given to walk at their own pace, aiming to cover as much distance as possible in six minutes.
    - HR and SpO_2 was continuously monitored, Blood Pressure (BP) and Respiratory Rate (RR) was measured immediately after the test.
    - The total distance walked was measured and recorded.

3. Post-test Assessment:

    (a) Immediately post-walk: Heart Rate (HR), Respiratory Rate (RR), and oxygen saturation (SpO_2) were measured and recorded.

3.4 INSTRUMENT FOR DATA COLLECTION

The following instruments and equipment was used to collect data in this study:

i. Stopwatch: Used to accurately time the duration of the Six minute walk test (6MWT).

ii. Measuring tape/ Calibrated walk track: A 30-meter flat walking track was used, marked clearly for distance measurement. A calibrated measuring tape confirmed the distance covered.

iii. Digital Sphygmomanometer: To measure blood pressure (Systolic and Diastolic) before and after the 6MWT.

iv. Pulse Oximeter: For measuring oxygen saturation (SpO_2) and pulse rate (Heart rate) at rest and Post-test.

v. Data Collecting sheets/questionnaires: Structured forms was used to record base line and post-test cardiopulmonary parameters and laboratory results for each participants

vi. Personal protective equipment.

3.5 VALIDATION OF RESEARCH INSTRUMENTS

To ensure the accuracy, reliability and validity of the instruments used in this study the following validation measures were taken:

i. Standardization of instruments

ii. Pretesting (Pilot testing): A pilot test will be conducted on a control group of individuals (males) with a minimum of 40.

iii. Expert validation.

iv. Instrument reliability checks.

v. Environmental Control.

3.6 RELIABILITY OF RESEARCH INSTRUMENTS

In this study the reliability of research instruments is crucial to ensure consistency and dependability of measurements. The following steps were taken to establish and maintain instrument reliability:

i. Use of clinically approved and calibrated equipment.
ii. Test-Retest Reliability: In this study for the use of cardiopulmonary parameters such as blood pressure, heart rate, oxygen saturation, duplicate measurements were taken at baseline and compared. A minimal difference between repeated values indicated high test-retest reliability of the instrument.
iii. Internal consistency in laboratory measurements.
iv. Standard Operating procedures (SOP's): All measurements and procedures were carried out according to internationally accepted standard operating procedures:

- The 6MWT followed the American Thoracic Society (ATS) guidelines.
- Blood sample collection and Analysis adhered to clinical hematology SOP's.

v. Environmental and procedural control.

3.7 Ethical Considerations

All experimental procedures were conducted in strict accordance with the guidelines of the EthicsCommittee of the College of Medical Sciences, University of Benin, Edo State, Nigeria (Approval ID: CMS/REC2025/79).

3.8 STATISTICAL ANALYSIS

Data was analysed using the GraphPad Prism version 8.1. The result was presented as mean +- standard error of mean. Unpaired student t-test will be used and P value of 0.05 was considered statistically significant.

CHAPTER FOUR

4.0 RESULTS

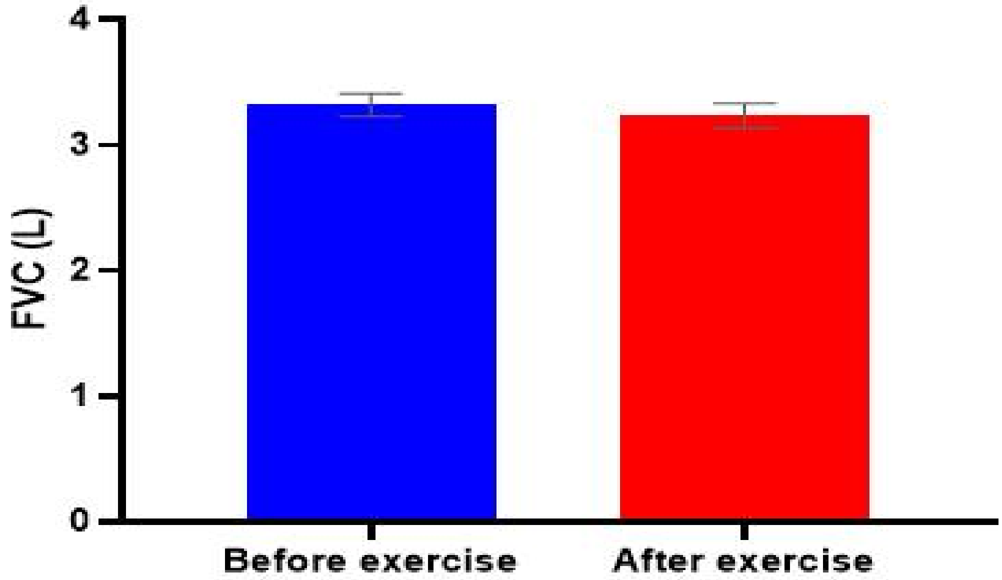

Figure 4. 1**: Showed FVC before and after six (6) minute walk exercise in young adult male**

There was no significant changes after exercise compared with before the exercise

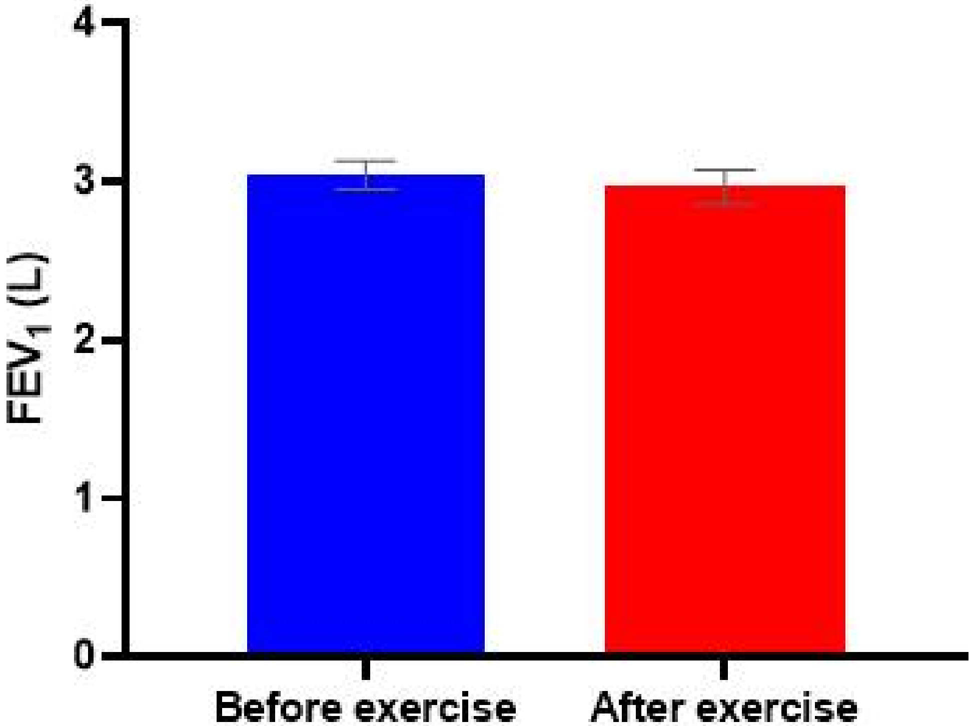

Figure 4. 2**: Showed FEV_1 before and after six (6) minute walk exercise in young adult male**

There was no significant changes after exercise compared with before the exercise

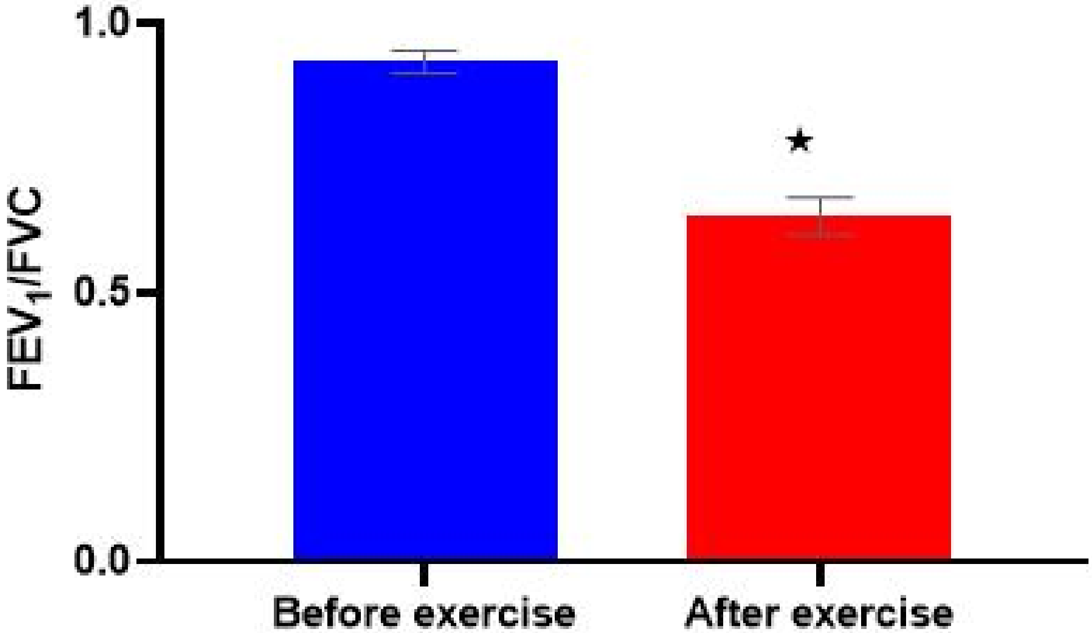

Figure 4. 3**: Showed FEV$_1$ /FVC before and after six (6) minute walk exercise in young adult male**

There was a significant reduction after exercise relative to before the exercise

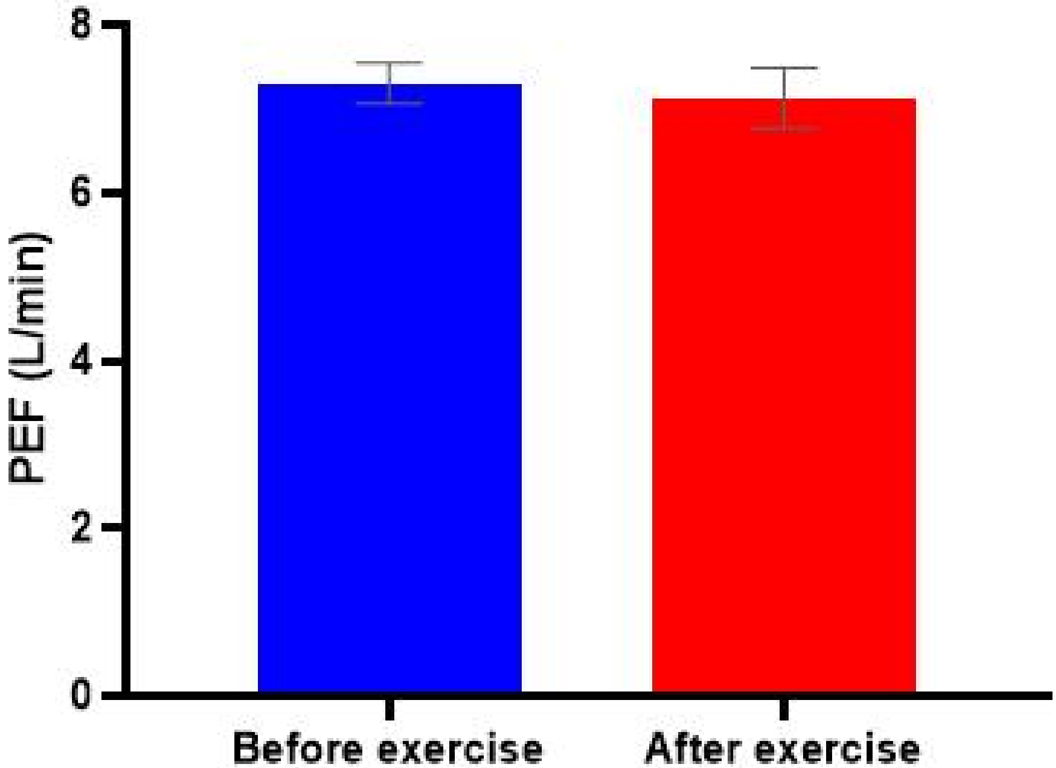

Figure 4. 4**: Showed PEF before and after six (6) minute walk exercise in young adult male**

There was no significant changes after exercise compared with before the exercise

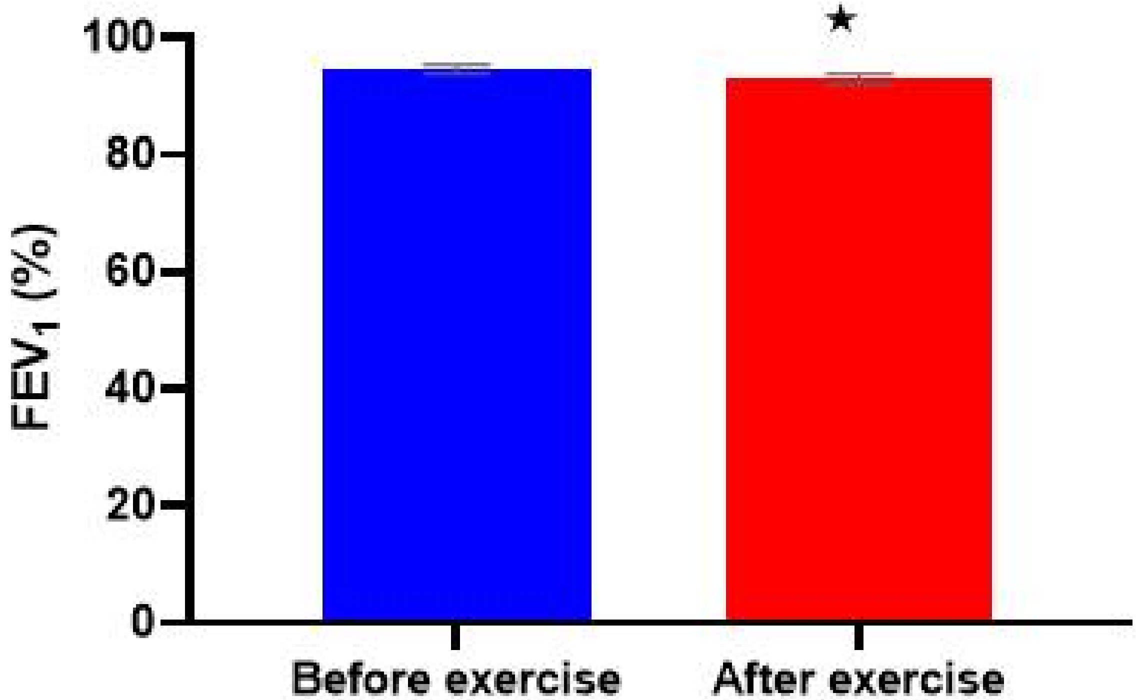

Figure 4. 5**: Showed FEV_1 before and after six (6) minute walk exercise in young adult male**

There was a significant reduction after exercise relative to before the exercise

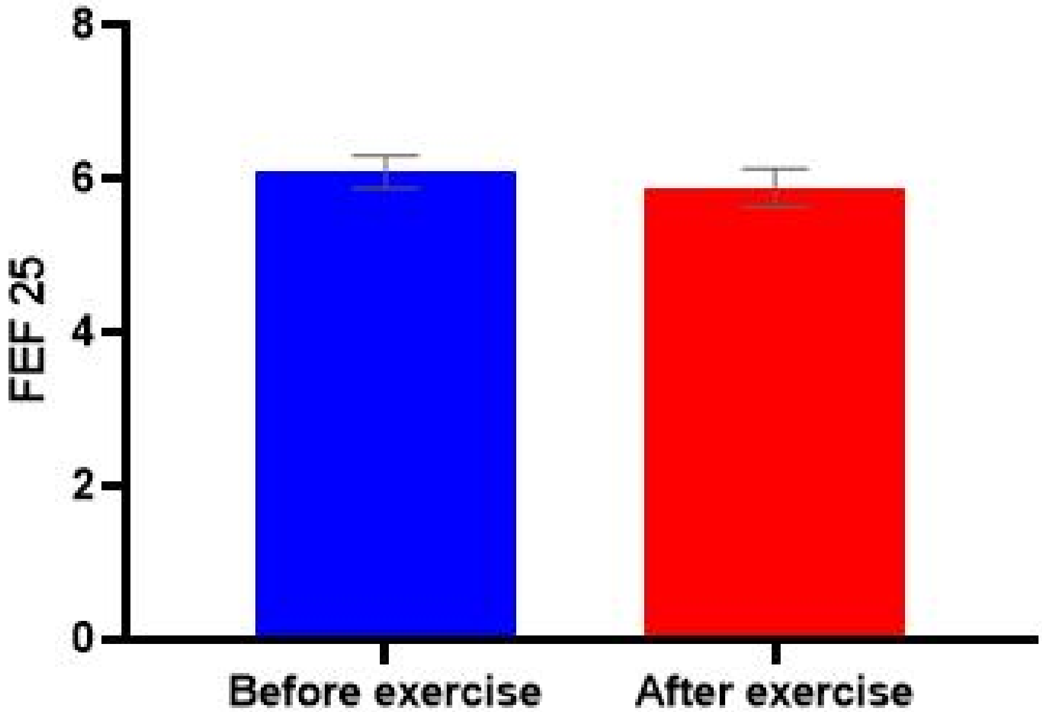

Figure 4. 6**: Showed FEF25 before and after six (6) minute walk exercise in young adult male**

There was no significant changes after exercise compared with before the exercise

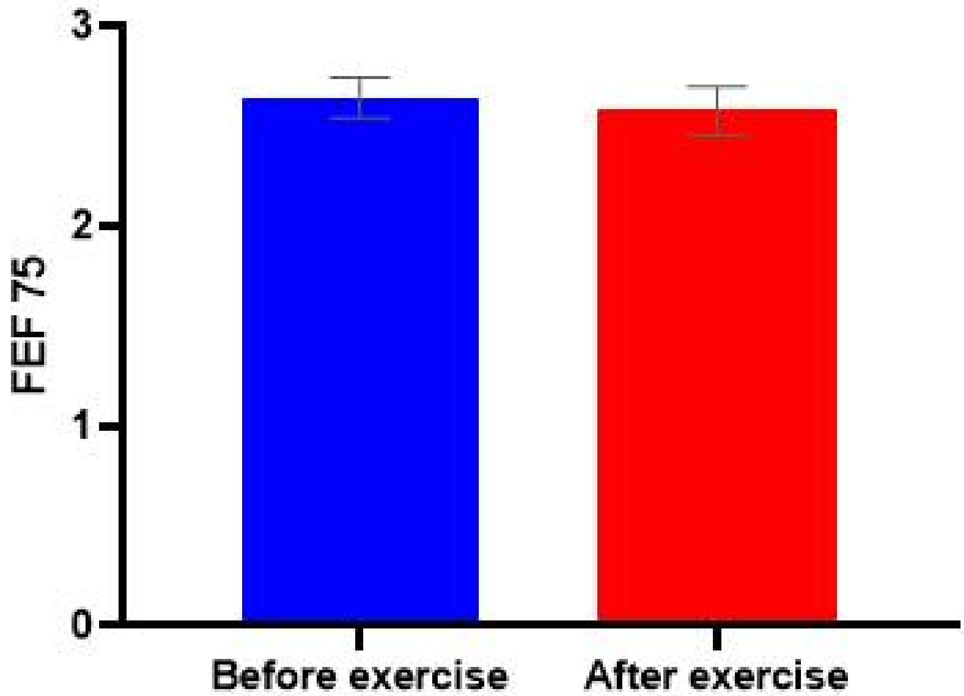

Figure 4. 7**: Showed FEF75 before and after six (6) minute walk exercise in young adult male**

There was no significant changes after exercise compared with before the exercise

CHAPTER FIVE

5.0 DISCUSSION AND CONCLUSION

5.1 DISCUSSION

This study aimed to investigate the acute effects of a submaximal functional exercise, the 6-Minute Walk Test (6MWT), on specific lung function parameters in healthy adult males.

The first objective was to determine the baseline lung function parameters (FVC, FEV1, FEV1/FVC ratio, PEF) in the studied cohort. The baseline values recorded in this study were within normal predicted ranges for healthy adult males (Eksombatchai *et al*., 2021). This confirms that the study population started from a point of normal respiratory health, which is crucial for accurately interpreting the changes induced by the 6MWT. A normal baseline ensures that any observed alterations are likely due to the exercise stimulus rather than pre-existing respiratory impairment.

The study found no significant changes in Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1) immediately after the 6MWT. This stability aligns with the expected physiology of submaximal exercise in healthy individuals. The 6MWT is a self-paced, submaximal test designed to assess functional capacity, not to induce maximal stress on the respiratory system (American Thoracic Society, 2002). Unlike high-intensity exercise, which can lead to respiratory muscle fatigue or dynamic hyperinflation, a phenomenon more commonly observed in patient populations like those with COPD (Blake *et al*., 2017), a 6-minute walk at a moderate pace does not typically overwhelm the ventilatory capacity of healthy lungs. The respiratory system can meet the increased demand for gas exchange without compromising its ability to perform a maximal forced maneuver immediately after.

A key finding was the statistically significant reduction in the FEV1/FVC ratio after the test. Since FVC remained stable, a decrease in this ratio suggests a relative, albeit small, reduction in FEV1. This can be explained by physiological changes in the airways following exercise.

Physical exertion can lead to a transient increase in airway resistance. This may be due to the release of inflammatory mediators like histamine or a temporary "fatigue" of the smooth muscles supporting the small airways, making them slightly more collapsible during a forced expiration (Arena *et al*., 2007; Cossio-Bolaños *et al*., 2024). This would disproportionately affect the FEV1, which is highly dependent on airflow in the initial second of exhalation. This finding is consistent with recent research. A 2025 study investigated the acute effects of the 6MWT on respiratory system resistance in healthy adults and found a significant *reduction* in parameters like R5 and R20 (measures of total and central airway resistance) immediately post-exercise (Roberts *et al*., 2022). The authors suggested that submaximal exercise might acutely reduce respiratory impedance, possibly through the dilation of airways due to increased sympathetic (adrenaline) drive. The slight decrease in the FEV1/FVC ratio observed in your study could be part of this complex, immediate post-exercise adjustment in airway caliber and resistance. The results for PEF, FEF25, and FEF75 showed no significant changes. However, one result indicated a significant reduction in FEV1 (in isolation) and another in FEF25-75%. The FEF25-75% is often considered a sensitive indicator of small airway function. Its potential reduction, coupled with a stable FVC, could point toward a mild, transient effect of exercise on the smaller, more peripheral airways.

5.2 CONCLUSION

In conclusion, 6MWT induces an acute, measurable reduction in large airway function in healthy males. This finding establishes that a degree of airway reactivity is a normal physiological response to submaximal exercise. Recognizing this baseline is essential for accurately differentiating normal post-exercise dynamics from pathological bronchoconstriction in clinical assessments.

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APPENDICES

APPENDIX I

SIX MINUTES WALK TEST QUESTIONNAIRE

Subject Session

1. Are you currently taking any medications? [ ] Yes [ ] No

If yes, please specify:

____

____
____
____

2. Have you had an ECG test in the last 5 months?[ ] Yes [ ] No

If yes, what was the result? ______________________________________

3. Have you had any recent surgery? [ ] Yes [ ] No

If yes, please specify the type and date:
____
____
____
____

4. Have you had a heart attack in the last 4 weeks? [ ] Yes [ ] No

5. Have you experienced chest pain in the last 4 weeks? [ ] Yes [ ] No

6. Do you mind if a blood sample is taken for this test? [ ] Yes [ ] No

7. Please describe your current state of health:
____
____

____
____

8. Do you smoke? [ ] Yes [ ] No

If yes, how many cigarettes per day? ____________________

9. Do you experience shortness of breath? [ ] Yes [ ] No

If yes, please describe when it occurs and how severe it is: ____
____
____
____

10. Are you asthmatic? [ ] Yes [ ] No

11. When was your last meal?

Please signify in hours: ____