A COMPARATIVE STUDY OF THE CARDIOPULMONARY FUNCTION IN ATHLETES AND SEDENTARY WORKERS

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CERTIFICATION

This is to certify that this project on **A COMPARATIVE STUDY OF THE CARDIOPULMONARY FUNCTION IN ATHLETES AND SEDENTARY WORKERS** was carried out by **OTAIGBE VALERIE EHIAGHE** with matriculation number **BMS1708733** in partial fulfilment for the award of Bachelor of science (B.Sc.) Degree in the Department of Physiology, School of Basic Medical Sciences, College of Medical Sciences, University of Benin, Benin City.

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ABSTRACT

Sedentary behaviour and physical inactivity are among the leading modifiable risk factors worldwide for cardiopulmonary disease and all-cause mortality while physically active persons reduce their risk of developing type 2 diabetes mellitus, hypertension, and cardiovascular disease. Evidence is accumulating that sedentary behaviour might be associated with increased cardiopulmonary-specific and overall mortality. Insufficient physical activity predicts premature cardiopulmonary disease mortality and disease burden. This study is aimed at investigating the cardiopulmonary function in athletes and sedentary workers using a range of indices including Blood Pressure (BP), Forced Vital Capacity (FVC), Forced Expiratory Volume$_1$ (FEV$_1$), Peak Expiratory Flow Rate (PEFR), Body Mass Index (BMI) and Pulse Rate (PR). 100 apparently normal healthy adult males were recruited for this study. They were selected into 5 groups with 10 subjects per range (range = 10) of athletes and sedentary workers. The result revealed that there were significant differences in the cardiopulmonary parameters and BMI across all groups. At the end of this study, the cardiopulmonary parameters showed significant differences in athletes than in sedentary workers mostly due to their physical condition, hence, sedentary workers are recommended to alternate their lifestyle to live a healthier life.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Evidence is accumulating that sedentary behaviour might be associated with increased cardiopulmonary-specific and overall mortality (Abiodun *et al.,* 2014, Oloroso *et al.,* 2016, Murray *et al.,* 2018). Insufficient physical activity predicts premature cardiopulmonary disease mortality and disease burden.

Physical activity medically and epidemiologically refers to activities that lead to a substantial increase in oxygen consumption (Gerald *et al.,* 2014). Regular sports practice has undeniable beneficial effects for health in general and especially for the cardiovascular system. However, regular, intense and prolonged physical activity, although beneficial, leads to clinical, electrical, morphological and functional changes in the cardiovascular system. These cardiovascular changes seen in high-level athletes are known as “athlete’s hearts” and are benign (Folsom *et al.,* 2016).

It is also true that the risk of a cardiopulmonary event is temporarily increased during an intense sport practice that may reveal an unknown heart disease. The causes of non-traumatic sudden death in sports fields are 85% - 90% of cases of cardiopulmonary origin and are secondary to cardiac arrhythmias (Gerald *et al.,* 2018, Murry *et al.,* 2019). Thus recommendations have been formulated for sporting practice (Henry and Tolbert, 2018).

Sedentary behavior is associated with a wide range of negative health outcomes, including an increased risk for obesity, cardiometabolic disease, and all-cause mortality (Maxwell *et al.,* 2017). Even though an athlete exercises regularly, the time that they spend in sedentary mode may have a significant impact on their health and performance. The term “sedentary athlete syndrome” has not been widely used in the research community, but that does not mean that the topic has been ignored. Several studies have been conducted in the past 20 years investigating the impact of sedentary behavior on people who participate in different levels of athletic activity.

Intensive regular physical exercise training is associated with a physiological increase in left ventricular (LV) wall thickness, cavity size and mass (Richardson *et al.,* 2011). The extent to which LV dilatation and hypertrophy are altered depends on the type of physical training, endurance or strength. This cardiac remodeling observed in the athletes is associated with the specific haemodynamic requirements of the exercise undertaken. It remains a question whether the athlete’s heart is merely a physiologic phenomenon or poses cardiovascular risk. Studies up to now about athlete’s heart primarily includes echocardiographic evaluation to detect morphological and functional changes. There were conflicting results of these studies about systolic and diastolic functional changes in athlete’s heart.

1.2 JUSTIFICATION OF STUDY

Sedentary behaviour and physical inactivity are among the leading modifiable risk factors worldwide for cardiopulmonary disease and all-cause mortality. The promotion of physical activity and exercise training (ET) leading to improved levels of cardiorespiratory fitness is needed in all age groups, race, and ethnicities and both sexes to prevent many chronic diseases, especially cardiovascular disease. Recently, a major emphasis has been directed at making health promotion a priority, including the promotion of PA and exercise training (ET) and improving levels of cardiorespiratory fitness (CRF) in the United States and worldwide in efforts to prevent chronic diseases, especially CVD (Wells *et al.,* 2018).

1.3 AIM OF STUDY

This study is aimed at investigating the cardiopulmonary function in athletes and sedentary workers.

1.4 RESEARCH QUESTIONS

- What is the effect of sedentary lifestyle on some cardiovascular functions (SBP, DBP, Pulse Rate, BMI)?
- What is the effect of sedentary lifestyle on some pulmonary/respiratory functions (FVC, FEV_1, PEFR)?
- What is the effect of athletic lifestyle on some cardiovascular functions (SBP, DBP, Pulse Rate, BMI)?
- What is the effect of athletic lifestyle on some pulmonary/respiratory functions (FVC, FEV_1, PEFR)?

1.5 SPECIFIC OBJECTIVES

- To determine the effects of sedentary lifestyle on some cardiovascular functions (SBP, DBP, Pulse Rate, BMI).

- To determine the effects of sedentary lifestyle on some pulmonary/respiratory functions (FVC, FEV_1, PEFR).
- To determine the effects of athletic lifestyle on some cardiovascular functions (SBP, DBP, Pulse Rate, BMI).
- To determine the effect of athletic lifestyle on some pulmonary/respiratory functions (FVC, FEV_1, PEFR).

CHAPTER TWO

LITERATURE REVIEW

2.1 THE CARDIOVASCULAR SYSTEM

The primary function of the cardiovascular system is the transport of oxy-gen, carbon dioxide, nutrients, waste products within the body. Since the body undergoes major changes during its life cycle, the capability of the cardiovascular system to accommodate vastly increasing body demands is a vital requirement (Tringelo *et al.*, 2007).

The system consists primarily of the heart, which serves as the pump, the blood, which serves as the conducting medium, and the vasculature, which serves as the conduit through which the blood flows (Humphrey, 2002).

Blood pressure (BP) is an important risk factor for cardiovascular disease, and it is a key component of any formula that predicts cardiovascular risk (Anderson *et al.*, 1991). However, uncertainties remain over which BP indices, systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), or pulse pressure (PP), are the most important risk factors for a cardiovascular event (Lawes *et al*., 2003).

In the past, greater emphasis was always placed on DBP than SBP, because elevation of the former variable was thought to confer greater risk for cardiovascular disease than elevated SBP (Lloyd-Jones *et al.,* 1999). More recently, attention has also focused on the role of MAP and PP in cardiovascular disease (Mitchell *et al.,* 1997).

Measurement of heart rate (HR) is an easily available cardiovascular phenotype in clinical practice. High resting heart rate (HR) is associated with increased cardiovascular risk in general populations, possibly due to elevated blood pressure (BP) or sympathetic over-activity. We studied the association of resting HR with cardiovascular function, and examined whether the hemodynamics remained similar during passive head-up tilt (Koskela *et al*., 2013).

2.2 THE PULMONARY SYSTEM

Respiratory system is an important system of a human body where gaseous exchange takes place with diffusion of enormous amounts of oxygen into the blood during physical activity (Khurana, 2005). The apparently simple function of the lung is to deliver O2 to gas exchange surface and exhaust CO2 to atmosphere (Singh *et al.,* 2012).

Over the time, pulmonary function tests have evolved from tools for physiologic study to clinical tools widely used in assessing the respiratory status (Fawibe *et al.,* 2017) Spirometry is an important pulmonary function test for assessing ventilatory function of the lungs. The measurement of ventilatory indices is very important in the identification and management of respiratory diseases. Pulmonary function tests have also become a part of routine health examination in respiratory, occupational, and sports medicine (Pellegrino *et al.*,2005). However, the results of pulmonary function tests should be interpreted in relation to reference values (Ferguson *et al.*, 2000).

Forced spirometry is one of the best tests for assessing pulmonary disorders. This simple test provides written record of forced vital capacity (FVC), % forced expiratory volume in 1st second (FEV1%) and peak expiratory flow rate (PEFR) (Saiyad *et al.*, 2013).

Pulmonary function tests permit a precise and reproducible assessment of functional state of the respiratory system. With the help of specific pulmonary function tests, quantification of the severity of disease becomes easier as also the assessment of its natural history and the response to therapy (Saiyad *et al.*, 2013). Although pulmonary function tests can specifically demonstrate a lung function that has been deranged by disease, most of these tests have their strengths and weaknesses e.g., variation can be caused by age, sex, height, occupation, smoking, climatic condition and the degree of air pollution (Jones and Barlet, 2008).

2.3 THE CARDIOPULMONARY SYSTEM

Efficient and coordinated functioning of the cardiopulmonary system is essential for supplying oxygen to the tissues of the body and removing carbon dioxide. The central organs—heart and lungs—and the distribution system—blood vessels—must quickly respond to the varying metabolic demands of each of the body's tissues (Nikel *et al.,* 2015).

The cardiopulmonary system includes the heart, blood vessels and blood, blowhole, trachea, bronchi and lungs. These interdependent systems are responsible for picking up and carrying oxygen to the cells of the body and transporting and discarding carbon dioxide (Garey *et al.,* 2011). The circulatory system (cardiovascular system) pumps blood from the heart to the lungs to get oxygen. The heart then sends oxygenated blood through arteries to the rest of the body. The veins carry oxygen-poor blood back to the heart to start the circulation process over.

In general, arteries carry blood away from the heart and veins carry blood back to the heart. The cardiovascular system delivers oxygen, nutrients, hormones, and other important substances to cells and organs in the body. It plays an important role in helping the body meet the demands of activity, exercise, and stress.

2.4 CARDIOPULMONARY SYSTEM AND ATHLETES

The most important function of the cardiopulmonary system is with respect to the flow and regulation of blood between the heart and the lungs, a process that centers upon the connection between the heart and the lungs made through the pulmonary artery (Lavie *et al.,* 2016).

There is no doubt about positive effects of physical activity (PA) on the human body. Physically active persons reduce their risk of developing type 2 diabetes mellitus, hypertension, and cardiovascular disease (Lavie *et al.,* 2016, Ferguson *et al.,* 2017). Prevalence of atherosclerosis is reduced as well as mortality of cardiovascular and cardiopulmonary diseases (Lavie *et al.,* 2016, Richardson *et al.,* 2016, Monica *et al.,* 2017). Studies that describe positive effects of physical fitness focus on moderate exercise intensity in children and adults (Ortega *et al.,* 2013). According to WHO recommendations on physical activity (WHO, 2007) children should exercise 60 min at moderate intensity per day with short bouts of anaerobic intensities. Exercises to strengthen muscles and bones should be performed three times a week (WH0, 2007). However, young competitive athletes train between 10 and 20 h per week with intensities exceeding WHO recommendations by far (Ortega and Balley, 2013). In this regard, the cardiovascular system has to increase its work five to six times, compared to moderate intensity levels (Ortega *et al.,* 2014), which potentially leads to adverse adaptations of the cardiovascular system.

The term "athlete's heart" describes a non-pathological electrophysiological, structural, and functional myocardial adaptation in response to continuous training stimuli in adults. Athletes present 10–15% increased left and right ventricles and a 10–20% increased left ventricular wall thickness. Functionally, an increased stroke volume and improved cardiac filling in diastole, improved capillary conductivity, and oxidative capacity of the skeletal muscle can be observed in athletes (Castro-Pinero *et al.,* 2017). Myocardiac cells adapt to regular PA according to the underlying stimulus (endurance or strength training). Endurance activities like long distance running or swimming reduce peripheral vascular resistance and systolic blood pressure (SBP), and increase cardiac stroke volume and output. As a result, myocardial oxygen consumption is reduced. Strength training increases myocardial oxygen consumption, heart rate, blood pressure, peripheral resistance, and stroke volume to a smaller extent (Schmermund *et al.,* 2013).

Contrary to positive effects of PA, maladaptations of the cardiovascular system may occur, sudden cardiac death (SCD) is the most severe one (Schmermund *et al.,* 2012, Liu *et al.,* 2015, Tevin *et al.,* 2017). In 46 endurance athletes, mean age of 31 years, 18 cases of severe cardiac arrhythmia and 9 cases of SCD were described (Liu *et al.,* 2015). The MARC study (Measuring Athlete's Risk of Cardiovascular Events) identified coronary sclerosis using cardio CT in almost 19% of athletes (>45 years) who had been asymptomatic, had a low cardiovascular risk profile according to the Systematic Coronary Risk Evaluation (SCORE) and an asymptomatic stress ECG (Schmermund *et al.,* 2014).

Characteristic myocardial adaptations to intensive exercise training such as bradycardia, early repolarization, atrial dilatation, and ventricular hypertrophy are also seen in young athletes (Franklin *et al.,* 2016). In an American long-term survey, 1,866 cases of SCD or cardiac arrest were reported in the period between 1980 and 2006 (Lavie *et al.,* 2016). In 56% SCD was caused by cardiovascular disease with hypertrophic cardiomyopathy (HOCM) as predominant diagnosis (36%) (Daniel *et al.,* 2017). In competitive athletes (12–17 years), SCD incidence was highest with 1.17 cases per 100 000 athletes per year (Sjostrom *et al.,* 2018) with male athletes bearing double the risk than female athletes (Franklin *et al.,* 2017). Regarding these results, it is of high importance to follow young athletes over the course of their career to detect pathophysiological changes in the myocardium as soon as possible (Sjostrom *et al.,* 2018).

In addition to cardiac adaptations to PA, there is evidence that PA also has an influence on the vascular system. (Green *et al*., 2018) postulated the concept of an “athlete's artery.” They hypothesize that persistently increased PA leads to an increase in diameter and reduction in wall thickness. Heffernan (2017) suggests that this vascular remodeling is due to previous cardiac remodeling and triggered by high training intensities. They describe the following cycle: persistently increased cardiac output leads to an adverse effect on the endothelium, an increase in vascular stiffness and consequently end-organ damage of the heart. Hereby SCD risk is increased dramatically.

In young, normally active adults, Boreham et al. (2018) found an inverse relationship between arterial vascular stiffness and cardiorespiratory fitness pointing toward reduced stiffness measures in athletes with higher maximum oxygen uptake (VO2max, $r = -0.21$, $p < 0.001$) and PA. Denham et al. (2019) report lower vascular stiffness in moderately active men ($r = -0.62$, $p < 0.001$). In contrast, among competitive athletes, exercising at very high intensities, and control persons, negative adaptations to increased training intensities were found. Vlachopoulos *et al.* (2019) report significantly higher blood pressure values and higher pulse wave velocity (PWV) in marathon runners (SBP 113 ± 15 mmHg vs. 102 ± 11 mmHg, diastolic blood pressure, DBP 79 ± 10 mmHg vs. 72 ± 9 mmHg, $p < 0.001$, and PWV 6.89 m/s vs. 6.33 m/s, $p < 0.01$). Abergel et al. (24) showed a 13% higher intima-media thickness (IMT) for professional road cyclists. Schmidt-Trucksäss *et al.* (2019) observed an increased IMT of the femoral artery in endurance and strength-trained athletes. All results refer to comparisons with a control group. In children, cIMT (carotid IMT) and arterial stiffness are inversely correlated with cardiorespiratory fitness and physical activity (Breuckmann *et al.,* 2020, Lehmann *et al.,* 2021). In contrast to these positive adaptations, Kim *et al.* (2020) observed higher vascular stiffness in young adult American football players. Feairheller *et al.* (2020) report a higher carotid IMT and larger diameter of the brachial artery. In youth, there are no studies examining possible adaptation mechanisms caused by intensive exercise training. Furthermore, the influence of different training stimuli (type of sport, training frequency, and intensity) on the cardiovascular system has not been sufficiently investigated. In summary, there is no consensus on the effect of intensive exercise on the vascular system. Studies show an influence of aerobic endurance training to vascular properties (Silverthorn *et al.,* 2019, Mohlenkamp *et al.,* 2020). However, the concept of the “athlete's artery” is not yet completely understood and only examined to a small extent. For this purpose, the structure and function of the vascular system and myocardium are examined as well as the association to intensive exercise training. Confounding variables are types of PA (endurance, muscular endurance, strength), cardiopulmonary fitness, muscular strength, and training stimuli (frequency and intensity).

2.5 CARDIOPULMONARY SYSTEM AND SEDENTARY BEHAVIOUR

Physical inactivity has become a major public health concern because it is the second leading single cause of death in the United States, trailing only tobacco use (Charchar *et al.,* 2018). Physical inactivity is also associated with increased risk of morbidity or worsening of many chronic diseases and health conditions. Some of these maladies include cardiovascular disease (CVD), congestive heart failure, stroke, certain cancers, osteoporosis, obesity, type 2 diabetes, and hypertension (O'Brien *et al.,* 2019).

In 2008, the Physical Activity Guidelines for Americans Advisory Committee concluded that adults should accumulate 150 minutes of moderate intensity physical activity, or 75 minutes of vigorous intensity physical activity, or a combination of both, each week (AAC, 2008). Research has also shown that meeting these guidelines is associated with better CVD risk profiles (Charchar *et al.,* 2018), as well as reduced risk of mortality (O'Brien *et al.,* 2018). In 2005, the CDC estimated that 37.7% of the United States population did not participate in the recommended amount of physical activity needed for health benefits, while an additional 14.2% did not participate in more than 10 minutes of moderate or vigorous physical activity throughout the average week (Nikolas *et al.,* 2017). Sedentary pursuits represent a unique aspect of human behavior and should not be viewed as simply the extreme low end of the physical activity continuum. For example, several studies have demonstrated that excess television (TV) viewing time, independent from overall physical activity levels, is adversely associated with metabolic risk factors (Falls *et al.,* 2018). The effects of extended periods of sedentary behavior in otherwise physically active persons have begun to be elucidated, and they seem to be characterized by metabolic alterations commonly seen in diabetogenic and atherosclerotic profiles (Denham *et al.,* 2017, O'Brien *et al.,* 2018). However, to date, formal public health recommendations on limiting sedentary behavior have not been developed.

Dong *et al.* (2016) showed that, on average, adults spend 170 minutes per day watching TV, which accounted for 8.6% of daily total energy expenditure. They also found that time spent driving in the car was the largest contributor to daily total energy expenditure (10.9%; not including sleeping). Furthermore, recent studies using objective measures of physical activity observed that adults spent nearly 55-57% of their monitored time, or ≥7.7 hours/day, in sedentary behaviors (Tomaszewski *et al.,* 2018). Nonetheless, few studies have linked sedentary behaviors, such as riding in a car and watching TV, to cardiopulmonary mortality. Because a large proportion of daily time is spent in sedentary activities, and extended periods of sedentary behavior are associated with adverse metabolic profiles (Breuckmann *et al.,* 2017, Regha *et al.,* 2018), more research is needed on the public health impact of various sedentary behaviors.

Sedentary behaviour has been defined as any waking behaviour characterized by an energy expenditure under 1.5 metabolic equivalents (MET; one MET is the same as 1 kcal/kg/hour and is roughly equivalent to the energy cost of not moving) while in a sitting or reclining posture (Bocho *et al.,* 2017). In adults, excessive sitting has been independently associated with adverse health, including abnormal glucose tolerance and type 2 diabetes, the metabolic syndrome, obesity, cardiovascular disease and mortality (Denham *et al.,* 2018).

Epidemiological studies have demonstrated a correlation between sedentary time and health risk (Tomaszewski *et al.,* 2017). Every 2 h of daily television viewing has been associated with a 20% increased risk of type 2 diabetes, and 13% increased risk of all-cause mortality, independently of physical activity (Prakken *et al.,* 2019). Sitting for more than 10 h per day has been associated with higher body mass index and waist circumference, systolic and diastolic blood pressure, total serum cholesterol, triglycerides and non-fasting glucose levels, compared to those reporting a total sitting time of less than 4 h per day (Mosterd *et al.,* 2016). In a controlled trial, replacing sitting with just 2 min of walking every 20 min was shown to reduce serum insulin and postprandial blood glucose by 24%, and lower blood pressure by a mean of 2–3 mm Hg.16

These findings suggest that adults should be encouraged to reduce their daily total sedentary time.

The benefits of light intensity activity (1.6–3.0 METs) such as standing and gentle walking are gaining interest, having been shown to improve blood glucose profiles (Mosterd *et al.,* 2017), as well as lipoprotein lipase activity and therefore triglyceride and high-density lipoprotein cholesterol levels, independently of moderate and vigorous physical activity (Ardern *et al.,* 2019). Genetics studies on muscle biopsy tissue have shown that compared with uninterrupted sitting, activity bouts favourably promote the expression of proteins modulating anti-inflammatory and anti-oxidative pathways (Braber *et al.,* 2020). The procoagulant effects of prolonged sitting can also be ameliorated (Prakken *et al.,* 2021). Excessive sedentary time is also likely to have implications on recovery and therefore sport performance. Muscle soreness following increased or unaccustomed exercise has been linked with reduced strength and performance (Mueller *et al.,* 2015). Studies involving short bouts of high intensity exercise, making them applicable to many sports including football, have shown that active recovery strategies, including light and moderate intensity activity, appear favourable when compared with passive (sedentary) recovery (Tierney *et al.,* 2018). Relative rest is necessary for recovery, but the impact of prolonged sedentariness on recovery and therefore athletic performance or injury risk is poorly understood.

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 MATERIALS

3.1.1 APPARATUS/EQUIPMENT: Apparatus and laboratory equipment used in this study include the following:

- Weighing scale
- Stadiometer

- Wright Peak flow meter
- Cotton wool
- Gloves
- Digital blood pressure monitor
- Mouthpiece
- Hand–held digital spirometer

3.2 EXPERIMENTAL PROTOCOL

3.2.1 STUDY AREA: The experiment was carried out in the physiology laboratory in The Department of Physiology, University of Benin, Benin-City, Edo State.

3.2.2 STUDY POPULATION: A total of 100 apparently healthy adult male subjects were used to carry out this study. The subjects were selected at random among individuals at the University of Benin Sports Complex and Samuel Ogbemudia Stadium as well as individuals in a number of sedentary work environment.

3.2.3 SAMPLE SIZE: A total of 100 apparently healthy adult males were recruited for this study.

3.2.4 INCLUSION CRITERIA

- Must be either an athlete or a sedentary worker.

- Must be an apparently healthy individual.
- Should be non-smokers.
- No history of abdominal or chest surgery in the last one year.
- No cardiorespiratory condition or other conditions such as diabetes, hypertension etc.

3.2.5 EXCLUSION CRITERIA:

- Females.
- Individuals below 18 years.
- Unhealthy individuals.
- Smokers.
- Had an operation in the last one month in chest or abdomen.
- Individuals with a cardiorespiratory condition or other conditions such as diabetes, hypertension etc.

3.2.6 ETHICAL CONSIDERATION:

Approval and clearance for this study was sought and obtained from the ethics and research committee of the University of Benin, Benin City. The study protocol was explained to the subjects. Informed oral and written consent was obtained from the subjects who participated in this study while confidentiality and anonymity were observed.

3.3 METHODOLOGY

3.3.1 MEASUREMENT OF FVC

PROCEDURE: The subjects inhaled maximally, then exhaled rapidly. Normal lungs generally can empty more than 80 percent of its volume in six seconds or less. The forced expiratory volume in one second (FEV1) is the volume of air exhaled in the first second of the FVC maneuver.

3.3.2 MEASUREMENT OF FEV$_1$

PROCEDURE: The subjects were made to breathe forcefully into the mouthpiece of a spirometer machine. The machine measures the amount of air that is exhaled in the first second of purposefully trying to breathe out as much air as possible. (FEV$_1$ stands for “forced expiratory volume in one second”).

3.3.3 MEASUREMENT OF PEFR

PROCEDURE: The subjects were made to stand up straight, and take in a deep breath. The mouthpiece was then placed in the subject’s mouth followed by a single, fast, forceful expiration. The marker slide outward on the numbered scale, indicating the peak expiratory flow rate for that attempt.

3.3.4 MEASUREMENT OF BMI

PROCEDURE: Body mass index (BMI) is a person's weight in kilograms divided by the square of height in meters. To measure the weight, the subjects were made to remove shoes, bulky clothing and ornaments that could possibly interfere with the measurement and stand with both feet in the center of the scale. To measure the height, the subjects were made to remove shoes, hats and bulky clothing and stand against the stadiometer with heels together, legs straight, arms at sides and shoulders relaxed. The readings were recorded and the BMI calculated.

3.3.5 MEASUREMENT OF BLOOD PRESSURE AND PULSE RATE

PROCEDURE:

- Subjects were made to rest in a chair next to a table for 5 to 10 minutes. Their arm was at rest comfortably at heart level. Afterwards, the cuff was placed around the arm. The fabric fastener was used to make the cuff tight.

- The digital blood pressure monitor was turned on. All display symbols appeared briefly, followed by a zero.
- Since the Omron BP monitor had an automatic cuff inflation, the start button was pressed.
- Participants were made to sit quietly and watch the monitor. Pressure readings were displayed on the screen. After these, the cuff was deflated and the record of the date, time, systolic and diastolic pressures were taken.

3.4 EXPERIMENTAL DESIGN: The test subjects were 100 apparently healthy adult males with 10 subjects per range (range = 10) of athletes and sedentary workers.

- Between ages 18 – 24.
- Between ages 25 – 32
- Between ages 33 – 39
- Between ages 40 – 46
- Above 46

3.5 STATISTICAL ANALYSIS

The statistical analysis was done using graph pad prism version 8.02. Result was presented as mean ± standard error of mean (SEM). Two way Analysis of variance (ANOVA) was used to compare the mean of test and control value while post-hoc test was done using least significance difference (LSD) and represented in charts. A P value of less than 0.05 ($P<0.05$) was considered as statistically significant, a P value of less than 0.01 ($P<0.01$) was considered more statistically significant and a P value of less than 0.001 ($P<0.001$) was considered most statistically significant.

CHAPTER FOUR

RESULTS

Table 1: The Mean ± SEM of some cardiopulmonary function indices in athletes and sedentary workers within the age ranges 18-24, 25-32, 33-39, 40-46 and >46.

		MEAN±SEM

		18-24		**25-32**		**33-39**		**40-46**		**>46**	
S/N		Athletes	Sedentary workers	Athletes	Sedentary workers	Athletes	Sedentary workers	Athletes	Sedentary workers	Athletes	Sedentary workers
1	SBP (mm Hg)	125.8±4.54	111.3±3.71	126.4±3.45	117.6±3.00	127.4±4.20	117.7±2.75	128.3±3.02	123.1±5.34	133.1±2.08	128±2.79
2	DBP (mm Hg)	65.3±2.54	67.4±3.14	77.3±1.99	72.1±1.59	73.1±1.43	71.6±1.80	75.1±2.71	72.7±2.93	73.7±2.29	74.6±2.98
3	FVC (L)	2.53±0.18	2.04±0.15	2.57±0.12	1.95±0.07	2.97±0.27	1.87±0.14	3.03±0.23	2.15±0.20	2.30±0.22	2.49±0.17
4	FEV1 (L)	2.52±0.18	2.03±0.14	2.56±0.12	1.94±0.07	2.98±0.27	1.88±0.14	3.031±0.23	2.13±0.20	2.9±0.19	2.52±0.16
5	PEFR (L/min)	497±21.55	399±22.28	464±22.22	372±18.37	530±16.73	412±18.31	525±19.62	376±18.15	524±14.08	391±24.88
6	BMI (Kg/m^2)	24.36±0.77	19.23±0.73	22.34±0.61	20.81±0.52	24.6±0.68	22.26±0.59	22.53±0.84	20.93±0.35	23.57±0.50	25.89±0.67
7	PR (bpm)	65.4±3.90	73.2±3.098	57.6±2.83	76.9±4.34	50.9±3.35	82.5±3.50	46.6±3.98	78.7±3.34	54.3±2.36	80±3.30

Table 2: The P values of some cardiopulmonary function indices in athletes and sedentary workers within the age ranges 18-24, 25-32, 33-39, 40-46 and >46.

	18-24		**25-32**		**33-39**		**40-46**		**>46**	
	Athletes	Sedentary workers	Athletes	Sedentary workers	Athletes	Sedentary workers	Athletes	Sedentary workers	Athletes	Sedentary workers
Systolic	0.0236		0.0698		0.069		0.4078		0.1602	

Blood Pressure (mmHg)					
Diastolic Blood Pressure (mmHg)	0.6083	0.057	0.5075	0.5488	0.816
Forced Vital Capacity (L)	0.0467	0.0003	0.002	0.0102	0.088
Forced Expiratory Volume $_1$ (L)	0.0416	0.0003	0.0021	0.0074	0.1465
Peak Expiratory Flow Rate (L/min)	0.0054	0.0051	0.0002	<0.0001	0.0002
Body Mass Index (Kg/m^2)	0.0001	0.07	0.0184	0.0949	0.0124
Pulse Rate (bpm)	0.1345	0.0016	<0.0001	<0.0001	<0.0001

*Significant difference when $P < 0.05$

**Significant difference when $P < 0.01$

***Significant difference when $P < 0.001$

****Significant difference when $P < 0.0001$

No Significant difference when $P > 0.05$

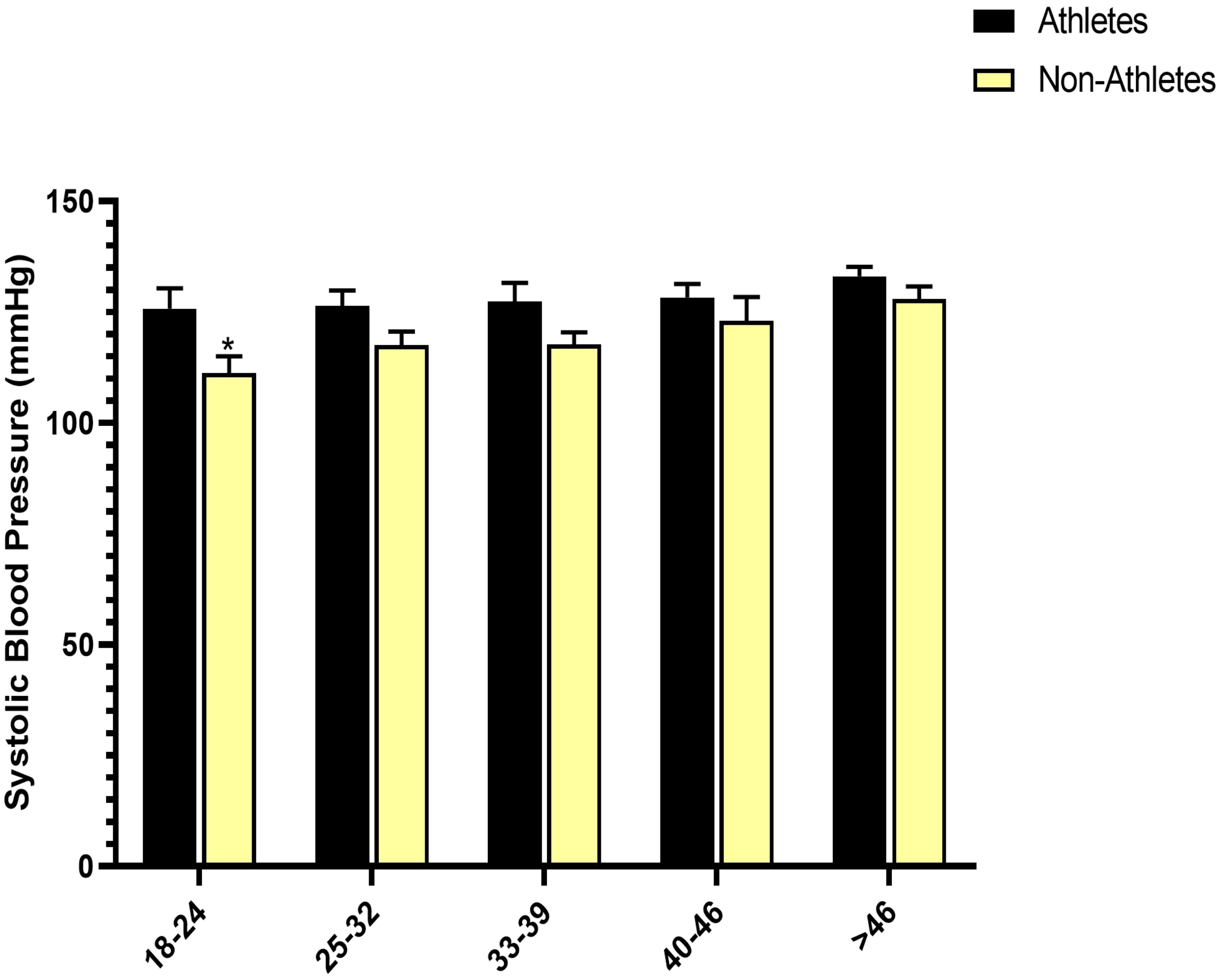

Fig 4.1: Systolic blood pressure values of athletes and sedentary workers. There were no significant differences across all groups.

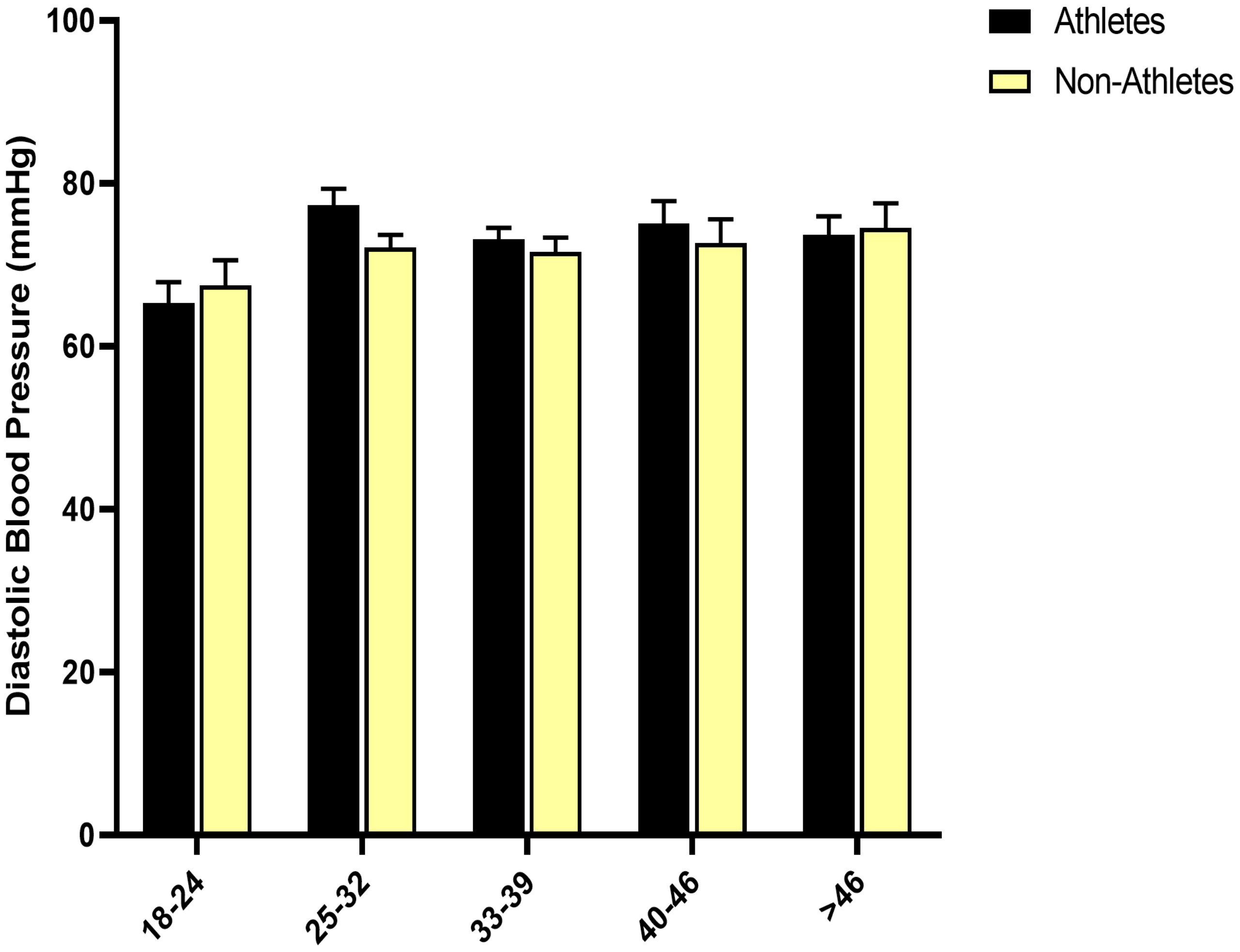

Fig 4.2: Diastolic blood pressure values of athletes and sedentary workers. There were no significant differences across all groups.

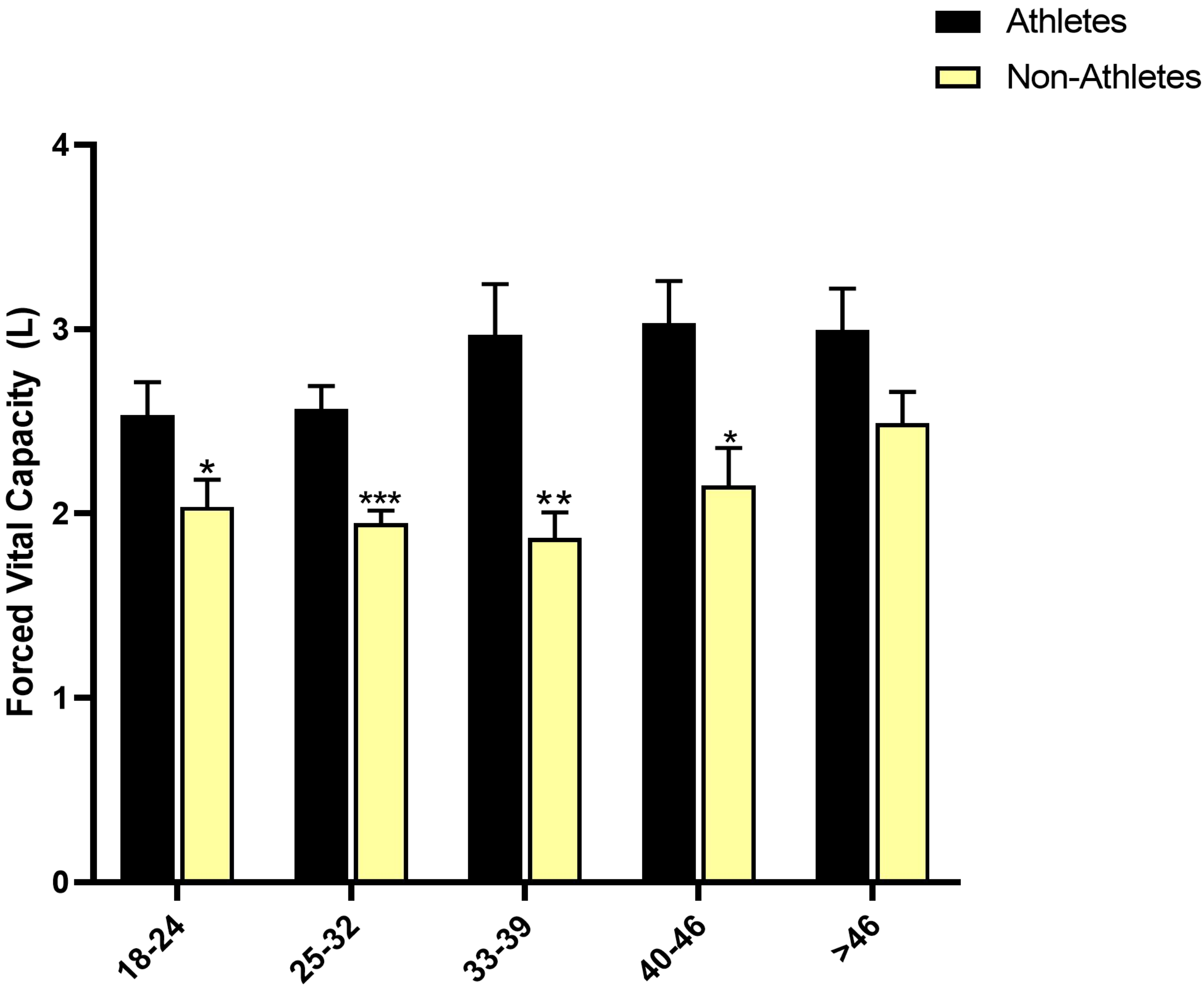

Fig 4.3: Forced Vital Capacity (FVC) values of athletes and sedentary workers. There were significant differences in the FVC of sedentary workers across all groups compared to athletes.

(*p>0.05, **p>0.01, ***p>0.001 Significant values are Mean ± SEM compared to the control) n=10

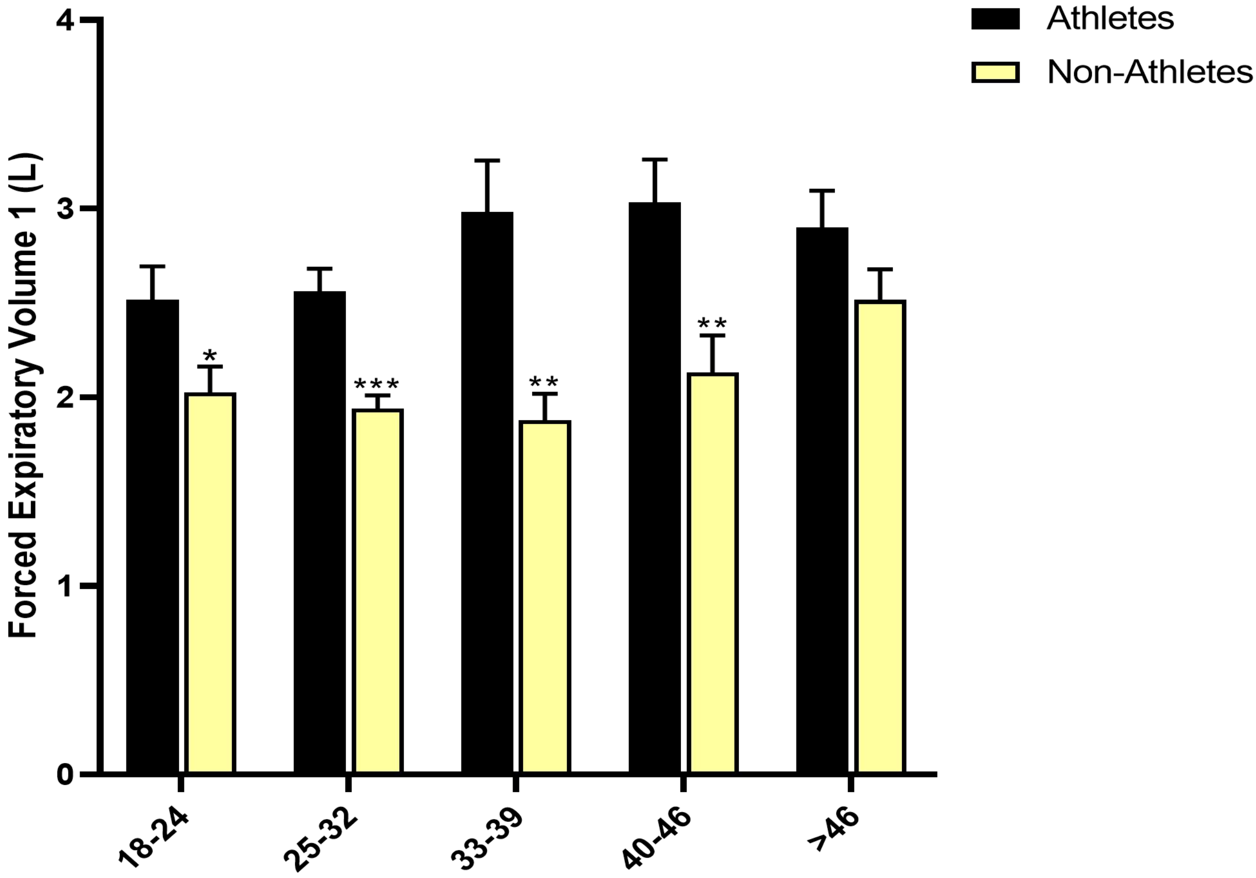

Fig 4.4: Forced Expiratory Volume $_1$ (FEV_1) values of athletes and sedentary workers. There were significant differences in the FEV_1 of sedentary workers across all groups compared to athletes.

(*p>0.05, **p>0.01, ***p>0.001 Significant values are Mean ± SEM compared to the control) n=10

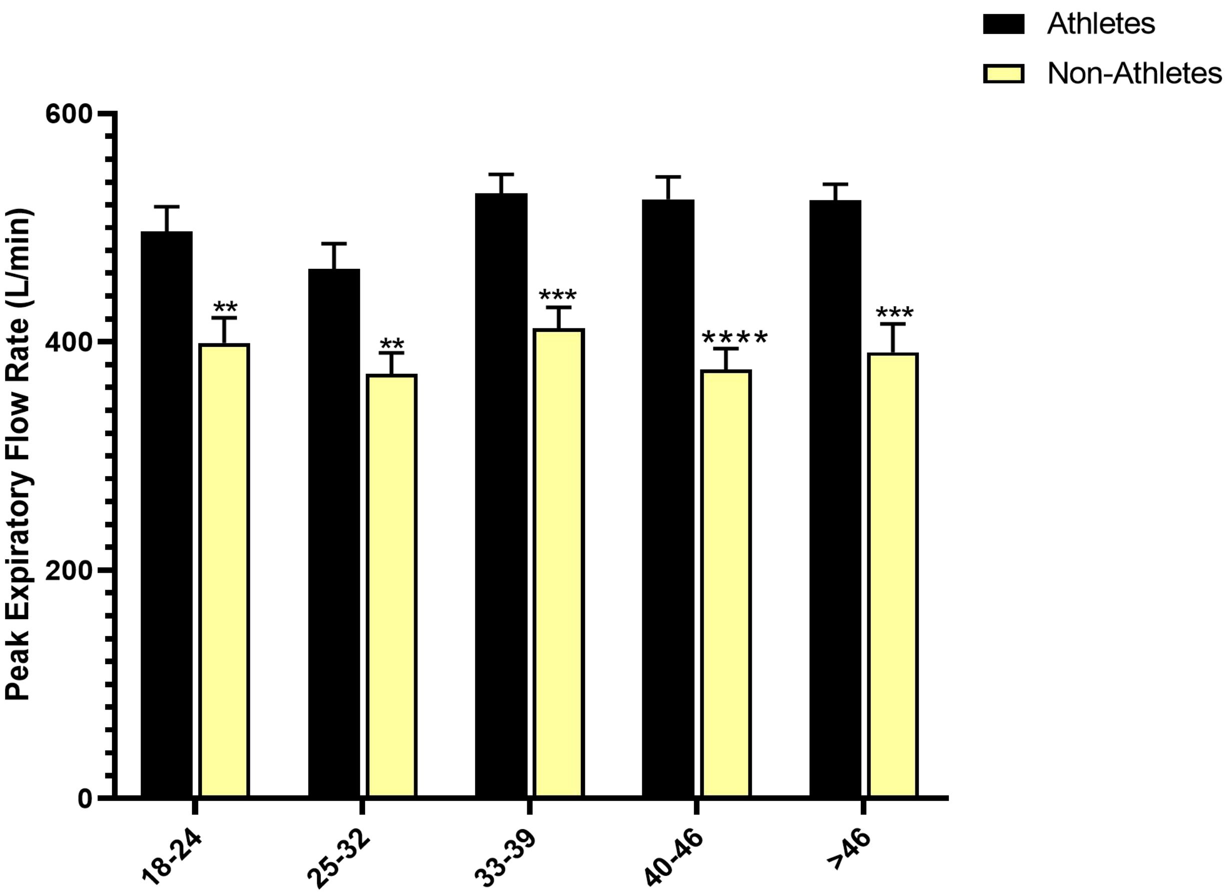

Fig 4.5: Peak Expiratory Flow Rate (PEFR) values of athletes and sedentary workers. There were significant differences in the PEFR of sedentary workers across all groups compared to athletes.

(**p>0.01, ***p>0.001, ****p>0.0001 Significant values are Mean ± SEM compared to the control) n=10

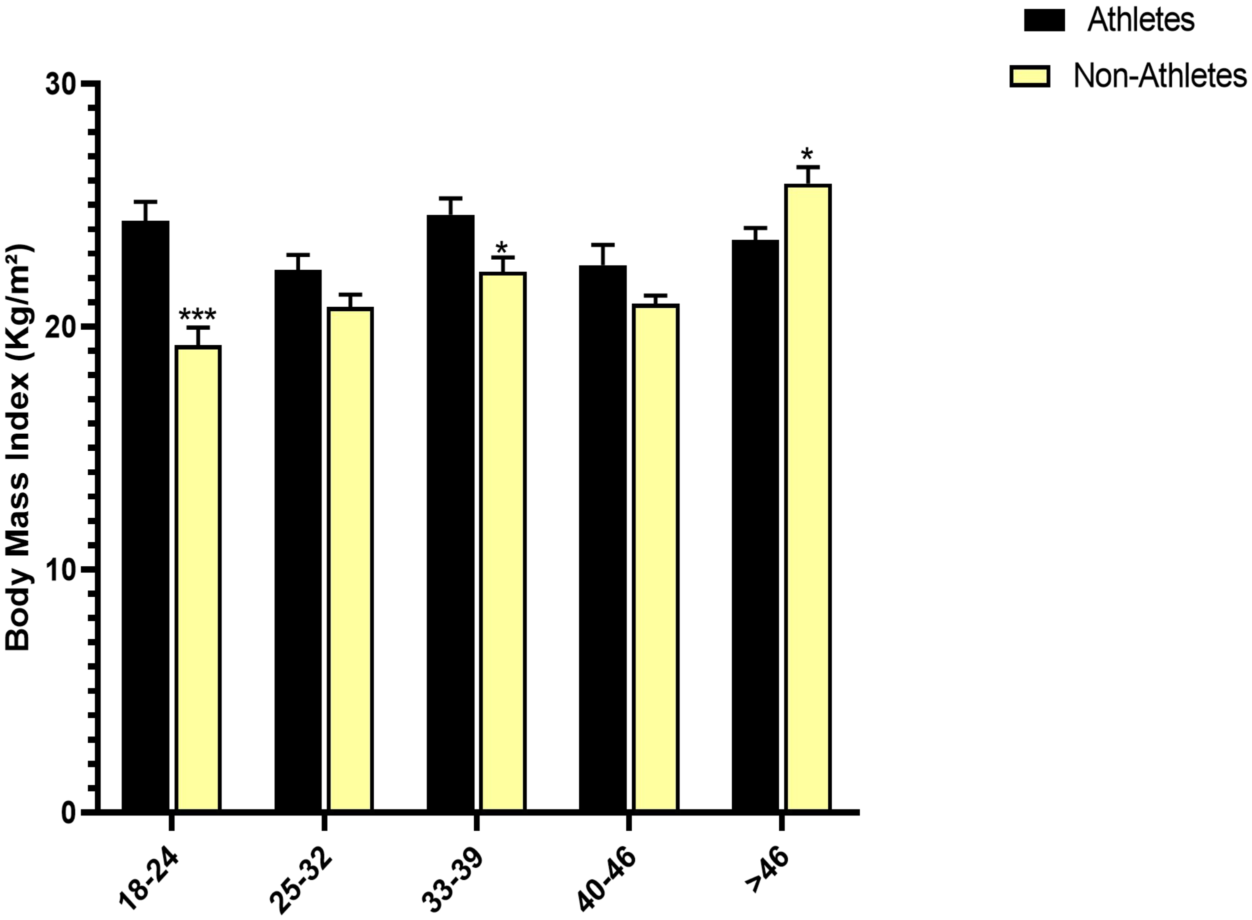

Fig 4.6: Body Mass Index (BMI) values of athletes and sedentary workers. There were significant differences in the BMI within the groups 18-24,33-39 and above 46 of sedentary workers compared to athletes.

(*p>0.05, ***p>0.001 Significant values are Mean ± SEM compared to the control) n=10

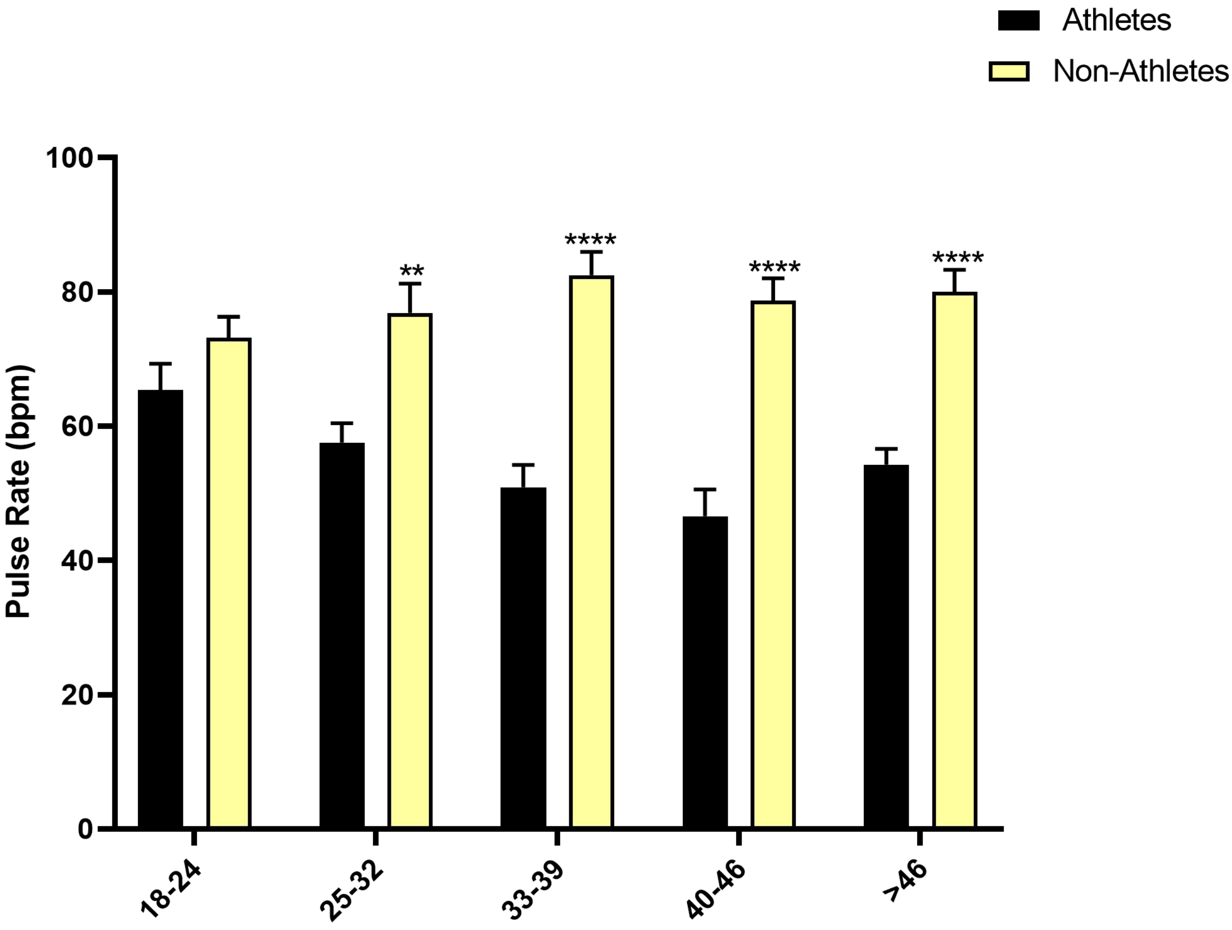

Fig 4.7: Pulse rate values of athletes and sedentary workers. There were significant differences in the pulse rate of sedentary workers across all groups compared to athletes.

(**p>0.01, ****p>0.0001 Significant values are Mean ± SEM compared to the control) n=10

CHAPTER FIVE

DISCUSSION

The primary aim of this study was to investigate the cardiopulmonary function in athletes and sedentary workers. Fig 4.1 and 4.2 show systolic and diastolic blood pressure of athletes and sedentary workers. There were no significant differences across all groups. Blood Pressure has been reported to remain steady except on the onset of moderate to intense physical activities. This result tallies with the study by Masons *et al.,* (2016). In their study, they revealed that sedentary workers and athletes have the same value in their systolic and diastolic pressures. Evidence in studies by Baur *et al*., (2006) and Ortega *et al*., (2007) opposed the result of this current study, citing that athletes tend to have a lower blood pressure than sedentary workers of the same age due in part to the fact that regular physical activity helps maintain healthy blood vessels and a healthy heart. Fig 4.3 and 4.4 show Forced Vital Capacity (FVC) and Forced Expiratory Volume $_1$ (FEV_1) of athletes and sedentary workers. There were significant differences in the FVC and FEV_1 of athletes across all groups compared to sedentary workers. This was obviously due to the differences in their respiratory acclimatization. Sanders *et al.,* (2017) reported that trained and acclimated athletes have increased FVC and FEV. Osuma *et al.,* (2017) reported that the cardiorespiratory parameters of new athletes after the 2016 summer

Olympic games was observed to significantly increase after the games. The differences are due to an increase in strength and size of muscles of respiration and breathing caused by increased physical activity, resulting in increased oxygen uptake and improves cardiorespiratory fitness (Durchin *et al.,* 2017). The peak expiratory flow rate was also revealed to increase. Fig 4.5 shows Peak Expiratory Flow Rate (PEFR) of athletes and sedentary workers. There were significant differences in the PEFR of athletes across all groups compared to sedentary workers. The maximum increase in PEFR was found in football players due to their strenuous exercise. Most of the lung volumes (Inspiratory and Expiratory reserve volumes, Residual volume, Total lung volume, and Vital capacity) are larger in athletes, than in non-athletes of the same sex and body size (Osuma *et al.,* 2017). This significant difference is indicative that athletes have stronger expiratory muscles and greater respiratory function. (Brown *et al*., 2013) agreed that endurance aerobic training leads to an improvement in PEF due to an improvement in cardiorespiratory fitness. (Landsberg *et al*., 2012) on the other hand, found no significant difference in FVC, FEV_1 and PEFR. It is important to note however, that the study was limited in sample size and specific populations studied and may not be generalizable to all athletes and sedentary workers. Fig 4.6 shows a significant increase in the Body Mass Index of athletes compared to sedentary workers except in the above 46 age range where they showed a significant decrease. The increase suggests an increased physical activity leads to an increase in muscle mass and bone density. This aligns with the results of the study by Hausenblas and Koceja, (2017). Fig 4.7 shows pulse rate of athletes and sedentary workers. There were significant differences in the pulse rate of athletes across all groups compared to non-athletes. The increase in heart rate that accompanies exercise is due in part to a reduction in vagal tone. Recovery of the heart rate immediately after exercise is a function of vagal reactivation. Because a generalized decrease in vagal activity is known to be a risk factor for death, we hypothesized that a delayed fall in the heart rate after exercise might be an important prognostic marker. This result aligns with the reports of Tasuel *et al.,* (2019) who concluded that delayed decrease in the heart rate during the first minute after graded exercise, which may be a reflection of decreased vagal activity, is a powerful predictor of overall mortality, independent of workload, the presence or absence of myocardial perfusion defects, and changes in heart rate during exercise. Evidence by Martins *et al*., (2007) also suggests that athletes have a lower resting pulse rate than sedentary workers which coincides with the result of this present study, and according to Chertoff in 2020, a lower pulse rate connotes greater fitness. This is likely because physical activity strengthens heart muscles which will allow the heart pump a greater amount of blood with each heartbeat thus, more oxygen go to the muscles.

CONCLUSION

The present study has shown there are significant differences in cardiopulmonary parameters between athletes and sedentary workers, and in most cases, those of the athletes showed healthier and more stable values. Therefore, it can be said that there is a lot of advantage in engaging in physical activity and it should be encouraged.

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