Effect of an 8-Week Circuit Training Programme on Physical Fitness Parameters of Academic Staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria

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Certification

This is to certify that Freedom Festus OGBARA with matriculation number LCU/PG/002896 carried out this research work titled "Effect of an 8-Week Circuit Training Programme on Physical Fitness Parameters among Academic Staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria" in the Department of Kinesiology, Sports Science & Health Education, Faculty of Education, Lead City University, Ibadan, Oyo State, for the award of Master of Science Education Degree (MSc (Ed) in Exercise Physiology and that this has not been previously submitted.

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Dedication

This thesis is dedicated to God Almighty.

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Abstract

This study investigated the effect of an 8-week circuit training programme on physical fitness parameters of academic staff of Bayelsa Medical University (BMU), Yenagoa, Bayelsa State, Nigeria. The study utilised a self-developed structured programme known as the Ogbara Freedom Festus Circuit Training programme. The effective-reflective theory of physical inactivity and exercise and self-determination theories, a pretest-posttest quasi-experimental design with a 2×2×4 factorial matrix, were used in this study. The population consisted of all academic staff at Bayelsa Medical University. Forty (40) academic staff members of BMU were purposively selected and randomly assigned into two groups: control and experimental. The instruments used for data collection included a blood pressure and heart rate monitor, a non-elastic measuring tape, a pulse oximetre and stop stopwatch. The parameters of interest were muscle strength, flexibility, heart rate, respiratory rate, oxygen saturation, and body composition. Data were analysed using descriptive analysis and analyses of covariance (ANCOVA). The results revealed that there was a significant main effect of treatment (8-week circuit training) on muscle strength ($F_{(1,37)}=48.84$, $p<0.05$, $\eta^2=0.57$), flexibility ($F_{(1,37)}=45.83$, $p<0.05$, $\eta^2=0.55$), heart rate ($F_{(1,37)}=36.93$, $p<0.05$, $\eta^2=0.50$), respiratory rate ($F_{(1,37)}=147.78$, $p<0.05$, $\eta^2=0.80$), oxygen saturation ($F(1,37)=8.09$, $p<0.05$, $\eta^2=0.18$) and body composition ($F_{(1,37)}=14.40$, $p<0.05$, $\eta^2=0.28$). In addition, there was no significant main effect of sex on muscle strength ($F_{(1,35)}=1.56$, $p>0.05$, $\eta^2=0.04$), flexibility ($F_{(1,35)}=0.35$, $p>0.05$, $\eta^2=0.01$), heart rate ($F_{(1,35)}=0.01$, $p>0.05$, $\eta^2=0.00$), respiratory rate ($F_{(1,35)}=1.40$, $p>0.05$, $\eta^2=0.04$), oxygen saturation ($F(1,35)=2.92$, $p>0.05$, $\eta2=0.08$), and body composition ($F_{(1,35)}=0.08$, $p>0.05$, $\eta^2=0.00$). There was no significant main effect of age on muscle strength ($F_{(3,31)}=1.94$, $p>0.05$, $\eta^2=0.16$), heart rate ($F_{(3,31)}=0.61$, $p>0.05$, $\eta^2=0.06$), respiratory rate ($F_{(3,31)}=1.00$, $p>0.05$, $\eta^2=0.09$), oxygen saturation ($F(3,31)=0.40$, $p>0.05$, $\eta2=0.04$), and body composition ($F_{(3,31)}=1.09$, $p>0.05$, $\eta^2=0.10$). However, there was a significant main effect of age on flexibility ($F_{(3,31)}=4.14$, $p<0.05$, $\eta^2=0.29$). Future research accounting for nutritional consumption and daily energy expenditure is recommended.

Keywords: Physical Fitness Parameters, Circuit Training, Academic Staff, Muscle Strength, Flexibility, Heart Rate, Respiratory Rate, Oxygen Saturation, Body Composition.

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List of Acronyms

Abbreviation	Meaning
LCU	Lead City University
SPSS	Statistical Package Social Sciences Software
BMU	Bayelsa Medical University
CT	Circuit Training
BP	Blood Pressure
HR	Heart Rate
WHR	Waist-Hip Ratio
RR	Respiratory Rate
BC	Body Composition
OS	Oxygen Saturation

Chapter One

Introduction

1.1 Background to the Study

The need to remain fit in order to live a meaningful life has recently been a concern among the young and old, as well as the government. This explains why so many keep-fit programmemes have emerged. One of the most significant components of an individual's life is their physical health. Human activities require different levels of endurance, force, and power[1]. Physical fitness has been related to improved health, lower medical costs, higher academic performance, and increased job productivity[2]. Being successful in particular in specialised cultural, psychological, and physical assessments is a prerequisite for admittance into schools and vocations such as the military in most countries of the world, including Nigeria[3]. Physical fitness is a broad term that encompasses two distinct aspects: health-related physical fitness and skill-related physical fitness. Health-related physical fitness, including cardiovascular endurance, muscular strength and endurance, flexibility, and body composition, is regarded as one of the most significant health markers and has been shown to be beneficial[4]. Agility, balance, coordination, power, speed, and reaction time are examples of skill-related physical fitness and motor skills that help in performance in sports and active games[5]. Muscle strength, flexibility, cardiorespiratory fitness, and body composition are the indices considered in this study.

Muscle strength is defined as a muscle's or a group of muscles' maximal capacity to apply force under a specific set of conditions[6]. Muscular strength is determined by how much force is exerted and how much weight is lifted in a short amount of time. Muscle strength improves general health and athletic performance[7].

Flexibility is the capacity to move a joint across its whole range of motion[8]. Flexibility is the anatomical degree of movement in a joint or sequence of joints, as well as the length of the muscles that span the joints to produce a bending movement or motion. Flexibility is vital for daily life and athletic success[9]. It is influenced by a number of factors, including joint capsule distensibility, adequate warm-up, and muscle viscocity.

Cardiorespiratory fitness refers to the ability of the cardiovascular and respiratory systems to supply oxygen to skeletal muscles during sustained physical activity. Cardiorespiratory fitness is related to the ability to perform large-muscle, dynamic, moderate-to-high intensity exercises for prolonged periods. Cardiorespiratory fitness is used to assess the functional capacity of the cardiovascular and respiratory systems to supply oxygen to skeletal muscle mitochondria for energy production needed during physical activity. Cardiorespiratory fitness is an important marker of physical and mental health and academic achievement in youth. Having a good degree of cardiovascular endurance has been linked to having a healthier cardiovascular profile[10]. Humans with a good level of cardiovascular endurance have been found to have less overall adiposity, abdominal adiposity, and reduced metabolic risk[11].

Body composition is the percentage of a body's weight that is fat tissue. It refers to the percentage of fat, bone, water, and muscle in human bodies. Body mass index, waist-to-hip ratio, circumferences, and skin fold calliper measurements are all anthropometric procedures to measure body composition. Benefits of a good body composition include a decreased risk of type 2 diabetes, hypertension, and heart disease and an increase in body functional ability[12].

Regular physical activity is necessary for the long-term maintenance of a person's ideal physical condition[13]. The ability to initiate rational muscle movements, rapid release of dangerous substances, an increase in oxygen demand, and activation of protein synthesis to stimulate the entire body are linked to regular involvement in physical activity. Conversely, a sedentary lifestyle and lack of physical activity are linked to chronic diseases, a decline in functional capacity, and an increase in morbidity and mortality in adults[14]. Low physical activity has been linked to poor cardiorespiratory fitness (CRF), and both low physical activity and cardiorespiratory fitness have been linked to the development of cardiovascular diseases (CVD) and obesity[15].

Physical inactivity is on the rise in Europe and around the world, with 70–90% of European teenagers failing to meet recommended levels of physical activity (PA) and engaging in excessive sedentary behavior[16]. In western industrialised countries, only about a third of the population is sufficiently physically active (active at a moderate intensity of physical activity, 30 minutes per day for at least five days per week). In the US, 40%, and in 15 European Union (EU) member states, on average, only about 31% of the adult population met the public health recommendation for moderate-intensity physical activity[17]. In 2015, physical inactivity was directly responsible for 21% of breast cancers, 25% of colon cancers, 27% of diabetes, and 30% of ischemic heart disease worldwide[18]. In 2014, the World Health Organisation (WHO) estimated that nearly three million people in sub-Saharan Africa died as a result of physical inactivity[19]. African countries, such as Nigeria, bear a disproportionately heavier burden. This may be attributable in part to rapid urbanisation and economic expansion, which has resulted in an increase in unhealthy lifestyles and sedentary living in a variety of settings[20]. Prevailing situations such as the influence of automation and information communication technology, demands placed on different categories of workers, economic challenges, and a poor work environment may also be causes. With a population of over 200 million people, Nigeria has a high rate of physical inactivity, ranging from about 25% to 57%, which is linked to higher prevalence rates of obesity, type 2 diabetes, and cancer[21]. In Nigeria, there is a dearth of epidemiological data on physical inactivity from many contexts, and there is no national report, resulting in a lack of or inefficient national policy on the subject.

The majority of recommendations for regular physical activity in children and adolescents refer to sixty (60) minutes of moderate to strenuous activity each day; adults and older people are to engage in one hundred and fifty (150) minutes per week of moderate activity, including three and two days per week [22, 23, 24]. The majority of training programmemes lasting from seven to ten weeks with two to three sessions per week have been proven to provide time-efficient and favourable benefits for enhancing cardiorespiratory fitness in non-obese children and adolescents[23, 25, 26, 27, 28]. Circuit training is recommended as one of the modalities for effectively boosting the physical attributes of fitness[29].

Circuit training (CT) is a training method that consists of a set of exercises arranged and numbered sequentially in a specific area, all of which are designed to improve strength, power, flexibility, quickness, and cardiovascular endurance based on sound anatomical, kinesiological, and physiological principles[29]. Approximately 6–12 exercises are performed in a circuit-style workout, with minimal rest in between[30]. Each participant moves from one station to the next with little (15 to 30 seconds) or no rest, performing a 15 to 45-second work-out of 8 to 20 repetitions at each station[31]. The exercise session can be completed in less time and with the participation of many people. Circuit training can be done at low, moderate, or high intensity. By focusing on maximal oxygen intake, maximum pulmonary ventilation, functional capacity, myocardial strength, power, and endurance, circuit training that incorporates endurance workouts is useful in improving cardiopulmonary parameters. Increased cardiorespiratory fitness and the development of aerobic capacity result from the improvement of hemodynamic parameters such as heart rate, cardiac output, and mean arterial pressure[32]. Numerous chronic diseases, such as hypertension and diabetes, have been shown to be impacted by circuit training and improvements in body composition, such as lower body fat and body mass index (BMI) [33]. Additionally, males with post-myocardial infarction were found to benefit from and be safe from participating in circuit training programmeme[34]. The nature of circuit training may offer an efficient, comprehensive exercise programmeme to increase older persons' overall fitness[33].

In the quest for overall fitness, the government of Bayelsa State, Nigeria, has committed to assisting people in improving their health status. It has in place comprehensive health promotion and disease prevention initiatives such as educating the public on the importance of participating in keep-fit programmemes, reducing fatty foods, eating a healthy and balanced diet, and engaging in more physical activities through school sensitization and gingles. Furthermore, the present administration in the state has mandated a weekly fitness walk for state government employees. To help students improve their health, the government has also detailed extensive programmemes in the teaching of Physical and Health Education (P. H. E.) and sporting activities such as inter-house sports. Despite this, there is no regular, organised training activity aimed at improving the physical condition of different categories of workers in the state, including the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

1.2 Statement of the Problem

Physical fitness plays a crucial role in human existence and may help achieve ideal weight, flexibility, proper cardiorespiratory fitness, muscular strength, and, at the same time, maintain it. However, numerous challenges affect the physical fitness of individuals, and academic staff are no exception to these challenges. In addition to the increased demand on lecturers and lengthy work hours, lecturers have been observed to be sedentary, characterised by prolonged periods of sitting, surfing the internet, studying with little or no break, increased consumption of carbonated drinks and junk food, as well as reduced sleep hours, which lead to the development of diseases such as hypertension, diabetes, weight gain, and death. The consequences of the existing challenges are multifaceted and far-reaching, and their negative implications for the achievement of goals are detrimental. Many studies have concentrated on the physical fitness parameters of top senior civil officials and other workers using high-intensity interval and resistance training[32, 33]. Others focused on the influence of circuit training programmemes on the physical fitness parameters of athletes[32, 33]. However, there is no data on the use of circuit training and its effect on the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria. Hence, this study determined the effect of circuit training on the physical fitness parameters of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

1.3 Aim and Objectives of the Study

The aim of this study was to assess the effect of an 8-week circuit training programmeme on physical fitness parameters of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

The objectives of this study were to:

i. examine physical fitness level of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

ii. examine the effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

iii. determine the effect of an 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

iv. examine the effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

v. examine the effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

vi. examine the effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

vii. determine the effect of an 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

viii. examine the effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

ix. examine the effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

x. examine the effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

xi. determine the effect of an 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

xii. examine the effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

xiii. examine the effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

1.4 Research Question

The following research question was answered:

1. What is the pre-field status of physical fitness parameters (Muscle Strength, Flexibility, Cardiorespiratory Fitness, and Body Composition) of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State?

1.5 Hypotheses

The following hypotheses were tested in this study:

H_O1: There will be no significant effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

H_O2: There will be no significant effect an of 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

H_O3: There will be no significant effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

H_O4: There will be no significant effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

H_O5: There will be no significant effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

H_O6: There will be no significant effect an of 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

H_O7: There will be no significant effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

H_O8: There will be no significant effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

H_O9: There will be no significant effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

H_O10: There will be no significant effect an of 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

H_O11: There will be no significant effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

H_O12: There will be no significant effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

1.6 Significance of the Study

The outcome of this study is considered significant as it may benefit participants, Bayelsa Medical University, exercise physiologists, and other related professionals by demonstrating the impact of circuit training on muscle strength, flexibility, cardiorespiratory fitness, and body composition in the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, who may adopt or adapt the programmeme.

This study focuses on the physical health and well-being of academic staff, a population that frequently suffers from stress and sedentary work. Understanding the influence of a planned fitness programmeme on their health can lead to increased job satisfaction, decreased stress, and an overall improved quality of life. Academic staff's physical fitness can have a substantial impact on their job performance. Fit and healthy staff may have more energy, better cognitive function, and more productivity. This research can provide insight on how investment in employee fitness can lead to improved educational outcomes and research contributions.

The findings can help Bayelsa Medical University and other academic institutions understand the advantages of instituting health and fitness programmemes for their employees. It has the potential to motivate institutions to create a wellness and fitness culture, ultimately benefiting the entire academic community. Promoting physical fitness and healthy lifestyles among academic staff can have a larger impact on the local and national levels by serving as a model for the community. It has the potential to help reduce the burden of lifestyle-related diseases and healthcare costs. Improved physical fitness might benefit academic staff's personal lives by potentially lowering healthcare costs and absenteeism. Furthermore, it can improve the staff's capacity to participate in physical activities and conduct research, thereby enhancing their careers. A physically fit and healthy academic workforce can boost an institution's worldwide competitiveness. As universities aim for international recognition and collaboration, the well-being of their faculty members becomes increasingly important.

The findings of this study may also assist individuals and sports trainers in making educated decisions about adopting or adapting circuit training programmemes as a modality for enhancing performance in sports. Exercise physiologists, physiotherapists, and trainers could use the findings of this study to create circuit training programmemes for the development of physical fitness, taking advantage of its effectiveness. The findings of this study will contribute to the field of exercise physiology by enriching the literature and providing empirical data for future research.

1.7 Scope of the Study

The geographical scope of this study is limited to Bayelsa State, Nigeria. Bayelsa State is located in the South-South part of Nigeria and is known for its diverse cultural heritage and historical significance. The study specifically investigated the effect of an 8-week circuit training programmeme on four physical fitness parameters of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria, namely: muscle strength, flexibility, cardiorespiratory fitness, and body composition. Academic staff of the Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria, were involved. Participants were grouped into two (2) control and experimental groups using a 2×2×4 factorial matrix. A randomised pre-test and post-test assessment was conducted. The circuit training programmeme took place at the football field of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

1.8 Limitation of the Study

There was lack of monitoring of either diet consumption or physical activity outside the study. Participants were provided with educational materials on maintaining a healthy diet and physical activity outside the study, empowering them to make informed choices and potentially mitigating unmonitored behaviors. Self-reporting of diet consumption and activity levels was encouraged, and incentives or rewards for compliance were offered. The study duration was extended to include follow-up periods, capturing changes in diet and physical activity patterns over time.

1.9 Operational Definition of Terms

The following terms are defined according to their usage in the study:

Physical Fitness: Physical fitness in this work refers to the body's capacity to complete circuit training at a set time.

Physical Fitness Parameters: Physical fitness parameters for this study consist of muscle strength, flexibility, body composition, and cardiorespiratory fitness.

Muscle Strength: Muscle strength refers to the upper arm muscle's ability to exert force during push-ups.

Flexibility: Flexibility refers to a joint's capacity to move through its full range of motion such as during sit and reach test, and back scratch test.

Cardiorespiratory Fitness: Cardiorespiratory fitness is the ability of the cardiovascular and respiratory systems to supply oxygen to exercising skeletal muscles which can be measured using resting heart rate, respiratory rate, and oxygen saturation level.

Body Composition: Body composition is the percentage of fat, bone, water and muscles measured using waist to hip ratio.

Circuit Training: Circuit training for this work will consist of a series of physically demanding, resistance-based, and aerobic activities separated by a set of time for each station to be completed such as lunges, squats, jogging, push-ups, sit ups, plank, burpee.

Physical Activity: Physical activity refers to any unplanned bodily physical movement that expends energy such as exercise.

Academic Staff: They are the teaching staff of the Bayelsa Medical University, Yenagoa, Bayelsa State.

Endnotes

1 F. E. Marino, *Adaptations, Safety Factors, Limitations and Trade-offs in Human Exercise Performance*, **Adaptive Human Behavior and Physiology,** 8, 2022, 98–113.

2 C. Nordzro; R. S. Sorkpo & B. Tsorhe, *Comparison of Health-Related Physical Fitness Levels of Girls in Day and Boarding Senior High Schools in Cape Coast*, **International Journal of Scientific Research and Management (IJSRM),** 6 (7), 2018, 31-40.

3 L. I. Pietro; S. Gabriele; P. Maurizio; A. Giampietro; F. Damiano & B. Andrea, *Circuit Training during Physical Education Classes to Prepare Cadets for Military Academies Tests:Analysis of an Educational Project,* **Sustainability**, 2020, 12, 5126.

4 C. Comeras-Chueca, J. Marin-Puyalto, A. Matute-Llorente, G. Vicente-Rodriguez, J. A. Casajus & A. Gonzalez-Aguero, *The Effects of Active Video Games on Health-Related Physical Fitness and Motor Competence in Children and Adolescents with Healthy Weight: A Systematic Review and Meta-analysis*, ***Int. J. Environ. Res. Public Health****, 18,* 2021, 6965.

5 R. X. Doe-Asinyo & B. C. M. Smits-Engelsman, *Ecological Validity of the PERF-FIT: Correlates of Active Play, Motor Performance and Motor Skill-Related Physical Fitness*, **Heliyon**, 7, 2021, e0790.

6 R. Pojednic, E. D'Arpino, I. Halliday, & A. Bantham, *The Benefits of Physical Activity for People with Obesity, Independent of Weight Loss: A Systematic Review*, **International Journal of Environmental Research and Public Health**, 19 (9), 2022, 4981.

7 C. Herbert, *Enhancing Mental Health, Well-being and Active Lifestyles of University Students by Means of Physical Activity and Exercise Research Programmes*, **Frontiers In Public Health**, 10, 2022, 849093.

8 I. Sulowska-Daszyk, & A. Skiba, *The Influence of Self-myofascial Release on Muscle Flexibility in Long-distance Runners*, **International Journal of Environmental Research and Public Health**, 19 (1), 2022, 457.

9 U. S. Ruzmatovich, & Q. Shohbozjon G'Ayratjon O'G, *Uzbekistan's General Education School Physical Education Programmeme: A Curriculum Analysis*, **Best Journal of Innovation in Science, Research and Development**, 2 (5), 2023, 184-193.

10 M. Vandoni, V. Calcaterra, V. Carnevale Pellino, A. De Silvestri, L. Marin, G. V. Zuccotti, V. Tranfaglia, M. Giuriato, R. Codella & N. Lovecchio, *Fitness and Fatness in Children and Adolescents: An Italian Cross-sectional Study*, ***Children**,* 8, 2021, 762.

11 M. Medrano, C. Cadenas-Sánchez, M. Oses, A. Villanuev, R. Cabeza, F. Idoate, A. Sanz, B. Rodríguez-Vigil, F. B. Ortega, J. R. Ruiz & I. Labayen, *Associations of Fitness and Physical Activity with Specific Abdominal Fat Depots in Children with Overweight/Obesity,* **SJMS**, 32 (1**)**, 2022, 211-222.

12 F. Perone, A. Pingitore, E. Conte, G. Halasz, M. Ambrosetti, M. Peruzzi, & E. Cavarretta, *Obesity and Cardiovascular Risk: Systematic Intervention is the Key for Prevention*, **In Healthcare**, 11(6), 2023, 902.

13 S. Y. Zavalishina, V. Y. Karpov, O. G. Rysakova, I. A. Rodionova, N. G. Pryanikova & A. M. Shulgin, *Physiological Reaction of the Body of Students to Regular Physical Activity*, **J Biochem Technol,** 12 (2), 2021, 44-47.

14 T. L. McKenzie, *Physical Activity within School Contexts: The Bigger Bang Theory*, **Kinesiol Rev**, 8 (1), 2019, 48-53.

15 L. F. DeFina, L. H. William, W. L. Benjamin, B. E. Carolyn, F. E. Carrie & L. D. Benjamin, *Physical Activity Versus Cardiorespiratory Fitness: Two (Partly) Distinct Components of Cardiovascular Health*, **Prog Cardiovasc Dis**, 57, 2015, 324-29.

16 L. Van Hecke, A. Loyen, M. Verloigne, H. P. van der Ploeg, J. Lakerveld & J. Brug, *Variation in Population Levels of Physical Activity in European Children and Adolescents according to Cross-European Studies: A Systematic Literature Review within DEDIPAC*, **Int J Behav Nutri Phys Activity**, 13, 2016, 70.

17 A. K. Akodu, O. B. A. Owoeye & A. I. Raufu, *Exercise, Recreation and Sport Participation among Lecturers in University of Lagos*, **University of Lagos Journal of Basic Medical Sciences**, 4 (8), 2022, 26-32.

18 S. Ortolan, D. Neunhaeuserer, G. Quinto, B. Barra, A. Centanini, F. Battista, M. Vecchiato, V. De Marchi, M. Celidoni, V. Rebba & A. Ermolao, *Potential Cost Savings for the Healthcare System by Physical Activity in Different Chronic Diseases: A Pilot Study in the Veneto Region of Italy*, ***Int. J. Environ. Res. Public Health****, 19*, 2022, 7375.

19 D. Adeloye, J. O. Ige-Elegbede, A. Auta, B. M. Ale, N. Ezeigwe, C. Omoyele, M. T. Dewan, R. G. Mpazanje, E. Agogo, W. Alem, M. A. Gadany, M. O. Harhay & A. O. Adebiyi, *Epidemiology of Physical Inactivity in Nigeria: A Systematic Review and Meta-analysis*, **Journal of Public Health**, 2021,1-11.

20 T. B. Darikwa & S. O. Manda, *Spatial Co-Clustering of Cardiovascular Diseases and Select Risk Factors among Adults in South Africa*, **International Journal of Environmental Research and Public Health**, 17 (10), 2020, 3583.

21 A. L. Oyeyemi, T. L. Conway & R. A. Adedoyin, *Construct Validity of the Neighborhood Environment Walkability Scale for Africa*, **Med Sci Sports Exerc**, 49 (3), 2017, 482-491.

22 W. Chen, A. Hammond-Bennet, A. Hypnar & S. Mason, *Health-Related Physical Fitness and Physical Activity in Elementary School Students*, **BMC Public Health**, 18, 2018, 195.

23 F.A. Engel, A. Ackermann, H. Chtourou & B. Sperlich, *High-Intensity Interval Training Performed by Young Athletes: A Systematic Review and Meta-analysis*, **Front Physiol**, 9, 2018, 1012.

24 A. Hammami, B. Harrabi, M. Mohr & P. Krustrup, *Physical Activity and Coronavirus Disease 2019 (COVID-19): Specific Recommendations for Home-based Physical Training*, **Managing Sport and Leisure**, 27 (1-2), 2022, 26-31.

25 A. García-Hermoso, A. Cerrillo-Urbina, J. T. Herrera-Valenzuela, C. Cristi- Montero, J. M. Saavedra & V. Martínez-Vizcaíno, *Is High-Intensity Interval Training more Effective on Improving Cardiometabolic Risk and Aerobic Capacity than other forms of Exercise in Overweight and Obese Youth?* **A Meta-Analysis, Obes Rev**, 17, 2016, 531–540.

26 P. Braaksma, I. Stuive, R. M. E. Garst, C. F. Wesselink, C. K. van der Sluis & R. Dekker, *Characteristics of Physical Activity Interventions and Effects on Cardiorespiratory Fitness in Children Aged 6-12 Years-A Systematic Review*, **J Sci Med Sport**, 21, 2018, 296-306.

27 W. T. B. Eddolls, M. A. McNarry, G. Stratton, C. O. N. Winn & K. A. Mackintosh, *High-Intensity Interval Training Interventions in Children and Adolescents: A Systematic Review*, **Sports Med**, 47, 2017, 2363–2374.

28 D. Thivel, J. Masurier, G. Baquet, B.W. Timmons, B. Pereira & S. Berthoin, *High-Intensity Interval Training in Overweight and Obese Children and Adolescents: Systematic Review And Meta-Analysis*, **J Sports Med Phys Fitness**, 59, 2018, 310–324.

29 B. S. Lee, S. Y. Shin & Y. O. Han, *Comparison of Male Adolescents' Physical Fitness Using Physical Activity Promotion System and Circuit Exercise Programme*, ***Int. J. Environ. Res. Public Health**, 18*, 2021, 7519.

30 T. P. Nuñez, F. T. Amorim, N. M. Beltz, C. M. Mermier, T. A. Moriarty, R. C. Nava, T. A. VanDusseldorp, & L. Kravitz, *Metabolic Effects of Two High-Intensity Circuit Training Protocols: Does Sequence Matter*? **J. Exerc. Sci**. **Fit**, 18, 2020, 14–20. https:// doi. org/ 10. 1016/j. jesf, 2019. 08. 001

31 S. Rathinakamalan & G. Abraham, *Effect of Circuit Training on Strength endurance among Players of Different Team Games*, **Journal of Xi'an University of Architecture and Technology**, 12 (2), 2021, 364-371.

32 U. C. Ikenna, O. G. Ngozichi1, I. Ijeoma, N. Ijeoma, N. Ifeanyichukwu & O. C. Martin, *Effect of Circuit Training on the Cardiovascular Endurance and Quality of Life: Findings from an Apparently Healthy Female Adult Population*, **JALSI**, 23 (3), 2020, 1-8.

33 S. Sato, S. Ukimoto, T. Kanamoto, N. Sasaki, T. Hashimoto, H. Saito, E. Hida, T. Sat, Ta. Mae & K. Nakat, *Chronic Musculoskeletal Pain, Catastrophizing, and Physical Function in Adult Women were Improved after 3-Month Aerobic-resistance Circuit Training*, **Scientific Reports**, 2021, 11, 14939.

34 G. I. Osifila & A. T. Abimbola, *Workload and Lecturers' Job Satisfaction in Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria*, **Journal of Education and Learning (EduLearn)**, 14 (3), 2020, 416-423.

Chapter Two

Literature Review

This chapter discusses literature review. The related literature are reviewed under the following sub-headings:

2.1 Conceptual Review

2.1.1 Overview of Circuit Training

Circuit training is a series of exercise performed in a sequence or a circuit with one exercise at each station. Circuit training is done moving from one exercise to another, performing one set of each exercise until the circuit is complete. A circuit is completed in about one to three times during a training session. Circuit training is a training that makes some form of physical training into posts[1]. Circuit training usually combines several exercises into one implementation[2, 3].

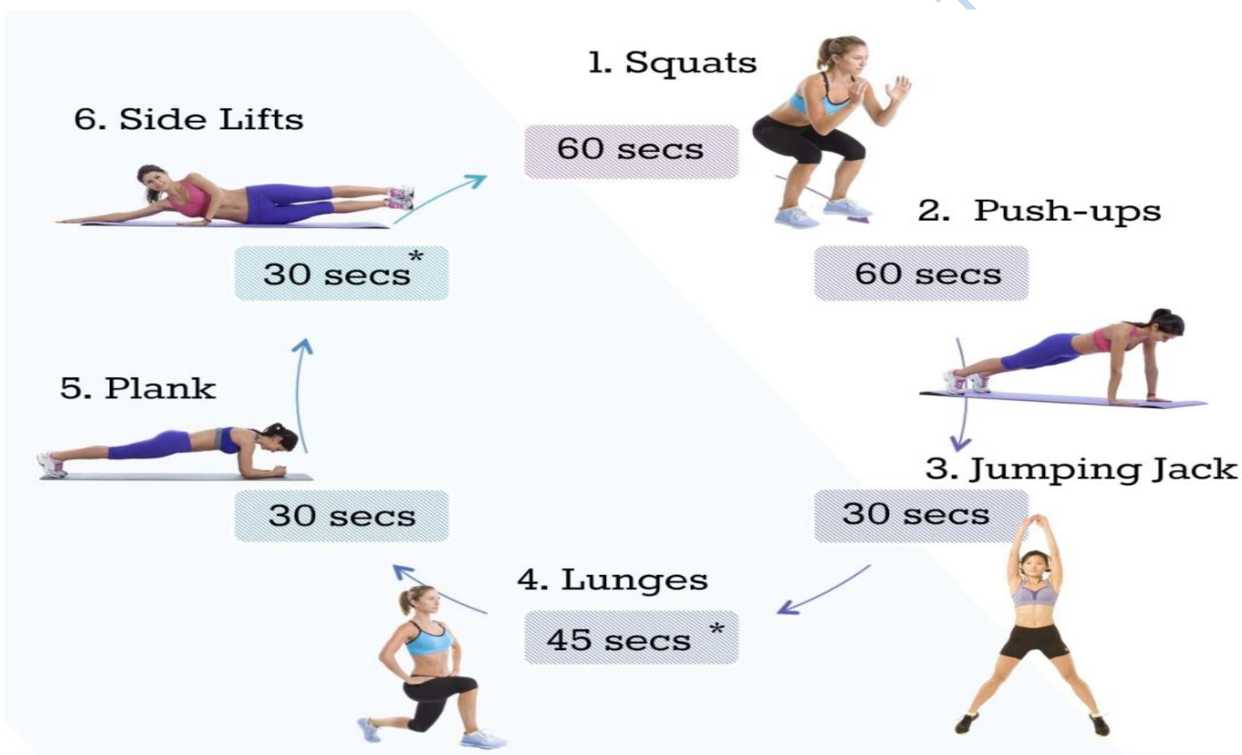

Fig. 2.1: Typical Circuit Training Programmeme

Source: [1]

It is a method of physical training that combines many forms of exercises. Summarily, circuit training is known as a combination of resistance training and high intensity[4]. A circuit may be desined to improve overall physical fitness such as power, endurance, strength, agility, speed, and other components of physical performance[5]. The circuit training method can be in the form of running up and down stairs, running sideways, running backwards, throwing the ball, hitting the ball with a racket, jumping, various forms of weight training, and so on. The forms of circuit training are usually in a cycle, which informed the term circuit training. The hallmark of circuit training is an exercise consisting of several activities with short rest intervals, even without a break with the aim of improving oxygen utilisationcapacity. In addition, sport-specific circuits can be designed to address the specific skill and fitness requirements of the athletes. Circuit training is a versatile training method, and can be adapted for different situations, sections of population and fitness requirements. It can also be used irrespective of seasons both outdoor and indoor.

Circuit training was first developed by Morgan and Adamson at the University of Leeds in the 1950s[6]. While these were the first important scientific research into circuit training, it did not result in the invention of circuit training itself. That honor probably dates back to the early nineteenth century, when a few of gymnastic instructors across Europe began to popularize physical activity for the masses.

In Germany, individuals like Johann Basedow and Friedrich Ludwig Jahn set up their own gymnastics schools for adults and children[7]. They were emulated by those in other countries like Pierre Henrik Ling in Sweden and Francisco Amorós y Ondeano in France. These men, and those they inspired, effectively kick-started the modern interest in physical training as they, and their writings, made possible, working out an acceptable and understandable practice. Operating in the early 1800s, these men did not have dumbbells or barbells, so they focused solely on bodyweight exercises. Jan Todd's work on Monsieur Beaujeu in Dublin, found that Beaujeu had his clients use dips and pull ups to build their strength. Why this is important today is that the men's training systems, and their implementation, were oftentimes done in a circuit fashion. The emphasis may not have been on short rest periods but the practice of quickly moving from one exercise to the next, moving briskly to use the term of the day.

Some in the fitness community of the nineteenth century cautioned against exercising too vigorously, even informing their clients to stop short of losing their breath while training, the practice of training groups in a rudimentary circuit fashion did exist, and in some cases, thrived. This was especially the case after the 1860s when the British military overhauled its training system. Done under the supervision Archibald MacLaren, soldiers were given three months physical training where they would alternate between *various conditioning drills involving rope-climbing, trapeze work, and the negotiation of obstacles while carrying packs and rifles.* Equally important was the growth of physical education in schools in Great Britain and the United States. Operating in a world in which exercise was now important, educationalists like Dio Lewis, began to write on new styles of exercise for children. Lewis' 1860 book[8]. New Gymnastics, was one successful example. Lewis himself was relatively silent on the point of how to set up training classes but split classes into groups using different exercises. This meant that groups could simultaneously use different exercises. The only thing missing was shortened rest time. Lewis was usually in favor of longer rest periods. James Johonnot's 1878 work Principles and Practices of Teaching, pushed for quick forms of physical education in classrooms in which students moved from exercise to exercise. The rudimentary or early kinds of circuit training existed long before the 1960s.

From the late nineteenth century, the desire to get some form of physical activity grew among the general public in Britain and the United States. Addressing, and fueling, this desire was the emergence of physical culture, a late nineteenth and early twentieth century fitness phenomena. With the growth of physical culture, trainees could now choose between dumbbells, barbells, calisthenics, Indian club swinging and any many of weighted implement. For trainees in the United States, Alan Calvert's Milo Barbell, founded in 1903, marked greater access to many of these items. Calvert's entrepreneurial spirit, which included Strength magazine, was matched by others, like Bernarr MacFadden, whose Physical Culture magazine became one of the most dominant voices in the health and fitness industry. Both men, in their own way, helped push more and more people into exercising which, in turn, meant that training methods capable of managing large crowds in a short space of time became a necessity. **While some tried to capitalize on the newfound interest in health and fitness by writing books about exercising in bed or losing weight with only five minutes of activity each day, others turned to fitness classes.** In the United States, Great Britain and much of Europe, the new interest in physical culture came to be seen in group exercise classes for adults and children. Again it wasn't the slick style of training found today, but it was something. Furthermore it intensified the importance of some form of circuit training. In exercise classes for men, lasting 90 minutes, trainees were put through a series of different exercises and movements. For twenty minutes, the men were put through a programme of 'vigorous' calisthenics which, the instructor later claimed, few could actually complete owing to the constant strain. Reading into the Washington gym's approach, the classes were split into different groups, all performing separate exercises. This, it seems, was a common approach.

Circuit training, in this way, sort of meandered on during the early 1900s. What helped change things was the First World War, 1914-1918. Physical training, in the military, could, at times, rely on circuit and group training. When War broke out, millions of men were introduced to exercise, many of whom had no experience training whatsoever. When the war ended in 1918, many retained their interest and belief in physical training. As a result, the 1920s and 1930s saw dozens of governments around the world began promoting mass systems of gymnastics and calisthenics. While this development was most clearly seen in Nazi Germany or Fascist Italy, where large-scale group exercise took a remarkable level of importance, the same was true in Great Britain and the United States. Using systems devised along the lines of Ling, Jahn and their contemporaries, circuit styles of training were used in larger numbers than ever before. This point became doubly true during the Second World War, 1939-1945.

Without delving too much into the history of things, the Second World War was important for two reasons. First it brought a new generation into physical activity and, more importantly, it was during the War that many first came into contact with progressive weight training. **Jason Shurley, Jan Todd and Terry Todd's recent work on the history of strength coaching highlighted the fact that many Americans first took an interest in weight lifting and bodybuilding during the time as troops in the War.** Troops met the best of both worlds-they had experience training in circuits and lifting weights. Second, it meant that many wanted to continue this interest. This also extended into their research, as many of the mid-century's leading exercise physiologists were bitten by the Iron bug during the conflict.

The Second World War also helped further the growth of exercise science and physiotherapy. Owing to the vast numbers of injured troops returning from the front, doctors and physiotherapists began to take a much greater interest in weight training. Specifically, they wondered, having trained with weights themselves, if weight training could help injured men recover faster. Thomas DeLorme in the United States used progressive weight training to help rebuild leg strength and size among American soldiers during the 1940s and 1950s. Prior to DeLorme, rehabilitation was based largely on light calisthenics from the early 1900s. DeLorme, in contrast, spoke of the need for weight lifting, and heavy weight lifting in fact. In this instance DeLorme's own interest in health and fitness spilled over into his medical testing.

It is against this backdrop that the first major scientific intervention in circuit training occurred. In Great Britain, two researchers took their own personal interest in fitness into the laboratory. Their goal was to discover the best way of producing 'holistic fitness', which is the kind of fitness applicable to both aerobic and anaerobic activities. **This led Morgan and Anderson, to create the first breakthrough study on circuit training following their research at the University of Leeds.** Done in 1953 and subsequently popularized for broader audiences in Sorani's 1966 work, Circuit Training, Morgan and Anderson's work was relatively simplistic at first glance. Set up 9 to 12 stations with different exercises to be performed at each station. Move trainees from station to station with relatively little rest in between exercises. Individuals would perform 8 to 20 repetitions at each station with a moderately heavy weight, rest 15 to 30 seconds and then begin again at a different station. The results appeared to speak for themselves. **After a short period of training, participants were not only stronger, but their cardiovascular health improved as well.** People began to take notice, not least because this form of training appeared to promise an effective way of exercising that anyone could do with relatively little time. In 1957 Morgan published another work, this time with another exercise physiologist, G.T. Adamson, which further refined this approach. According to Morgan and Adamson, Circuit training encapsulated three things; it increases muscular mass and cardiovascular fitness, it employs progressive overload, and it enables large groups of individuals to train at the same time.

There are numerous methods for performing circuit training. Continuous circuit training and competitive circuit training are two types of workouts in the circuit training approach. Continuous circuit training is a type of exercise that focuses on long-duration training sessions that are performed without pause. Aerobic sports such as running, biking, swimming, and rowing are common forms of continuous training[9]. The continuous workout's purpose is to keep the same heart intensity throughout the activity. Competitive circuit training is an activity that is performed or developed in the form of a game in which athletes compete to be the fastest in completing the training circuit[10]. This is similar to a timed circuit, but is done in a set time period. Conventional training and aerobic-resistance training is also a type of circuit training. Conventional training consists of workouts that combine a single body part with single or multiple joint movements. Basic exercises such as presses, rows, flys, and squats are examples of these. They are machine-based or free-weight loaded exercises that use a single joint to execute the activity, such as quad extension machines or dumbbell bicep curls. Aerobic-resistance exercise adapts the cardiovascular system and improves muscle development and function.

2.1.2 Design of an Effective Circuit Training

1. **For General Fitness**: Completing a variety of resistance workouts and high-intensity cardiovascular exercises in rapid succession will help develop strength and endurance[11]. For those with limited time, 3-4 shorter workouts each week are an efficient strategy to increase overall fitness.

Circuit Training Guidelines for General Fitness: Circuit exercise should be done 2-4 times a week. As with resistance training, a minimum of 48 hours should elapse between sessions that target the same muscle groups[12]. For general fitness, a resistance that permits the station to be completed in the time allotted should be selected[13]. Bodyweight and the weight of the objects used, such as medicine balls, can also influence resistance. Circuit exercise classes typically have 8-12 stations[14]. These are typically completed for 30-90 seconds, with a 30-90 second rest period between each station. Progression can be achieved by either increasing station time or lowering rest periods. However, only one at a time. A normal circuit consists of 1-3 circuits with 2-3 minutes respite between each cycle. Athletes can also use this type of circuit during off-season training. Intersperse two or three circuit resistance training sessions with 2-3 cross-training cardiovascular activities.

2. **Circuit Exercise for Basic Strength Development:** When beginning a sport-specific strength training programmeme, athletes should always begin with a phase of fundamental strength training. This is typically done during the off-season in the early stages of preparation to prepare the body for more hard work later on. Even seasoned players require a period of basic strength training to help rectify some of the muscle imbalances that are unavoidable in professional sports. Circuit training is a good option since alternating workouts allow for maximum muscle recovery[15]. Rest times between stations should be increased because this phase of training should not be too strenuous.

Circuit Training Guidelines for Short-Term Strength-Endurance: Sports like soccer and field hockey benefit from repeated bouts of high-intensity work[16]. Circuit training with 30-60 second stations is an excellent technique to improve particular strength endurance for these sports[17]. The number of exercises in a circuit should be lower than in most general fitness circuits. Circuits and workout selection should ideally mimic competition movements.

Circuit Training Guidelines for Long-Term Strength-Endurance: Distance cycling, running, and rowing are examples of continuous endurance events that necessitate a different programmeme design[18]. While exercises are still performed in order, the time of each station and rest intervals bore little relation to traditional circuit training. To allow each exercise to be completed for an extended amount of time, very light loads are used. Progression steadily reduces the rest intervals between stations to zero, thereby completing each station back-to-back.

3. Circuit Training for Strength-Endurance Development: Many athletes require excellent muscular endurance to perform well in sport. [19]. A circuit training session can be developed to meet their specific needs. By keeping rest intervals short a cardiovascular element is developed and by alternating exercises abdominal muscle groups, more work can be completed for a longer period. Circuit training for a multi-sprint sport such as soccer will differ significantly compared to circuit training for a marathon runner for example. Proper circuit workout is composed of many different exercises. Many fitness sources recommend this routine: Upper body exercise, Lower body exercise, Core exercise, and Cardiorespiratory exercises. This circuit is completed three (3) times for a total number of twelve (12) sets. A 3-step circuit, use this format: Upper and lower body exercise, Core exercise, and Cardiorespiratory exercises. This circuit is completed four (4) times for a total number of twelve (12) sets. Upper body exercises include Pushups, Tricep dips, and Seated rows. Lower body exercises include Lunges, Jumping lunges, Squats, Deadlift. Combined upper/ lower body exercises include Burpees, Kettlebell swing, Squat to bicep curls. Cardiorespiratory exercises include Jump rope, Sprints, Jumping jacks, Leaps. Core exercises include Crunches, 30 seconds plank, and Side plank.

2.1.3 Typical Activities in Circuit Training

A circuit works on each section of the body seperately. Activities in circuit training include the following

1. **Pushups:** Pushups are a basic exercise used in athletic training or during physical education classes or commonly in military physical training[20]. The pushup is a multi joint upper body exercise that can increase the upper body muscular push strength, shoulder strength, and performance of activities demanding high level of relative strength[21]. Pushups are one of the basic and most common exercises for the human body. Pushups are great exercise for the chest, and also help tremendously for shaping and defining abs, triceps, shoulders and torso. Pushups exercise and its variations can be progressed, regressed, and performed throughout a training year[22].

Muscles Used: The pectoral muscles, triceps, anterior deltoids, serratus anterior, coracobrachialis, and the abdominal muscle as a whole[23].

Pushup Types: There are two versions of the pushup mainly; the normal base (wide pushup) and the narrow pushup.

- The normal base pushup requires placing hands on the floor, a little wider than shoulder-width apart.
- The narrow pushup involves placing the hands on the floor forming a diamond shape with the fingers, in line with the head. Each version of pushup produces related movements in shoulders and elbows, but the wide pushup gives a greater range of motion.

Pushup Phases: There are two phases of the pushup movement: Pushing Phase and Lowering Phase[24]. During the pushing stage, motions are occurring at the elbow, shoulder and scapular joints. In the elbow, extension occurs, powered mainly by the triceps brachia muscle. In the shoulder joint, horizontal adduction occurs. This motion occurs when the upper arms move horizontally toward the midline of the body. The pectoralis major, deltoids, biceps and coracobrachialis muscles contract during horizontal adduction. At the scapular joint, scapular abduction occurs during the pushing phase. In this fashion the scapulae move forward as they round the back of the ribcage, a motion also known as protraction. The serratus anterior and pectoral minor muscles power protraction. During the lowering phase, the same muscles that work in the pushing phase are active, but this time eccentrically. For an example, in the elbow, flexion occurs as the body is lowered, but with the triceps eccentrically allowing this motion. In the shoulder joint, horizontal abduction occurs, eccentrically controlled by the pectoral major, deltoid, biceps and coracobrachialis muscles. At the scapula, scapular adduction, or retraction, occurs, which the serratus anterior and pectoral minor eccentrically control.

There are number of complex muscles and tendons that allow the elbow to move, and these are connected to three bones. The humerus bone of the upper arm joins with the radius laterally and the ulna medially bones of the forearm to form an elbow joint. The troclea of the humerus attaches to the ulna, and the capitulum of the humerus attached to the head of the radius. The joints are lubricated by a large bursa sack that allows the muscle to interact with the joint so that it doesn't lead to damage or cause any pain[25]. Shoulder joint is consisted of two separate joints. The first joint is called the glenohumeral, where the upper arm bone fits into the shoulder blade and second is called acromioclavicular and is formed by the meeting of the collarbone with the shoulder blade. The joints are held together by ligaments and muscles, but it is susceptible to dislocation due to sudden twist or movements of the arm.

Benefits of Pushups:

- Pushups can be performed at home without the expensive exercise equipment, which can save money on a gym membership[26].
- Pushups exercise on a regular basis strengthen, tone up the muscles and build major muscles, which can make daily activities easier and also improves sports performance[27].
- Pushups also strengthen core muscles, specifically the rectus abdominus and transversus abdominis.
- Pushups exercise stimulates metabolism and blood circulation, allowing burning of more calories throughout the rest of workout.
- Pushups provide better results than many similar exercises. Athletes who include pushups in their workout routine reach fitness goals more easily than those following workouts that rely on other methods.
- Research had shown that performing pushups can help increase testosterone levels, reducing risk of developing osteoporosis[28].
- Pushups use a large number of muscles at the same time.

Proper Execution: Proper way of performing pushups is by placing the body in a horizontal position balancing on both the hands and toes while facing down, with arms extended, hands shoulder width or more apart, and feet touching or slightly apart[29]. This movement is excellent for the pictorials major and the triceps brachii. Inhale and bend the elbows to bring the rib cage close to the ground without arching the low back excessively. Push back up to complete arm extension and exhale at the end of the each movement.

2. **Dips:** A dip is an upper-body strength exercise[30]. Narrow, shoulder-width dips mainly trains the triceps, with major synergists being the anterior deltoid, the pectoralis muscles, and the

rhomboid muscles of the back. Wide arm training places additional emphasis on the pectoral muscles, similar in respect to the way a wide grip bench press would focus more on the pectorals and less on the triceps. To perform a dip, the exerciser supports themselves on a dip bar with their arms straight down and shoulders over their hands, then lowers their body until their arms are bent to a 90 degree angle at the elbows, and then lifts their body up, returning to the starting position. Usually dips are done on a dip bar, with the exerciser's hands supporting their entire body weight. For added resistance, weights can be added by use of a dip belt, weighted vest, or by wearing a backpack with weights in it. A dumbbell may also be held between the knees or ankles. For less resistance, an assisted dip/pull-up machine can be used which reduces the force necessary for the exerciser to elevate the body by use of a counterweight. One may also use resistance bands hooked under the feet to help if there is lack of strength to properly perform a dip. Another variation of the dip is done on gymnastic rings. Similar to a bar dip, the exerciser hand's grasps the rings, supporting the entire body weight. The unsteady nature of the rings adds additional challenge, although there are variations to make the exercise easier. In the absence of equipment, a lighter variation of the dip can be performed called the Bench Dip. The hands are placed on one bench directly underneath the shoulders or on two parallel benches. The legs are straightened and positioned horizontally; the feet rest on another bench in front of the exerciser. This variation trains the upper body muscles in a similar though not exact manner as the normal dip, whilst reducing the total weight lifted by a significant amount. This exercise can be done also off of the edge of a sofa, a kitchen counter, or any surface that supports the lifter. It should be done under control.

Benefits of Dips:

- Allows addition of extra weight.
- It's a compound exercise.
- Increase flexibility. ·
- Reduces injuries[31].

How to do a Proper Dip Exercise:

- **Grab the parallel bars (rings), and hoist the body.**
- **Bend the knees.**
- **Keeping the elbows at the side, lower the body until the triceps is parallel to the floor.**
- **Once the body hit parallel, explode back up until just before the elbows are locked.**

3. **Back Extension:** A back extension is an exercise that works the lower back as well as the mid and upper back, specifically the erector spinae[32]. There are two Erector spinae muscles, one on either side of the spine that runs along the entire length of the spine[33]. Erector spinae muscles are actually formed of three (3) smaller muscles; spinalis, longissimus, and iliocostalis. The name hyperextensions are being used for back extension exercises that are done using a hyperextension bench in a fitness gym.

Muscles Used:

- **Posterior Chain Muscle Group.** These are the muscles of the backside of the body and include the lower back, glutes, hamstrings, and calf muscles. They work together to help jump, rotate, lift, or land.
- **Erector Spinae Muscle Group.** These muscles form the intermediate layer of the back muscles and comprise three subgroups. They work together to help with spine extension.

- **Quadratus Lumborum.** This muscle is located in the deep areas of the spine and involves the iliac crest, the lumbar vertebrae, and the 12th rib. It helps neighboring muscles in the posterior chain muscle group exert tension better.

Back extension muscles may also include the middle and upper back muscles as well as the oblique muscles for stabilization[34].

Benefits of Back Extension:

Back extension exercises improve the stability and strength of the erector spinae muscles[35]. They also improve the range of motion of the lower back and can have a rehabilitative effect on people with poor lumbar or thoracic back posture[36]. Back extensions help with exercises that require significant use of the posterior chain muscles:

- **Improved back stability.** This helps with better posture and better performance during other exercises.
- **Reduced injury risk.** Back strengthening prevents the spine from being overextended. Improving lower back flexibility lowers the likelihood of spinal column and low back problems.
- **Improved body awareness.** Stronger back stability helps with other exercises where there is need to maintain a straight back, such as deadlifts and barbell rows.
- **Low impact alternative for recovery.** Back extensions are good low-impact alternative exercises for people recovering from back injuries or who have limited mobility for various reasons.

Equipments Used:

- **Without any Equipment**: It may be performed on the ground by lying prone with arms overhead and lifting the arms, upper torso, and legs as far as possible[37]. Gravity is used as resistance to strengthen the back extensor muscles.

- **Using a Roman Chair**: A Roman chair helps to stabilize the legs up until the hip joints while performing low back extension38. To perform the exercise, the torso from above the hip joints is flexed forwards and down towards the floor. And to complete the exercise, the back muscles (Erector spinae) are contracted and the torso is raised up till the whole body is in a straight line from the head to heels. Lighter weights may be used to begin with to prevent straining the back muscles with over-exertion.
- **Using Hyperextension Bench**: There are two varieties of Hyperextension bench depending upon the angle that they support the lower body, the 45 degrees and 90 degrees hyperextension bench[39]. The 90 degrees Hyperextension bench is also called Roman chair as discussed above. Here the body lies horizontally and the person can experience full back range of motion. As compared to the 45 degree Hyper extension bench, where the person would be almost standing and it allows extension only up to partial range of motion. In both the versions of the Hyperextension bench, the person is requested to fold the arms in front or place the hands on the back of the head with the elbows pointing to the sides, while performing the exercise.
- **Using Reverse Hyperextension Machine**: This machine has been used to strengthen not only the errector spinae muscle, but also gluteus maximus and part of hamstring muscles (biceps femoris).

4. **Medicine Ball Chest Pass**: The Medicine ball wall chest pass is an upper body exercise for power development. The medicine ball chest pass builds strength and explosive power through the chest, shoulders, and arms while improving muscular and cardiovascular endurance. It targets abs and chest and also involves biceps, shoulders and triceps[40].

Muscles Used:

- **Primary Muscle Groups**: Supinator, Upper Chest, Middle Chest, Lower Chest, Pectoralis Minor, Pronators.
- **Secondary Muscle Groups**: Side Shoulders, Front Shoulders, Rear Shoulders, Triceps, Laterals (back), Quads, Elbow Flexors.

How to do Medicine Ball Chest Pass:

Step 1: Grab a medicine ball and hold with both hands in front of chest. Palms should be facing each other and thumbs pointing toward the face.

Step 2: Stand with feet shoulder-width apart and knees slightly bent. Weight should be evenly distributed on the feet. Stand about 3 feet away from a concrete wall.

Step 3: Begin exercise by throwing the ball against the wall as hard as possible, extending arms straight out in front. Catch ball off the wall, bring back to chest and repeat.

Benefits of Medicine Ball Exercises

- They can improve flexibility and increase range of motion[41].
- They are an easy way to add resistance training to abdominal workouts.
- They are a creative way to change up strength training routine.
- They can be used for sport-specific strength training exercises[42].
- They can help to improve coordination[41].
- They are suitable for people of all ages, fitness levels and abilities.
- They can be done alone or with a partner.
- Medicine balls come in various styles and sizes.

5. **Bench Press**: The bench press, often known as the chest press, is a weight training exercise that involves pressing a weight upwards while lying on a weight training bench[43]. The bench press is an upper body mass-building exercise that targets some of the largest muscles in the body, including the chest, triceps, shoulders, front deltoids, and even the upper back. It is also widely utilized to develop the chest muscles in weight training, bodybuilding, and other sorts of training. Bench press strength is significant in combat sports because it corresponds closely with punching power. Bench press can also help contact athletes improve their performance by increasing upper body effective mass and functional hypertrophy.

Muscles Used: Although the bench press is a full-body exercise, the pectoralis major, anterior deltoids, and triceps, among other stabilizing muscles, are the primary muscles employed.[44].

6. **Sit-ups:** The sit-up (also known as a curl-up) is an abdominal endurance training exercise that helps to strengthen, tighten, and tone the abdominal muscles. Sit-ups strengthen more muscles and have a greater range of motion than crunches, which work the rectus abdominis as well as the external and internal obliques. A sit-up is accomplished by lying on one's back with the knees and toes bent and the arms crossed over the chest or positioned behind the head to reduce the tension on the back muscles and spine[45]. The upper and lower vertebrae are then elevated off the floor until the buttocks and any areas above them are free of contact.

Benefits of Sit-ups

- **Core Strength:** One of the most common reasons people do sit-ups is to strengthen their core[46]. When the core is strengthened, tense, and toned, back pain and injuries are less likely to arise[47]. Furthermore, carrying out daily duties and engaging in physical activity are made easier.
- **Improved Muscle Mass:** Sit-ups strengthen the abdominal and hip muscles[48]. The inability to perform sit-ups could be a good indicator of muscular atrophy.

- **Athletic Performance:** Athletes with strong core muscles have increased muscular strength and endurance. A strong core allows for maintenance of good posture, stability, and form while participating in any sport or physical activity[49].

- **Better Balance and Stability:** A strong core helps the body stay balanced and steady during daily and athletic activities. They aid in the coordination of the pelvic, lower back, and hip muscles with the abdominal muscles. A good sense of balance reduces the likelihood of falling.

- **Increased Flexibility:** Moving the spine aids in the release of stiffness in the spine and hips. Sit-ups promote hip and back flexibility, which improves mobility and relieves stress and tightness. Flexibility enhances circulation and focus, lowers stress, and increases energy levels.

- **Improved Posture:** Building a strong, firm core makes it simpler to keep the hips, spine, and shoulders in line, which aids in posture improvement. Less discomfort and tension, more energy, and better breathing are all advantages of proper posture.

- **Reduced Risk of Back Pain and Injury:** Sit-ups also improve lower-back, hip, and pelvic strength. A strong core allows for a solid, firm centre, which reduces the likelihood of back pain and damage.

- **Diaphragm Strengthening:** Sit-ups are an excellent technique to work on diaphragmatic breathing. Sit-ups produce abdominal compression, which can be beneficial to the diaphragm. A healthy, robust diaphragm helps improve breathing patterns, reduce stress, and increase physical endurance.

7. **Stomach Crunch:** Crunches are a fantastic compound-muscle abdominal exercise. In a crunch, unlike a sit-up, the lower back never leaves the floor. A crunch is a more specific and isolated workout that exclusively targets the rectus abdominis[50].

Benefits of Stomach Crunch: Crunches, done correctly, can help increase core strength and definition[51]. Core is an important aspect of balance and helps to avoid damage during other exercises. It's simple to perform and doesn't require any special equipment or skill.

8. **Back Extension Chest Raise**: Back extensions are great for training the spinal erectors, glutes, hamstrings, and lower back muscles.

Muscles Used for Back Extension Chest Raise

- Posterior chain muscle group. These are posterior muscles, which include lower back, glutes, hamstrings, and calf muscles.
- Erector spinae muscle group.
- Quadratus lumborum.

Benefits of Back Extensions: Back extension workouts strengthen and stabilize the erector spinae muscles[52]. They also enhance lower back range of motion and can be rehabilitative for persons with weak lumbar or thoracic back posture.

9. **Squat Jumps**: Squat Jumps are a powerful plyometric exercise that improves the entire lower body while increasing heart rate to burn a considerable amount of calories[53]. Squat Jumps work the quads, hamstrings, glutes, and calves, as well as the abdomen and back muscles. Furthermore, squat leaps improve posture. Traditional squats have been taught and strongly emphasized for toning the buttocks and legs; however, the addition of the jump allows for additional strength and muscular density, as well as the highest heart rate for a high volume of calorie burn, leading to fat loss.

How to Do Squat Jumps

Here are the steps to performing squat jumps:

Begin by standing with both feet hip-width apart and lowering into a squat position by bending the knees. Maintain a straight spine, an elevated chest, and knees behind the toes. For balance, place the arms in front of the chest.

Jump up straight and swing the arms high. Return to a squat position.

10. **Step-ups**: The step-up combines the lunge and stepping upward, like climbing the stairs[54].

Muscles Trained

The step-up works the legs and core primarily, with little involvement from the upper body. The step-up exercises the following muscles.

- Quadriceps: The quadriceps is a group of four muscles that work together to stretch the knee.
- Glutes: When the hip is in flexion, the glutes extend to help the rise up.
- Hip adductors: Help in hip flexion and offer support for the knee to prevent it from collapsing inwards.
- Hamstrings: Assists the glutes with hip extension, and the hamstring's eccentric strength aids in controlled lowering.
- Calves: The step-up involves a minor plantar flexion, but the calf muscles work overtime to keep balanced on one leg.

Benefits of Step-ups

- **Better single-leg balance. Step-ups increase proprioception and balance.**
- **Increased muscular growth and unilateral strength.**

- **Simple to learn and progress.**
- **Less strain on the lower back.**
- **May improve barbell squat.**

How to Do the Step-up Exercise

- Depending on the hip mobility and strength, place the foot on a box with the knee bent at a 90-degree angle or the hip crease slightly below the knee. Check that it is on a level surface.
- Perform with the body weight or with dumbbells on the side while standing one foot away from the box.
- Put the entire lead foot on the box, toes pointing forward.
- To stand up, push through the lead foot.
- Once the knee is extended, either rest the other foot on the box, balance on one leg, or drive the non-working leg into a high knee.
- Take a cautious step down with the non-lead leg, reset and repeat.

11. **Shuttle Runs:** The shuttle run is a cardiovascular workout that predominantly focuses the quadriceps while also targeting the calves, glutes, groine, hamstrings, hip flexors, and outer thighs to a lesser extent[55]. A shuttle run is a fitness test used to assess speed, agility, and endurance[56]. It is a simple exercise that involves running back and forth between two points at a steady speed. Shuttle running is a simple and straightforward activity that has numerous advantages. This includes increasing speed and agility, conditioning fitness, and strengthening muscle tissues surrounding the lower extremities.

How to do Shuttle Run:

Step 1: Set the cones at the proper spacing (usually 10 or 20 meters).

Step 2: Place two little blocks or balls at the far end of the cone.

Step 3: Begin at the cone farthest away from the blocks.

Step 4: Assume sprinter position. Sprint to the other cone as quickly as possible.

Step 5: Take one of the blocks in your hand, turn around, and dash back to the starting cone.

Step 6: Place the first block at the starting cone and dash back to get the second.

Step 7: Pick up the second block and race through the starting cone.

Step 8: Time stops after crossing the first cone for the last time.

12. **Bench Squats**: A bench squat is a squat performed on a bench. Bench squats are leg-muscle-targeting strength-building exercises. Bench squats, which are sometimes preferred over conventional squats by those with knee difficulties, allow the exerciser to improve leg strength without having to worry about sinking too low into the squat or having the knees give out at the bottom of the squat. The workout primarily targets the quadriceps, hamstrings, and glutes.

13. **Burpees:** A burpee is a full-body exercise that consists of a squat thrust with an added stand in between repetitions[57]. The movement is primarily an anaerobic exercise, but when repeated over a longer length of time, it can be used as an aerobic exercise.

Benefits of Burpee: In addition to fat loss, integrating burpees in a training regimen will help get numerous additional cardiovascular benefits, such as:

- a stronger heart and lungs.
- better blood flow.
- reduced risk of heart disease and diabetes.
- reduced blood pressure.
- decreased cholesterol levels.
- improved brain function.

How to Do a Burpee

- Stand with the feet shoulder-width apart, the weight in the heels, and the arms at thesides.
- Squat by pushing the hips back, bending the knees, and lowering the body.
- Place hands precisely in front of and barely inside feet. Transfer weight to the hands.
- Jump the feet back and land softly on the balls of the feet in a plank position. From head to heels, the body should form a straight line. Back sag and buttocks sticking up in the air can also inhibit effective core activation.
- Optional: Lower into a push-up or lower the body all the way to the floor while maintaining the core engaged. Push up to raise the body off the floor and return to the plank posture. (Form tip: Lift chest first and leave hips on the ground while bringing body back up off the floor to avoid "snaking" off the ground.)
- Jump het feet back so that they fall just outside the hands.
- Raise the arms high and leap into the air. For the next rep, land and instantly descend back into a squat.

14. **Skipping:** A skipping rope or jump rope is equipment used in the activity of skipping/jump rope, in which one or more competitors jump over a rope slung under the feet and over the heads[58]. Skipping/jump rope has several subtypes, including single freestyle, single speed, pairs, three-person speed (Double Dutch), and three-person freestyle (Double Dutch freestyle). Rope skipping is a popular workout or recreational activity[59]. Skipping is a cardiovascular workout that has a high metabolic equivalent of task (MET) or intensity level, similar to jogging or bicycle riding[60]. This aerobic workout can generate a burn rate of up to 700 to over 1,200 calories per hour of strenuous activity, with approximately 0.1 to nearly 1.1

calories expended every jump, depending mostly on the pace and intensity of the hops and leg folding.

15. **Jogging:** Jogging is a type of slow or leisurely trotting or running[61]. The major goal is to improve physical fitness while putting less strain on the body than faster running but more than walking, or to keep a constant speed for longer periods of time. It is a type of aerobic endurance training that is done over vast distances. Jogging is a leisurely pace of running. In general, jogging speeds range from 4 to 6 miles per hour (6.4 to 9.7 kilometres per hour). Jogging can also be used as a warm-up or cool-down for runners before or after a workout or race. Serious runners frequently utilize it as an active recovery method during interval training. Jogging has been shown to increase human longevity and reduce the symptoms of ageing, as well as to assist the cardiovascular system. Jogging can help you fight weight and keep healthy. Jogging also helps to prevent muscle and bone deterioration that comes with age, improves heart performance and blood circulation, and aids in the maintenance of a healthy weight gain.

2.1.4 Benefits of Circuit Training

There are numerous benefits associated with circuit training. Some of them include the following

- **Improves Muscular Endurance:** Muscular endurance is the body's ability to exercise for an extended amount of time. Circuit training causes the recruitment of slow-twitch muscle fibers, which aids in the endurance of exercise[62].

- **Increases Strength and Muscle Growth:** Depending on the exercises perform during the circuit; the body is able to build stronger and larger muscles. Since circuit training puts muscles under ongoing tension, this can stimulate neuromuscular adaptations and muscle growth to build larger and stronger muscles[62].

- **Improves Heart Health:** Circuit training is a favorite for many because it combines strength training and cardiorespiratory training[63]. Since there is little rest between exercises, the heart rate stays elevated throughout the circuit. This helps strengthen and decrease stress on the heart, allowing it to push more blood into the body with less effort. It also helps increase lung capacity, allowing for more efficient breathing during exercise.
- **Offers a Full-body Workout:** Instead of splitting workouts throughout the week to target specific muscle groups, circuit training includes a variety of exercises to give a full-body workout[64]. Moving from one exercise to another aids alternating between different muscle groups. Ultimately, this can help get the most out of workouts.
- **Is Time Efficient:** Since there are minimal breaks during a session, workout can be completed in a short time frame.
- **Improves Exercise Adherence:** People are less likely to stick to a workout programme if they get bored easily. Fortunately, circuit training may be the solution, since constantly involves going from one exercise to another. Furthermore, circuit training classes provide a fun, entertaining environment that can keep one connected with others.
- **May Promote Weight Loss:** A lot of calories can be burned with circuit training, which may help lose weight[65]. Since the heart rate stays elevated the entire workout, burning a high volume of calories. Plus, performing strength training, metabolism can stay elevated hours after workout.
- **May Improve Mood:** Circuit training may help lift mood and improve mental health by combining the mood-boosting benefits of both cardio and strength training exercise. Both forms of exercise found in circuit training help improve mood by releasing feel-good endorphins and

increasing self-efficacy. Along with this, circuit training classes offer a friendly social environment that can contribute to a positive mood.

- **Perfect for All Levels:** Circuit training is highly versatile, making it suitable for almost everyone. Circuits can be designed for all difficulty levels. This is done to suit people of all fitness levels.

2.1.5 Physical Fitness

Physical fitness is a set of attributes that are either health or skill-related66. Being physically fit has been defined as the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies[67]. Physical fitness is a state of health and well-being and, more specifically, the ability to perform aspects of sports, occupations and daily activities[68]. Physical fitness is generally achieved through proper nutrition, moderate-vigorous physical exercise, and sufficient rest along with a formal recovery plan[69]. Fitness is defined as the quality or state of being fit and healthy. The degree to which people have these attributes can be measured with specific tests. Physical fitness measures are closely allied with disease prevention and health promotion, thus it is common and appropriate to measure components of physical fitness before preventive and rehabilitative programmes. Physical fitness can be modified through regular physical activity and exercise[70]. Physical fitness components have been shown to have a significant positive relationship with enhanced outcomes in physical activity, including sports participation[71].

Benefits of Physical Fitness

Controlling Blood Pressure: Physical fitness has been shown to help lower blood pressure[72]. Regular physical activity and exercise strengthens the heart**.** The heart is the primary organ in control of systolic and diastolic blood pressure. Physical activity causes blood pressure to rise. When the patient finishes doing the activity, the blood pressure returns to normal. The more physical activity, the easier this process becomes, and the better cardiovascular profile as a result. It gets easy to raise blood pressure through regular physical activity. This reduces the force on the arteries and hence lowers overall blood pressure.

Inflammation: Increased physical activity has been linked to decreased inflammation in studies[73]. It causes a short-term inflammatory reaction as well as a long-term anti-inflammatory effect. Physical activity lowers inflammation in conjunction with or independently of weight reductions. However, the mechanisms underlying the relationship between physical exercise and inflammation are unknown.

Immune System: Exercise/ Physical activity strengthens the immune system[74]. The concentration of endogenous variables (such as sex hormones, metabolic hormones, and growth hormones), body temperature, blood flow, hydration condition, and body position all influence this. Physical activity has been shown to increase the levels of natural killer (NK) cells, NK T cells, macrophages, neutrophils and eosinophils, complements, cytokines, antibodies and T cytotoxic cells[75]. However, the mechanism that connects physical activity to the immune system is not completely understood.

Weight Control: Achieving resilience through physical fitness promotes a vast and complex range of health-related benefits. Individuals who keep up physical fitness levels generally regulate their distribution of body fat and prevent obesity[73]. Abdominal fat, specifically visceral fat, is most directly affected by engaging in aerobic exercise. Strength training has been known to increase the amount of muscle in the body; however, it can also reduce body fat. Sex steroid hormones, insulin, and appropriate immune responses are factors that mediate metabolism in relation to abdominal fat. Therefore, physical fitness provides weight control through regulation of these bodily functions[76].

Mental Health: Studies have shown that physical activity can improve mental health and well-being[77]. This improvement is due to an increase in blood flow to the brain, allowing for the release of hormones as well as a decrease stress hormones in the body (e.g., cortisol, adrenaline) while also stimulating the human body's mood boosters and natural painkillers. Not only does exercise release these feel-good hormones, it can also help relieve stress and help build confidence. These trends improve as physical activity is performed on a consistent basis, which makes exercise effective in relieving symptoms of depression and anxiety, positively impacting mental health and bringing about several other benefits.

2.1.6 Components of Physical Fitness

Physical fitness can be broadly divided into health- related and skill-related[78].

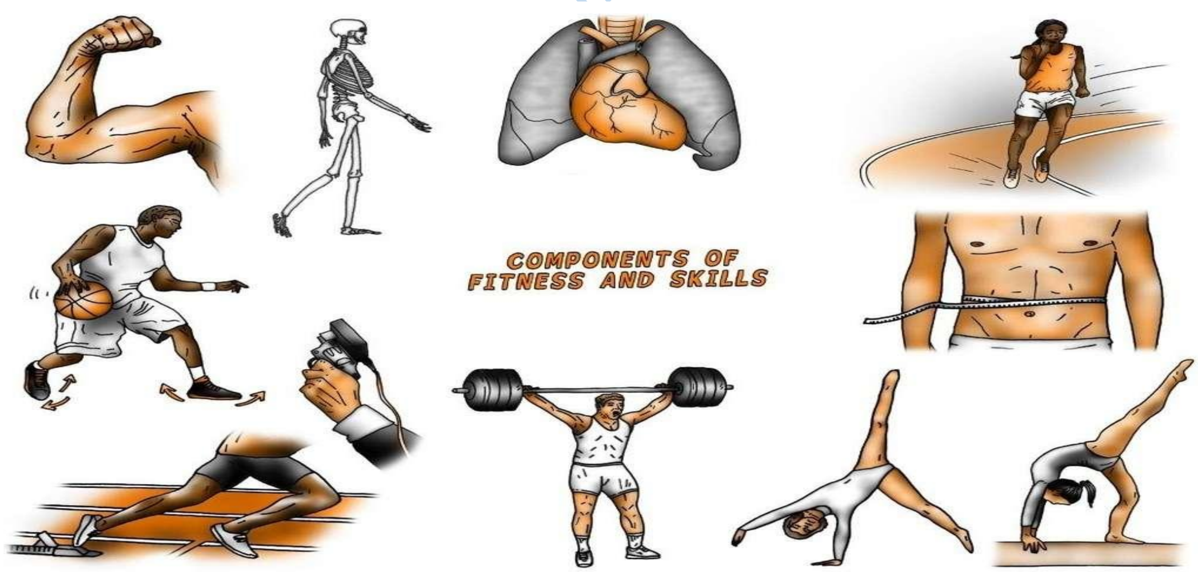

Fig. 2.2: Components of Physical Fitness

Source: [78]

Health- related Physical Fitness: Good health have a strong relationship with health related components of physical fitness because it determines the ability of an individual to perform daily activities with vigor and demonstrate the capacities associated with low risk of premature development of the hypokinetic diseases. It is also known as physiological fitness. The main aims of health-related fitness testing are:

- Educating clients about their present health-related fitness status in relationship to standard age and sex- matched normative values.
- Providing data that are helpful for making clinical decision while prescribing exercises to address all fitness components.
- Collecting baseline and follow up data that allow evaluation of progress by exercise programme participants.
- Cardiovascular risk classification

The components of health-related fitness includes: body composition, muscular endurance, muscular strength, cardiovascular endurance and flexibility[79].

Skill-related Physical Fitness: It is also known as performance-related fitness components. It is associated with athletic competition but should be considered in the overall fitness of all individuals. These components are pertaining with the athletic ability of an individual. There are six (6) components of skill-related physical fitness: balance, co-ordination, agility, speed, power, and reaction time[80].

Balance: This is the ability of an individual to maintain their line of gravity within their base of support[81]. It can be classified into static and dynamic. Balance is control by three different systems: somatosensory, visual and vestibular system. It can be assessed by various outcome tools such as berg balance scale, BESTest, etc[81].

Co-ordination: It is the ability to use the senses, such as sight and hearing, together with body parts in performing motor tasks smoothly and accurately[82]. Alternate hand wall toss test is one the test via which co-ordination can be assessed.

Agility: This is described as a fast whole-body movement with a change in velocity or direction in reaction to a stimulus. It executes a sequence of explosive power motions in opposite directions in fast succession[83].

Power: It is the rate at which one is able to exert maximal force[84]. Vertical jump test and hop test are some examples of power testing for lower extremity. Medicine ball throw test can be used to assess upper extremity power.

Reaction Time: Reaction time is related to the time elapsed between stimulation and the beginning of the reaction to it. Reaction time is affected by several variables including attentive, cognitive and motor functions.

Speed: It relates to the ability to perform a movement within a short period of time. Speed combined with strength will provide power and force. Sprint test is one of the examples of the test that can be used to examine person's speed.

Muscle Strength

It is the muscle's ability to exert force at high intensities over short periods of time[85]. Muscular strength is defined as the maximum amount of force that a muscle or muscle group can exert against an opposing force.

Forms of Muscle Strength: There are four ways to display muscle strength. These four types of strength include absolute strength, strength endurance, power or explosive strength, and relative strength[86].

The absolute or maximal strength of a muscle or group of muscles in a given exercise equals the most external resistance an athlete can overcome or maintain with full voluntary mobilization of the neuromuscular system. This means that it is the absolute maximum amount of force that can be produced for a single repetition at a single point in time. A one repetition maximum (1RM) is another term for this.

Explosive strength is the speed with which one may employ strength. It entails intense loading during shorter, high-speed movements with lower repetition ranges with long rest periods in between sets. The rate of force development (RFD) is the primary factor in explosive strength. The RFD measures an athlete's explosive strength, or how quickly he or she can create force. This is defined as the rate at which the muscle's contractile components can generate force. Strength endurance is the ability to continually apply sub-maximal force against a sort of resistance. It is shown in tasks that involve a reasonably lengthy duration of muscle tension with a minor drop in efficiency. Strength endurance movements necessitate settings in which a high level of muscle endurance is demonstrated, such as hill sprints, sledge pushes, high volume weightlifting sessions, and so on. Lower weights moved frequently by a muscle are ultimately what strength endurance is[87].

Relative strength is the maximum amount of strength in a movement in comparison to one's body size or weight. Relative strength is how strong someone is in comparison to their bodyweight[88]. Absolute or maximal strength and relative strength are connected. Unless the individual's body weight grows, relative strength should increase. Gymnastics, wrestling, weightlifting, and other sports require a lot of relative strength. Sporting competitions that need weight classes or bodyweight control necessitate a high level of relative strength. Furthermore, movement patterns like pull ups necessitate relative strength.

Muscle Strength Testing

The One-Repetition Maximum (1RM) Test: It is simply defined as the most weight an individual can lift in one repetition using proper technique. The assessment of the 1RM is used to measure maximal strength capacities, it can also be used to measure force-time, power-time, and velocity-time characteristics when performed using specialized equipment such as a force plate. The 1RM test is often considered as the 'gold standard' for assessing the strength capacity of individuals in non-laboratory environments[89]. Purpose of the test is to determine the maximum weight that can be lifted for one complete repetition of the movement. Equipment required are weights dependent on muscle group testing.

Test procedure:

a. The subject should warm up, completing a number of sub-maximal repetitions.

b. Determine the 1-RM (or any multiple RM) within four trials with rest periods of 3 to 5 minutes between trials.

c. Select an initial weight that is within the subject's perceived capacity (~50%–70% of capacity).

d. Resistance is progressively increased by 2.5 kg to 20 kg until the subject cannot complete the selected repetition(s). All repetitions should be performed at the same speed of movement and range of motion to instill consistency between trials.

e. The final weight lifted successfully is recorded as the absolute 1-R or multiple RM.

Multiple Repetition Maximum (M-RM) Strength Tests: The M-RM is defined as the maximum weight that a person can lift in a given number of repetitions using proper lifting technique[90]. The 5-repetition maximum (5-RM), for example, is the maximum weight that a person can lift five times using proper lifting technique. The M-RM strength test serves the same functions as the 1-RM strength test. Furthermore, the M-RM strength test is approved for determining strength training intensity. In addition, the M-RM can be utilized to predict the 1-RM. The 5-RM, in particular, enables accurate estimate of the 1-RM.

Dynamic Strength Test: The dynamic strength test uses a machine called an isokinetic dynamometer to examine the upper body strength. Isokinetic dynamometers are able to test the strength (torque) and power of different muscle groups[91]. The test consists of five seated chest pushes and five seated back pulls. The final result will be the average of the five pushes and five pulls.

Resistance training exercises such as weightlifting, bodyweight exercises, and resistance band exercises are examples of workouts that improve muscle strength[92]. Running, cycling, and mountain climbing are also options.

Flexibility

Flexibility is defined as the ability to move a joint through its full range of motion[93]. Flexibility is the anatomical degree of movement in a joint or series of joints, and length in muscles that span the joints to induce a bending movement or motion. It is essential for activity of daily livings (ADLs) and athletic performance. It is affected by a number of factors, including joint capsule distensibility, proper warm-up, and muscle viscosity. Because flexibility is joint specific, no one flexibility test can be used to assess total body flexibility. Some common devices for measuring flexibility in degrees include goniometers, inclinometers, electrogoniometers, the Leighton flexometer, and tape measures. One type of flexibility test is the sit and reach test.

Flexibility Test

Sit and Reach Test: The sit and reach test is a typical flexibility test that assesses the flexibility of the lower back and hamstring muscles[94]. The test has several versions. Many variations of this test involve differences in the value of the feet's level. The most rational measure is to record the level of the feet as zero, such that any measurement that does not reach the toes is negative and any measurement that exceeds the toes is positive. The typical sit and reach approach has the limitation that persons with long arms and/or short legs would have a better outcome, while those with short arms and/or long legs would be at a disadvantage.

Equipment Needed: A sit and reach box (or a ruler and a step or box can be used alternately).

Procedure: This test requires sitting on the floor with the legs straight ahead. Shoes must be removed. The feet's soles are pressed flat against the box. Both knees should be locked and flat against the floor. The person being examined reaches forward as far as possible along the measuring line, palms down, hands on top of each other. Make sure that both hands are at the same level, with neither reaching further forward than the other. The individual stretches out and retains that position for at least one to two seconds while the distance is measured[95]. The score is recorded to the nearest centimeter or half inch as the distance achieved by the hand. To convert the score measurement to a rating, use the chart.

Sit and Reach Test Scores								
	Men				Women			
Percentile Rank	20-29 years		30-39 years		20-29 years		30-39 years	
	in.	cm	in.	cm	in.	cm	in.	cm
99	>23.0	>58	>22.0	>56	>24.0	>61	>24.0	>61
90	21.75	55	21.0	53	23.75	60	22.5	57
80	20.5	52	19.5	50	22.5	57	21.5	55
70	19.5	50	18.5	47	21.5	55	20.5	52
60	18.5	47	17.5	44	20.5	52	20.0	51
50	17.5	44	16.5	42	20.0	51	19.0	48
40	16.5	42	15.5	39	19.25	49	18.25	46
30	15.5	39	14.5	37	18.25	46	17.25	44
20	14.5	37	13.0	33	17.0	43	16.5	42
10	12.25	31	11.0	28	15.5	39	14.5	37
01	<10.5	<27	<9.25	<23	<14.0	<36	<12.0	<30

Fig. 2.3: Nomogram of Sit and Reach Test

Source: [96]

Back Scratch Test: The back scratch test, also known as the scratch test, determines how close the hands can be brought together behind the back[97]. This test assesses the general range of motion of the shoulder. A yardstick or a ruler is required as equipment.

Procedure: This test is performed while standing. Place the hand behind the head and back over the shoulder, reaching as far down the centre of the back as possible, palm touching the body and fingers pointing downwards. Place the second arm behind the back, palm outward, fingers up, and extend up as high as possible, striving to touch or overlap the middle fingers of both hands. If the fingertips make contact, the score is zero. If they don't contact, measure the distance between their finger tips (a negative score), and if they do, measure how much they overlap (a positive score). Practice twice, and then test twice. Take the best score and round it up to the nearest centimeter or 1/2 inch. The better the outcome, the higher the score.

The chart below shows the recommended ranges (in inches) for this test based on age categories[98].

Age	Below average	Normal (inches)	Above average
60-64	< -6.5	-6.5 to 0	> 0
65-69	< -7.5	-7.5 to -1.0	> -1.0
70-74	< -8.0	-8.0 to -1.0	> -1.0
75-79	< -9.0	-9.0 to -2.0	> -2.0
80-84	< -9.5	-9.5 to -2.0	> -2.0
85-89	< -10.0	-10.0 to -3.0	> -3.0
90-94	< -10.5	-10.5 to -4.0	> -4.0

Fig. 2.4: Nomogram of Back Scratch Flexibility for Men

Source: [96]

Age	**below average**	**normal (inches)**	**above average**
60-64	< -3.0	-3.0 to 1.5	> 1.5
65-69	< -3.5	-3.5 to 1.5	> 1.5
70-74	< -4.0	-4.0 to 1.0	> 1.0
75-79	< -5.0	-5.0 to 0.5	> 0.5
80-84	< -5.5	-5.5 to 0	> 0
85-89	< -7.0	-7.0 to -1.0	> -1.0
90-94	< -8.0	-8.0 to -1.0	> -1.0

Fig. 2.1.5: Nomogram of Back Scratch Flexibility for Women

Source: [96]

Trunk Rotation Tests: The goal of this flexibility test is to assess trunk and shoulder flexibility, which is vital for injury prevention in sports like racquet sports, throwing, and swimming. A wall, a bit of chalk or pencil, and a ruler or tape measure is all required.

Procedure: Draw a vertical line across the wall. Stand with the back to the wall and the feet shoulder width apart in front of the line. Place approximately an arm's length away from the wall. Extend the arms directly in front, parallel to the floor. Twist the trunk to the right and then use the fingertips to touch the wall behind, keeping the arms extended and parallel to the floor.

Turning the shoulders, hips, and knees is permitted as long as the feet do not move. Measure the distance from the line to the point where the fingertips contacted the wall. A point before the line results in a negative score, whereas a point after the line results in a positive score. Repeat with feet in the same position on the left side. Calculate the average of the two scores (left and right). To convert the score measurement to a rating, use the chart[99].

Ratings	**Score**
Excellent	20cm
Good	15cm
Very Good	10cm
Fair	5cm
Poor	0cm

Fig. 2.6: Nomogram of Trunk Rotation Test Chart

Source: [96]

Cardiorespiratory Fitness

Cardiorespiratory fitness is related to the ability to perform large muscle, dynamic, moderate to high intensity exercise for prolonged periods. The performance depends upon the functional state of the cardiovascular, respiratory, and skeletal muscle systems.

The Cardiovascular System: The cardiovascular system is made up of the heart, a muscular pumping device, and a closed network of vessels known as arteries, veins, and capillaries[100]. The heart circulates blood through the blood vessels. Blood vessels transport blood throughout the body. Blood carries nutrients and oxygen to tissues while also removing carbon dioxide and waste materials.

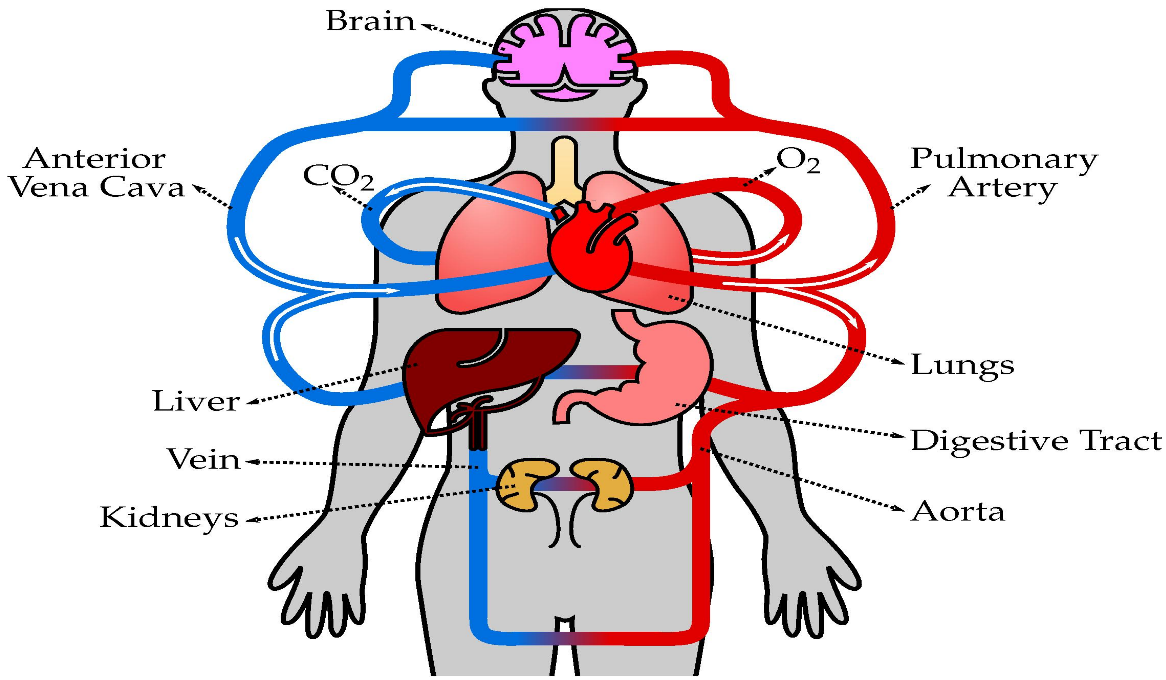

Fig. 2.7: The Cardiovascular System

Source: [100]

The Heart: The heart is a muscular organ that circulates blood throughout the body[101]. It is located in the mediastinum, between two lungs. It has four chambers: two atria and two ventricles.

The Right Side of the Heart: The right side of the heart is divided into two chambers: the right atrium and the right ventricle. The right atrium is a low-pressure chamber with thin walls. It has a pacemaker known as the sinoatrial node, which generates cardiac impulses, and an atrioventricular node, which distributes the impulses to the ventricles.

Two major veins supply venous (deoxygenated) blood to the right atrium:

1. The superior vena cava, which transports venous blood from the head, neck, and upper limbs.
2. Inferior vena cava that returns venous blood from lower parts of the body.

Right atrium communicates with right ventricle through tricuspid valve. Venous blood from the right atrium enters the right ventricle through this valve. From the right ventricle, pulmonary artery arises. It carries the venous blood from right ventricle to lungs. In the lungs, the deoxygenated blood is oxygenated.

Left Side of the Heart: The left half of the heart is divided into two chambers: the left atrium and the left ventricle. The left atrium is a low-pressure chamber with thin walls. Through pulmonary veins, it obtains oxygenated blood from the lungs. This is the single instance in the body when an artery transports venous blood while a vein transports arterial blood. The mitral valve (bicuspid valve) allows blood from the left atrium to reach the left ventricle. The left ventricle's wall is extremely thick. The left ventricle circulates arterial blood throughout the body via the systemic aorta.

Blood Vessels: The cardiovascular system's vessels include the aorta, arteries, arterioles, capillaries, venules, veins, and venae cavae. Blood vessels are in charge of delivering oxygen and nutrients to tissues as well as collecting waste products. The aorta, next the arterioles, and finally the capillaries in the tissues deliver oxygenated blood from the left ventricle. The arteries are the blood vessels that transport blood, while the capillaries are the sites of material exchange that maintain the tissue microenvironment. Deoxygenated blood flows from capillaries in the peripheral tissues to the right atrium of the heart via the venous system[102].

The Respiratory System: The respiratory system is an organ system made up of particular organs and tissues that are responsible for gas exchange. The respiratory tract is separated into upper and lower respiratory tracts. The nose, nasal cavities, sinuses, pharynx, and the region of the larynx above the vocal folds are all part of the upper tract. The lower tract consists of the larynx's lower section, the trachea, the bronchi, the bronchioles, and the alveoli[103].

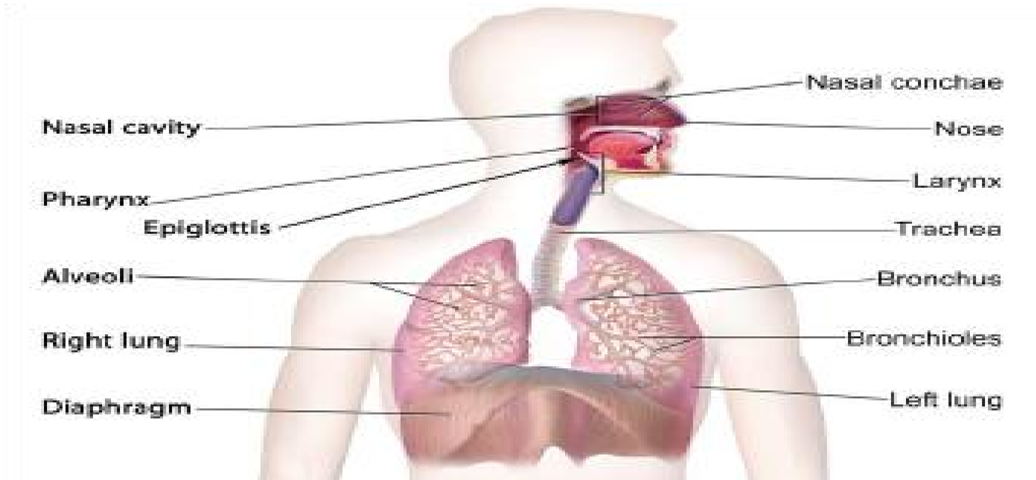

Fig. 2.8: Diagram of the Respiratory System

Source: [109]

The Nose: A nose is a protuberance that contains the nostrils, or nares, which receive and exhale air for respiration.

The Nasal Cavities: The nasal cavity is a wide, air-filled region in the centre of the face above and behind the nose. The nasal cavity is the topmost section of the respiratory system and contains the nasal tube that transports inhaled air from the nostrils to the nasopharynx and the remainder of the respiratory tract.

Pharynx: The pharynx transports food and air to the oesophagus and larynx respectively. Generally, the human pharynx is divided into three sections: the nasopharynx, oropharynx, and laryngopharynx. It is also essential in vocalization[104].

Larynx: The larynx, often known as the voice box, is an organ on the top of the neck that helps with breathing, producing sound, and protecting the trachea from food aspiration.

The Trachea: The trachea, commonly known as the windpipe, is a cartilaginous tube that connects the larynx to the bronchi of the lungs, allowing air to pass, and is found in almost all air-breathing animals with lungs. The trachea connects the larynx to the two major bronchi.

The Bronchi: A bronchus is a lower respiratory tract conduit or airway that transports air to the lungs. The right and left major bronchi are the initial or primary bronchi to branch from the trachea at the carina[105].

The Bronchioles: Bronchioles, also known as bronchioli, are tiny branching of the bronchial airways in the lower part of the respiratory system. They are the terminal bronchioles, followed by the respiratory bronchioles, which mark the beginning of the respiratory zone and provide air to the gas exchanging components of the alveoli.

Alveoli: A pulmonary alveolus (alveoli), also known as an air sac or air space, is a hollow, distensible cup-shaped cavity in the lungs that serve as sites of pulmonary gas exchange.

Assessment of Cardiorespiratory Fitness: The criterion measure of cardiorespiratory fitness is determined by maximal oxygen uptake (VO_2max). Others include the measurement of arterial blood pressure, heart rate, respiratory rate, oxygen saturation level etc. The best measure of cardio-respiratory fitness is VO_2 max, volume (V) of oxygen used when a person reaches his or her maximum (max) ability to supply oxygen (O_2) to muscle tissue during exercise.

Maximal Oxygen Uptake (VO_2max): VO_2 max is the maximum quantity of oxygen a person can consume and it remains constant over time despite an increase in effort. The absolute value of VO_2 max is liters/min, while the relative value is milliliters/kg/min. The VO_2 max can be calculated using either maximum or submaximal testing, as well as direct or indirect approaches. Walking/running tests are the most often utilized, followed by cycling and step tests[106]. The maximum oxygen uptake (VO_2 max) is one of the most commonly used metrics in exercise science. The gold standard for determining cardio-respiratory endurance is a person's VO_2 max.

The maximum aerobic power (VO_2 max) of a person can be measured using maximal or submaximal tests, as well as direct or indirect approaches. The direct approach (laboratory method) involves measuring an individual's expired gases in order to analyze their pulmonary ventilation, inhaled oxygen, and expired carbon dioxide. Direct measures, such as breath-by-breath analysis, reliably identify an individual's maximum oxygen consumption. Indirect methods, such as field testing, assess a person's aerobic capacity based on their heart rate, distance travelled, and/or time of trial when following a certain procedure[106].

Arterial Blood Pressure: Arterial blood pressure is defined as the lateral pressure produced by the blood column on the artery wall. When blood travels through the arteries, pressure is exerted. The word 'blood pressure' often refers to arterial blood pressure. Arterial blood pressure can be expressed in four ways: Systolic blood pressure, Diastolic blood pressure, Pulse pressure, and Mean arterial blood pressure are all measurements.

Systolic Blood Pressure: Systolic blood pressure (systolic pressure) is the greatest pressure exerted in the arteries during the heart's systole[107]. Normal systolic pressure is 120 mmHg (range: 110-140 mmHg).

Diastolic Blood Pressure: Diastolic blood pressure (diastolic pressure) is the lowest pressure in the arteries during diastole of the heart. Diastolic pressure should be between 60 and 80 mmHg.

Pulse Pressure: The pulse pressure is the difference between systolic and diastolic pressure[108]. Normal pulse pressure: 40 mmHg (120 – 80 = 40).

Mean Arterial Blood Pressure: The mean arterial blood pressure is the average pressure in the arteries. It is not the arithmetic mean of systolic and diastolic pressures. It is equal to the diastolic pressure plus one-third of the pulse pressure. The diastolic pressure is taken into account before the systolic pressure when calculating the mean pressure. It is because the diastolic length of the heart cycle is longer (0.53 second) than the systolic period (0.27 second). The normal mean arterial pressure is 93 mm Hg (80 + 13 = 93).

Heart Rate: Heart rate is the frequency of the heartbeat measured by the number of contractions of the heart per minute (beats per minute, or bpm) [109]. The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide, but is also modulated by numerous factors, including (but not limited to) genetics, stress or psychological status, drugs, diet, hormonal status, environment, physical fitness, and disease/illness as well as the interaction between and among these factors. The average heart rate is 72 beats per minute. It varies between 60 and 80 beats per minute. Tachycardia is defined as an increase in heart rate above 100 beats per minute. Bradycardia is defined as a drop in heart rate below 60 beats per minute[109].

Respiratory Rate: The respiratory rate is the rate at which the body breathes; it is regulated and controlled by the brain's respiratory centre. The respiratory rate of a human is often measured in breaths per minute. In humans, the respiratory rate is calculated by measuring the number of breaths taken in one minute and the number of times the chest rises. A healthy adult's resting respiratory rate is 12-15 breaths per minute[110].

Oxygen Saturation Level: Oxygen saturation the amount of haemoglobin linked to molecular oxygen at a specific time point. The percentage of oxyhemoglobin (oxygen-bound haemoglobin) in the blood is measured by oxygen saturation, which is expressed as arterial oxygen saturation (SaO_2) and venous oxygen saturation (SvO_2). Oxygen saturation is a critical metric for determining blood oxygen content and oxygen delivery. Each haemoglobin molecule includes four heme groups that can quickly bind molecular oxygen in the blood. This means that a haemoglobin molecule can bind up to four oxygen molecules during blood transit. The typical range of SaO_2 for humans is 95-100%[111]. A result less than 90% is termed poor oxygen saturation and necessitates the use of supplemental oxygen supplementation.

Coopers 12-Minute Run Test: The Cooper 12 minute run is a common maximum running test of aerobic fitness in which participants attempt to cover the greatest distance in 12 minutes. The purpose is to assess aerobic fitness (the body's ability to utilize oxygen to power itself while running or walking). The following items are required: a level oval or running track, marker cones, recording sheets, and a stop watch.

Either of the following formulas is used to calculate expected VO_2 Max results (in ml/kg/min):

- Kilometres: VO_2 max = (22.351 x km) - 11.288
- Miles: VO_2 max = (35.97 x miles) - 11.291

How to Carry Out a Cooper Run Test

- Warm up by jogging lightly and performing energetic motions.
- Mark a distinct starting position on a level, firm surface, ideally a 400-meter track. Be aware of the distance to travel by completing one lap or returning to the starting place.
- Stay in the same lane for the duration of the test.
- Start a stopwatch as soon as running starts.

- Count how many laps that is completed.
- Stop after 12 minutes and record how many laps completed.
- Walk for 10 minutes to cool down.

Age	Excellent	Above Average	Average	Below Average	Poor
Male 20-29	over 2800 meters	2400-2800 meters	2200-2399 meters	1600-2199 meters	under 1600 meters
Females 20-29	over 2700 meters	2200-2700 meters	1800-2199 meters	1500-1799 meters	under 1500 meters
Males 30-39	over 2700 meters	2300-2700 meters	1900-2299 meters	1500-1999 meters	under 1500 meters
Females 30-39	over 2500 meters	2000-2500 meters	1700-1999 meters	1400-1699 meters	under 1400 meters
Males 40-49	over 2500 meters	2100-2500 meters	1700-2099 meters	1400-1699 meters	under 1400 meters
Females 40-49	over 2300 meters	1900-2300 meters	1500-1899 meters	1200-1499 meters	under 1200 meters
Males 50	over 2400 meters	2000-2400 meters	1600-1999 meters	1300-1599 meters	under 1300 meters
Females 50	over 2200 meters	1700-2200 meters	1400-1699 meters	1100-1399 meters	under 1100 meters

Fig. 2.9: Nomogram of Coopers Test

Body Composition

The term "body composition" refers to the percentages of fat, bone, water, and muscle in human bodies[112]. Body Composition is a term used to describe the many components that make up a person's body weight when considered together. Using a two-compartment model, body composition can be stated as the relative fraction of body mass that is fat and fat-free tissue. It can be measured using both laboratory and field procedures, which vary in complexity, expense, and precision. Body mass index (BMI), waist to hip ratio, circumferences, and skin fold measurement are all anthropometric procedures. Some procedures used in the lab include hydrodensitometry, weighing, and plethysmography.

Body Mass Index (BMI): Body mass index (BMI) is a weight-for-height measurement computed as weight in kilogrammes divided by height in metres squared (kg/m^2) [113]. BMI is a straightforward, low-cost, non-invasive proxy for body fat. BMI is the most generally used measure for determining body fat levels and is a screening method for measuring and categorizing weight in humans. Underweight, Normal Weight, Overweight, and Obesity are the four main categories.

Classification	**BMI (kg/m^2)**
Underweight	<18.50
Normal range	18.50-24.99
Overweight	≥25.00
Obese	≥30.00

Fig. 2.10: Nomogram of Basal Metabolic Rate

Source: [114]

Body Mass Index: Body Mass Index (BMI) will be calculated using the following equation: BMI = Weight (in kilograms)/ Square of Height (in meters square). This will be done by measuring the weight and height of each participant[5].

Required Equipment: Tape measure, scales, pen, clipboard, Fitness Testing Recording Form

Procedure:

- Measure the client's height. Ensure the client removes shoes, stand up straight with the heels against the wall.
- Record their height in meters.
- Measure the client's weight. Ensure the client removes shoes and wear minimal clothing.

- Record their weight in kilograms.
- Use the formula below to calculate the client's BMI

Formulas and Calculations:

BMI = weight (kg) / height (m)^2

Skin Fold Thickness: Skin fold thickness (SFT) assessment is a reliable, inexpensive, simple, non-invasive way of estimating body fat at all ages, including newborns. It examines the thickness of subcutaneous fat at several places on the body in order to determine total body fat and thus the contribution of fat to body mass[115]. Skinfold thickness data can be used in a variety of ways. They can be directly compared to reference values to assess sufficiency, insufficiency, or excess. Skinfold thickness readings can also be used in predictive mathematical formulas to calculate body fat indices such as % body fat and hence fat mass and fat-free mass. Special calipers are used to measure skinfold thickness in millimeters. Skinfold thickness measuring sites are sometimes divided into limb and core sites. Biceps, triceps, quadriceps, and calf regions are limb sites, while pectoral, subscapular, abdomen, and suprailiac areas are central sites. For uniformity of results, one side of the body, either right or left, is usually employed[115]. The skinfold thickness method is based on measuring a pinch of skin precisely at several standardized sites on the body to determine the subcutaneous fat layer. Measurement will be made by lifting the skin with the thumb and index finger with care being taken to exclude any underlying muscle. The skinfold of the female participants will be measured using slim guide caliper at the triceps, thigh and iliac-crest[116]. The triceps skinfold will be measured from a vertical skinfold on the back of the arm half way between the acromium and olecranon process. Iliac-crest skinfold will be measured from a vertical skinfold over the iliac-crest (point to the hip) in the midaxilliary line (middle of the armpit) while the thigh skinfold will be measured at anterior midline of the thigh, half way between the hip and the knee joint and also the body weight was placed on the opposite leg during measurement. The skinfold of the female participants will be measured using slim guide caliper at the chest, abdomen and thigh. A constant distance of one (1) centimeter would be maintained between the caliper, the thumb and the finger holding the site. The measurement read without delay to ensure that the subcutaneous adipose tissue was not dispersed from the measuring position. All the measurements will be taken on the right side of the body with the participants in the standing position. After taking the three skinfold measurement, the measurement will be summed then on the normogram, a ruler will be used to connect the point on the left that corresponds to the age with the point on the far right that corresponds to the sum of the three skinfold measurement. Then the score will be recorded.

Waist-Hip Ratio (WHR): Waist-to-hip ratio, also known as waist-hip ratio, is the circumference of the waist divided by the circumference of the hips[117]. The waist-hip ratio (WHR) is the dimensionless ratio of the circumference of the waist to that of the hips. The WHR measurement entails using a tape measure to determine the size of the waist and hips[117]. This is determined as waist measurement divided by hip measurement. The WHR has been used as an indicator or measure of health, fertility rates, and the risk of acquiring major health issues.

WHR measures the ratio of waist circumference to hip circumference. Wrap the non-elastic measuring tape around the narrowest portion of the stomach, near or just above the belly button, and measure the circumference. The tape measure should be placed softly on the skin and not pulled taut. Once the tape measure is properly positioned, slowly inhale and exhale to take the measurement. Take note of the measurement in inches. Stand with the feet precisely beneath the hips and wrap the tape over the broadest region of the hips and buttocks. Take note of the measurement in inches. WHR is calculated by dividing the waist size by the hip size[118].

Health risk	**Women**	**Men**
Low	0.80 or lower	0.95 or lower
Moderate	0.81-0.85	0.96-1.0
High	0.86 or higher	1.0 or higher

Fig. 2.11: Nomogram of Waist to Hip Ratio

Source: [117]

2.1.7 Assessment of Physical Fitness

A physical fitness examination comprises measurements of cardiorespiratory endurance, body composition, muscular fitness, and musculoskeletal flexibility. Hydrostatic weighing, skinfold measures, and anthropometric measurements are the three most used procedures for determining body composition. Because of its strong relationship with health and health concerns, cardiorespiratory endurance is an important component of physical fitness testing. The usual criterion for determining cardiorespiratory endurance is maximal oxygen uptake (VO_2max) [120]. Although VO_2max must be measured using maximal-effort testing, submaximal exercise can be utilized to estimate this value.

Muscular fitness has traditionally been used to define an individual's combined state of bodily strength and endurance. Muscular strength in an individual is specific to a certain muscle or muscle group and refers to the maximum force (N or kg) that the muscle or muscle group can generate. The movement of an individual's body against an external load can be used to determine dynamic strength. Isokinetic testing involves measuring the muscular tension generated over a range of motion at a constant angular velocity. Muscular endurance refers to a muscle group's ability to perform repetitive contractions over a defined time period long enough to generate tiredness. Musculoskeletal flexibility examinations concentrate on the joints and the structures, ligaments, and muscles that cross the joints. Many of the criteria for physical examination of musculoskeletal flexibility are satisfied by the sit and reach test and the behind the back reach test. To measure and promote health, a physical fitness assessment must be integrated into all everyday activities as well as the physician's examination[121].

2.2 Theoretical Framework

2.2.1 Affective-Reflective Theory of Physical Inactivity and Exercise

Affective-Reflective Theory (ART) of physical inactivity and exercise is a dual-process theory, which assumes that stimuli (e.g., a friend's reminder that you intended to go for a run, or remembering that you had planned to go for a run) trigger automatic associations and a resulting automatic affective valuation of exercise[122]. An automatic affective valuation is the unattended assignment of positive (association with pleasure) or negative (association with displeasure) value to a stimulus, either as the result of repeated exercise-related emotional experiences mediated cognitive appraisals (e.g., pride, embarrassment) or as a result of repeated experiences of core affective reactions to stimuli (e.g., sense of physical reinvigoration, bodily discomfort). The automatic affective valuation serves as the basis for a controlled, reflective evaluation, which can follow if self control resources are available. The reflective evaluation draws on propositions about exercise and physical inactivity, derived from previous experience and mental simulation (e.g., anticipation of the affective consequence of actions). Higher-level cognitive operations, such as deliberative reasoning about one's needs and values may also contribute to this process.

The automatic affective valuation is connected to an action impulse (approach or avoidance), whereas the controlled response can result in action plans. The ART aims to explain and predict behavior in situations in which people either remain in a state of physical inactivity or initiate action. It assumes that experience, feelings, and thoughts connected with exercise influence whether someone would be willing to undergo physical strain similar to that previously experienced during exercise. Related to the topic of this opinion article, the ART posits that, in the face of an exercise-related stimulus, one's negative affective valuation of exercise will act as a restraining force that may counteract any positive cognitive motivational drives toward action (or, on the other hand, if the affective valuation is positive, it will present a driving force and thus make it more likely that the person will change his or her current state of physical inactivity) [122].

2.2.2 Self-Determination Theory

One psychological theory that has demonstrated successful outcomes in other chronic conditions is Self-determination theory (SDT) [123]. This theory describes the mechanisms by which psychological needs influence behavioral regulation and provides clear guidelines for interventions to effectively change the environment, in support of improved need satisfaction and self-determined regulation towards behavior change. SDT focuses on the quality of an individual's motivation, as opposed to other psychological models which emphasize the quantity of motivation. The theory posits that there are three basic psychological needs; autonomy, competence, and relatedness. Autonomy is the need to be a causal factor in one's life and engage in actions due to interest and integrated values. Competence refers to the need to feel environmental effectiveness and have opportunities to demonstrate and enact on one's capabilities.

Lastly, relatedness is the need to feel connected to other individuals or groups and to care, and be cared for, by these significant others. The more that these needs are satisfied, the greater an individual's self-determined motivation will be toward a given behavior and thus the greater the probability that the behavior will be conducted and maintained[124]. If needs are not satisfied (i.e. dissatisfaction) it is less likely behaviors will be conducted. It is also typical to experience several types of regulation toward one behavior, and this often occurs, for example, having a mixture of introjected and external regulation to exercise. Although these three needs are theoretically distinct from one another, research has also found that they correlate highly.

2.3 Review of Empirical Studies

2.3.1 Effect of Circuit Training on Strength

A study on the effect of circuit training on strength endurance among players of different team games revealed that circuit training is one of the best training methods for improving the strength endurance. The results of the study showed that it is possible to develop strength endurance by means of an eight week circuit training programme. With the circuits method the pupils can easily reach the minimum motor engagement time at the same time they execute many types of exercises. The study suggests that it is possible to develop and maintain strength endurance through a short-term programme for women players. Thirty (30) students were selected from different area of Chennai club players and the age of students were between 19 and 24 years. The selected players were divided in to two equal groups included of fifteen players (n = 15), namely, experimental Group-I (CTG), and Control Group-II (CG). Experimental Group underwent eight weeks of circuit training, and the control group did not involve any special training apart from their regular activities and practices. Strength endurance was selected as criterion variable for this study and it was measured by using bent knee sit ups. These were the exercises used as a circuit 1. Spot running, 2. Burpees, 3. Crunches, 4. High knee, 5. Half squat, 6. Triceps dips, 7. Butt kicks, 8. Superman, 9. Pushups, 10. Lunges. The collected data were statistically examined by analysis of covariance (ANCOVA). The confidence level was fixed at 0.05 levels[125].

A research on circuit training during physical education classes to prepare cadets for military academies tests: analysis of an educational project and concluded that an intervention based on circuit training, power training and strength training did not improve physical performance in military high school students when included into a scholastic reality at the military high school. The researchers reported that the limited amount of physical education hours due to ministerial programmemes and the high psychophysical effort probably interfered with the expected improvement. However, the application of a method based on an action-reflection principle, where participants were protagonists of their improvement and learning process, was widely appreciated by the students. Sixty-four students were enrolled in this study and randomly assigned to an experimental (EG, circuit training) or a control group (CG, traditional physical education programme). Immediately before and after the eight-week training period, participants were tested on strength and endurance performance, circuit training tests, and military tests. The acquisition of the educational objectives and the pleasantness of the experimental intervention were tested using a qualitative approach. Results showed that despite the higher workload in experimental group than control group during the training period, the effect of the experimental intervention compared to the control was only possibly to likely positive for a few strength and endurance performances and circuit training tests, respectively. A trivial effect was shown in the military tests. Also, the high percentage of motivation, understanding and collaboration showed by the students suggests the achievement of acquisition of the educational objectives and a fair pleasantness of the lessons[126].

In a study titled the effect of intensity and interval levels of trapping circuit training on the physical condition of badminton players. The researchers aimed at knowing the extent to which low-intensity and high-intensity circuit trapping training with a combination of training using different intervals can affect the strength, speed and agility abilities of badminton players. A quasi-experimental study was used to develop the approach. There were 48 badminton players who were separated into four groups of 12 samples each. The treatment group was assessed by doing trapping circuits at 60% and 80% intensity with a 1: 1/2 interval and a 1: 1 interval to increase strength, speed, and agility. The participants' strength was measured using a digital back and leg dynamometer, in which participants wore a waist strap attached to the dynamometer leg, then stood by bending their knees to an angle of 110-1200 (degrees) and tried their hardest to straighten their legs before looking at the tool needle. The findings of this study show that the trapping circuit training approach has an influence on strength, speed, and agility abilities[127].

In a study on the effects of a moderate-to-high intensity resistance circuit training on fat mass, functional capacity, muscular strength, and quality of life in elderly, the researchers sought to determine how moderate-to-high intensity resistance circuit training affected body composition, functional autonomy, muscular strength, and quality of life in the elderly. A randomized controlled trial was used in the investigation. A total of 45 subjects (27 females, 18 males) aged 65-75 years old from Murcia (Spain) were randomly assigned to one of two groups: experimental (n=33, mean age 69±3.2 years old) receiving 12 weeks of moderate-to-high intensity resistance circuit training and control (n=33, mean age 70±4.1 years old) receiving no exercise intervention. Upper body strength was assessed by having subjects perform a chest press

(CHP) and military press (MP) to assess the deltoids and triceps muscles; lower body strength was assessed by having subjects perform a leg extension (LE) and hip extension (HE) to assess the gluteals, hamstrings, and quadriceps muscles. Total body weight, fat mass percentage, and lean body mass (LBM) were all evaluated. For data analysis and processing, the statistical software SPSS v21.0 (Chicago, IL) was utilized. This study demonstrated that a 12-week progressive moderate-to-high intensity resistance circuit training (from 60% 1-RM to 80% 1-RM) designed in the current study is connected with a significant gain in upper and lower muscular strength as well as functional capacity, as well as significant improvements in body composition and physical performance in senior people[128].

2.3.2 Effect of Circuit Training on Flexibility

In a study titled the effect of circuit training upon flexibility among non-athletes of college students, the researchers investigated the effects of circuit training on flexibility in college students who were not athletes. A total of 142 male students aged 18 to 22 participated in the study. This study was experimental in nature, using a pre- and post-test design. The study was made up of two groups, Group A (Experimental) and Group B (Control). Before treatment on Group A (Experimental), each subject in the two groups was given a standardized assessment (the Sit and Reach test) to determine their flexibility, and their pre-test data was collected. For 12 weeks, the experimental group received Circuit Training three times each week. The control group received no treatment and was not permitted to engage in any aerobic or anaerobic activities outside of their usual routines. After intervention to the experimental group, each participant in both groups A and B was retested on the dependent variable. The final post-test scores of the subjects in two groups were recorded against the dependent. The study's findings revealed that flexibility increased dramatically among Non-athlete College students who participated in circuit training[129].

A study discovered that plyometric training and circuit training significantly improved speed, muscular endurance, flexibility, agility, explosive strength, vital capacity, and anaerobic capacity in their study titled the effect of plyometric training and circuit training on selected physical and physiological variables among male volleyball players. Twenty four (24) men volleyball players between the ages of 18 and 25 were selected randomly from several engineering colleges in Chennai, Tamil Nadu. Subjects were randomly assigned to one of three groups: experimental I, experimental II, and control. For six weeks, three alternate days per week, the experimental group I participated in a mixed plyometric training group and the experimental group II in a circuit training group. The control group continued with their usual routines and received no special training. The data for the variables in this study were examined using the dependent 't' test to determine the significant improvement and analysis of covariance (ANCOVA) for each variable separately to determine the differences and tested at the 0.05 level of significance. A post hoc test was also administered whenever the 'f' ratio was significant. The dependent 't' test was applied to data acquired for speed, muscular endurance, flexibility, agility, explosive strength, vital capacity, and anaerobic capacity of the experimental and control groups[130].

In a study on the effect of floor and Swiss ball exercises using circuit training methods, balance, strength, flexibility and muscle endurance were variables of interest. This study used a quasi-experimental, floor exercise therapy and Swiss ball exercise using the circuit training method with ten training posts. The study included sixty (60) male students with an average age of 19 years, height 166.31cm, and weight 58.63kg. The study included two sample groups: one experimental group that received floor exercise and Swiss ball exercise utilizing the circuit training method with ten training posts, and one control group. After the last treatment, measurements were taken 48-72 hours later. The study concluded that: 1) there was an effect of floor and Swiss ball exercises aided circuit training method, there was a significant enhancement of balance, strength, flexibility, and muscle endurance; 2) there was also a significant enhancement of balance, strength, and flexibility in conventional training[131].

In a study on the effect of circuit training on obesity, vital capacity and flexibility among school going obese children, obesity (% of body fat), vital capacity, and flexibility of overweight and obese boy/male students from Chinmaya Vidyalaya, Kolazhy, Thrissur, Kerala, ages 10 to 14 were assessed. The researcher selected thirty obese and overweight boys based on BMI scores, greater than 26. The thirty subjects were divided into two groups: experimental and control. Each group was made up of 15 participants. The experimental group received a circuit training programmeme for 12 weeks (3 days per week), whereas the control group received no treatment. Before and after the circuit training programmeme, pre and post data were gathered. Data collected were analyzed using the SPSS statistical tool. The paired t-test was used to determine whether there was a significant effect of training between groups. The findings indicated that the training programmeme had a significant impact on the dependent variables and was found to be effective[132].

2.3.3 Circuit Training on Cardiorespiratory Fitness

In a study entitled circuit training as a method of adaptation and prevention for people with type 2 diabetes, the researchers reported that circuit training carried out for 8 weeks, lasting forty (40) minutes with intensity between 50 and 75% of the VO_2max, obtained appreciable improvements on cardiorespiratory form, muscle level and also on glided hemoglobin (HbA1C).

A sample of thirty (30) subjects with an average age of 50 years (with type 2 diabetes mellitus) was recruited in random mode. Subjects did a circuit training workout for eight weeks with a frequency of 3 weekly sessions of 40 minutes each for a total of 120 minutes per week. The 6-minute walking test was administered. The T-test for dependent samples was used to detect the difference between the two groups at 0.05 level of significance. The circuit training programmeme led to an increase in the level of cardiorespiratory form. The average VO_2max also increased significantly compared to the basic values[133].

Some scholars conducted a research entitled the effect of circuit training on the cardiovascular endurance and quality of life. Findings showed that from an apparently healthy female adult population circuit training had positive effects on cardiovascular endurance and maintenance of functional quality of life (QOL). A total of 60 apparently healthy female students who gave consent were randomly selected using simple randomized sampling technique and were further randomly assigned into the experimental group and control group. A pre-test-post-test control group experimental research design involving 60 apparently healthy females (30 in the experimental group, 30 in the control group) was undertaken. The circuit training duration for the first 2 weeks was 35 minutes with the warm up and cool down exercise time inclusive. The circuit training section was 3 times per week and duration of the training session was increased with 10 minutes after every 2 weeks for the 6-week duration of this study. The high intensive interval circuit training exercises was adopted and they included the following: high knees, knee raise claps, kick raise, alternating jump lunge, burpees and abdominal twist or knee combo. There were 6 stations with short periods of rest between them. The body composition parameters, anthropometric measures and quality of life of the participants were measured at the beginning and at the end of the 6-week duration. The control group involved in this study were not engaged in circuit training, rather they continued with their normal daily activities of life and their body composition parameters, anthropometric measurements and quality of life were also assessed before and after 6-weeks duration of the study using the WHO quality of life Brief (WHOQoL-Bref) questionnaire. The data was summarized using descriptive statistics of mean and standard deviation, and paired t-test was also used to analyze the data obtained. All data were analyzed using IBM SPSS version 18.0 (IBM Co., Armonk, NY, USA). $P < 0.05$ was considered to indicate a statistically significant difference. Findings from the study showed that there was a significant difference ($P<.05$) in partial oxygen saturation, respiratory rate, mean atrial pressure, maximal oxygen consumed, and heart rate. It is therefore necessary for circuit training to be encouraged as a strategy that can be used among young female adults[134].

Effects of applying a circuit training programme during the warm-up phase of practical physical education classes was carried out. A group of twenty five (25) students belonging to a Portuguese school-mean age (15.67 ± 1.02), weight (67.31 ± 9.29 kg), height (1.72 ± 0.08 m) and body mass index (BMI) (22.50 ± 2.65%) participated in the study. None of the participants had regular strength training habits. The training programmeme lasted 3 weeks and was carried out during the academic year, between February and March. In addition, on a weekly schedule of 3 per week, divided into 2 classes of 1hour 30minutes, the students took part in a training programmeme that included exercises lasting 15 minutes. All experimental procedures were performed in coordination with the teachers and, therefore, did not cause any change in the individuals' routine. Pre and post-tests were carried out in the internal space to eliminate the effect of climatic conditions on the results. These tests were chosen because they could be applied quickly and because they did not influence the normal course of activities in the classroom. Four specific variables were analyzed with adaptations to previously used protocols:

the shuttle test, sit-up test, push-up test, and horizontal impulse test. These were evaluated in 2 distinct phases: before the application of the training programmeme (i.e. pre-test) and after the application of the training programmeme (i.e. post-test). The training programmeme was applied twice a week for 3 weeks. The programme had a weekly increment of one repetition. The exercises applied contained strength exercises: burpees, jumping, squats, sit-ups, push-ups, and countermovement jumps. The programmeme was also composed of sprints, with changes in direction (5 m) and speed (20 m) [135].

In a study entitled continuous and competitive circuit training: methods to increase VO_2max on young badminton players, this study are a pre-experiment with a pretest and posttest group design. This study's subjects were sixty male badminton players. The sample for this investigation was chosen using simple random sampling. The samples were randomly assigned into two groups: Continuous Circuit Training (age = 110.8 years; height = 1436.5 cm; weight = 37.33.7 kg) and Competitive Circuit Training (age = 11.21.0 years; height = 141.46.7 cm; weight = 43.45.0 kg). All samples' VO2max was assessed using a Multistage Fitness Test (MFT) before and after treatment in each group. The data were analyzed using a paired sample t-test with a significant level of ($p<0.05$) to examine if there was a significant effect of continuous circuit training and competitive circuit training on VO_2max. The tests were performed after the normality test using Levene's test and the homogeneity test using the Kolmogorov-Smirnov test. The data analysis employed is an independent sample t-test with a significant level of ($p<0.05$) to determine whether there was a significant difference in value between groups of continuous circuit training and competitive circuit training[136].

In a study entitled Effects of aerobic dance circuit training programmeme on blood pressure variables of obese female college students in Oyo state, Nigeria, the researchers determine the effects of Aerobic Dance Circuit Training Programmeme (ADCT) on blood pressure variables (Diastolic Blood Pressure (DBP), Systolic Blood Pressure (SBP). The research strategy for this study was a pretest-posttest control group quasi experimental design with a 2x2x4 factorial matrix. Seventy (70) obese female teenagers aged 21.10±2.46 years participated in the study. The participants for the study were chosen using the purposeful sampling technique. Two institutions in Oyo town were selected using the purposeful sampling technique. The participants were divided into two (2) groups at random (35 per group), experimental and control. The experimental group received 12 weeks of aerobic dance circuit training, whereas the control group received a placebo (12 weeks of lifestyle instruction). For the physical features of the participants, descriptive statistics of means, range, standard deviation, frequency, percentage, pie chart, and bar chart analyses were utilized. The T-test was employed to analyze stated hypotheses obtained at 0.05 alpha levels to assess acceptance and rejection. The study's findings demonstrated that circuit training lowered participants' systolic blood pressure[137].

In another study entitled circuit training intervention for adaptive physical activity to improve cardiorespiratory fitness, leg muscle strength and static balance of intellectually disabled children. The study examined the effects of six weeks of adaptive exercise circuit training done three times per week on the cardiorespiratory fitness (VO_2 max), leg muscular strength, and balance of intellectually impaired children. The research approach was experimental, with a pretest-posttest design for groups. The participants in this study were 15 male adolescents with modest intellectual disabilities aged 15 to 17 years who participated in extracurricular sports. The modified Queen's College Step Test was used to assess cardiorespiratory fitness (VO_2 max); a leg dynamometer was used to assess leg muscular strength; and a stork stand test was utilized to assess static balance. SPSS was used to analyze the data using a paired samples test. The results demonstrated that cardiorespiratory fitness, leg muscle strength, and static balance were significantly improved ($p<0.05$) at the end of the circuit training physical activity adaptive programmeme intervention period. It was determined that a six-week circuit training physical activity adaptive plan at three times per week was efficient for enhancing cardiorespiratory fitness (VO_2 max), leg muscle, strength, and balance[138].

2.3.4 Effect of Circuit Training on Body Composition

In a study titled Circuit Training Improvements in Korean Women with Sarcopenia, examined how circuit training affected body composition, balance, muscle mass and strength, and pulmonary function in sarcopenic Korean women. The study included 20 participants (10 members per group). Participants in the experiment (EG) completed two days of pre-testing, followed by 12 weeks of circuit exercise training sessions, and then two days of post-testing. The exercise intervention consisted of a warm-up period followed by three 25-75 minute sessions per week for a total of 12 weeks for the EG. For the duration of the trial, Control Group (CG) maintained their usual level of physical activity.CG individuals were subjected to the same pre- and post-intervention assessment as EG. Bioelectrical impedance was used to determine participants' height, body weight, fat-free mass, and % body fat. Means and standard deviations were used as descriptive statistics. A two-way ANOVA with repeated measures of the time factor was used to compare the EG and CG groups and examine the effects of the 12-week exercise intervention on each dependent variable for 12 weeks. To find within-group differences, the Bonferroni post hoc testing procedure was applied. The IBM Statistical Package for the Social Sciences for Windows version 23 was used for all analyses. The significance threshold was set at.05. Circuit training for 12 weeks improved body weight, BMI, percent body fat, free fat mass, balance ability, and muscle and pulmonary function in aged women, according to the study[139].

A circuit exercise training (CET) study on body image, cardiorespiratory indices, and body composition of obese undergraduates in a Nigerian University was carried out. A total of one hundred and one participants were recruited for the study (50 participants in the control group and 51 participants in the study group). Fishbowl simple random sampling method was used to randomize participants into a study group (51 subjects) or a control group (50 subjects). An adapted body image questionnaire from the cosmetic procedures screening questionnaire (COPS) was used to assess the body image of the subjects. This questionnaire was a nine-item self-report measure of body dysmorphic disorder (BDD) symptoms. It generated a total score ranging from 0 to 72. It measures the severity of BDD symptoms and identifies people with BDD. A positive and negative affect score was used in assessing the impact of the CET on the body image of the subjects. The COPS has good internal consistency ($\alpha = 0.86 - 0.91$), good test-retest reliability, evidence of single-factor structure, and moderate to good corrected item-total correlations ($r = 0.41$-0.86). OMRON Body composition monitor (BF511, OMRON HEALTHCARE Co. Ltd, Kyoto Japan) was used to measure body composition. Age, height, gender, and weight of the subjects were inputted into the device which were taken into consideration to generate the following body composition parameters: total BF (%), visceral fat (VF) (%), BMI, body weight (BW), muscle mass (MM), and resting metabolic rate. The waist circumference (WC) in centimeters was measured with a non-elastic tape measure which ranges from 0-150cm. A locally constructed stadiometer made of wood and calibrated in centimeters (cm) was used to measure the height of the subjects. A digital metronome provided a rhythmic cadence which produced a steady pulse (or beat) that helped maintain an established tempo during exercise sessions. Digital sphygmomanometer was used for checking the systolic and diastolic blood pressure. Kadio Stopwatch was used to track the duration of the exercise sessions. Exercise mats were used for resistance exercises during the circuit training sessions that require lying down. Data were summarized using descriptive statistics of mean, standard deviation, percentages and frequency. The normality of data distribution was tested and confirmed by Shapiro–Wilks test. The mean differences of variables between the groups were compared using an independent sample *t*-test while the mean differences of variables within the group were tested with the paired t-test. Alpha level was set at $p < 0.05$. A statistical package for the social sciences (SPSS version 21) was used to analyze all data[140].

In a research entitled the effect of circuit training on body composition, physical fitness, and metabolic syndrome risk factors in obese female college students. Circuit exercise was the training mode. Results showed dramatic reduction in body weight, body fat, and body mass index. This study included 20 female college students who were obese, with more than 30% of their body fat accumulated. All willing participants were randomly assigned to one of two groups: the control group (n=10) and the circuit training group (n=10). The 12-week training programmeme included ten different types of resistance and aerobic exercise performed three times each week. The resistance exercise programmeme included push-ups, squats, crunches, lunges, and superman exercises, while the aerobic exercise programmeme included light leaping, running on the spot, foot stomping, steps, and jumping jacks. Circuit training lasted 60 minutes, including warm-up and cool-down periods of 10 minutes each. Each exercise in the circuit training programmeme lasted 30 seconds, with a rest period of 20 seconds between exercises and 3 minutes between sets. Body composition, back strength, sit-ups, flexibility, and cardiopulmonary function were all measured for health purposes. The In body 720 (Biospace Co., Seoul, Korea) was used to validate the height, weight, % body fat, body fat, and lean body mass (LBM) before and after 12 weeks of circuit training. Back strength was assessed using a digital back muscle dynamometer (T.K.K. 5402 BACK D, Takei Scientific Instrument Co, Niigata, Japan) and a 60-second sit-up (T.K.K. 5,505 m, Takei Scientific Instrument Co.). The digital anteflexion metre (T.K. 5,111 sit and reach, Takei Scientific Instrument Co.) was used to assess flexibility, and the 1,600-m record was used to assess cardiopulmonary function. Except for the 1,600-m run, all measures were repeated twice, and the best time was chosen. The effect of 12-week circuit training was determined using PASW Statistics ver. 18.0 (SPSS Inc., Chicago, IL, USA). A two-way repeated analysis of variance was used to confirm the main effect. An independent t-test between groups or a paired t-test between times was used if there was a significant interaction effect. All values were given in terms of mean standard deviation. P 0.05 was deemed significant. Circuit training for 12 weeks, according to the study, may be useful in boosting physical fitness and reducing metabolic disorders[141].

Another study entitled high-intensity circuit training for improving anthropometric parameters for women from low socioeconomic communities of Sikandarabad carried out using clinical trial interval-based high intensity circuit training. Results showed the programmeme to be effective for improving BMI, BF%, and WHR. A quasi-experimental study design was used. Women aged 18 to 35 years old with a sedentary lifestyle (any resting behavior such as sitting, reclining, or laying position that needed 1.5 metabolic equivalents of task energy expenditure) were the target demographic. As part of the study, participants were invited through the distribution of flyers in the neighborhood with information about the free camp exercise service. Following screening for the study's inclusion criteria, participants were enrolled using a convenience sample technique. The study recruited women with a BMI of 25.0-29.9 kg/m2 and a sedentary lifestyle who scored 26 on the Rapid Assessment Disuse Index questionnaire. Meanwhile, those with any chronic disease (uncontrolled hypertension or diabetes) or a history of any abnormal cardiac events were excluded from the study, as were those who were pregnant or had a history of giving birth in the previous 6 months, who actively exercised daily (two days per week), and who answered "yes" to one or more questions on the Physical Activity Readiness Questionnaire for exercise. The study sample size was chosen at 60 individuals using the Open Epi software version 3 for a power of 0.80, an effect size of 0.5, and alpha = 0.05, with overweight BMI > 25 kg/m2 mean differences and standard deviations of 0.81.5 and 2.73.1, respectively[142].

2.3.5 Interaction Effects of Exercise Training and Sex and Age

In a pilot study of the moderating effect of gender on physical activity and fatigue severity among recovered COVID-19 patients, the researcher aimed to characterise PA and fatigue severity in a cohort of patients recovering from COVID-19 infection and measure the extent to which gender-based differences moderate the relationship of PA with fatigue. A cross-sectional survey was conducted in Riyadh, Saudi Arabia. The sample comprised patients recovering from COVID-19 over at least 3 months. Recovered patients were stratified into two groups based on gender. The survey included items pertaining to sociodemographics, a fatigue severity scale, and a self-reported international PA questionnaire. Compared with men, women reported sedentary behaviour (70%) and high fatigue severity (64%). A significantly higher number of women had a low PA score compared with men (p = .002). The findings indicated that gender significantly moderates the effect of total PA on metabolic equivalents. The current study suggests that women might be at risk of higher fatigue severity in addition to engaging less in PA. Physical activity may play a significant role in modulating fatigue severity[143].

In a study on the effects of moderate-to-high-intensity resistance circuit training on fat mass, functional capacity, muscular strength, and quality of life in the elderly: A randomised controlled trial. The researcher determined the effects of moderate-to-high-intensity resistance circuit training on different parameters of body composition, functional autonomy, muscular strength, and quality of life in the elderly. A randomised controlled trial was conducted. A total of 45 subjects (27 females, 18 males) aged between 65–75 years old from Murcia (Spain) were divided by sex and randomly assigned to the experimental group (n = 33, mean age 69 ± 3.2 years old) receiving 12 weeks of moderate-to-high intensity resistance circuit training and the control group (n = 33, mean age 70 ± 4.1 years old) receiving no exercise intervention. In the intra-group comparison, the experimental group showed a significant increment in lean body mass in women and men, which also presented a decrease in fat mass. Both sexes presented a significant improvement in functional autonomy and significantly higher values of muscular strength. But no changes were observed regarding quality of life in these groups. The control group did not show any differences pre- and post-intervention in women, but in men, there was an increase in body mass index and total weight post-intervention. No changes were shown in the other variables. Similar results were found in the inter-group comparison. The moderate-to-high-intensity resistance circuit training showed an increase in total lean body mass, improvements in functional capacity, and a significant increase in upper and lower muscular strength in women and men. Progressive resistance circuit training should be promoted for the elderly as it has the potential to improve physical performance, thereby prolonging healthy independent ageing[130].

In a study on the effects of gender on physiological responses to strenuous circuit resistance exercise and recovery, the researcher determined the effects of gender on cardiovascular and metabolic responses to circuit weight training (CWT) and consequent recovery. Ten healthy men and 10 healthy women completed an initial session to collect descriptive data and determine a 12-repetition maximum (12RM) for six different upper- and lower-body resistance exercises. This was followed by two identical sessions of the CWT protocol on two separate days at least 48 hours apart. The first session was used to familiarise subjects with the equipment and the testing protocol. The second session was used to determine physiological responses. Each subject performed 10 repetitions of 6 exercises for 3 circuits at a 12RM load. Vo_2 and respiratory exchange ratio (RER) were continuously monitored, whereas heart rate (HR) and blood pressure (BP) were taken at the end of each circuit. Across the exercise session, men revealed greater absolute and relative Vo_2, relative lean body mass Vo_2, systolic BP (SBP), RER, and recovery Vo_2 when compared with the female subjects. There were no differences in HR, diastolic BP (DBP), or recovery RER. The present study provides a greater insight into gender differences in cardiovascular and metabolic responses to circuit weight training. These gender differences should be taken into consideration for the development of CWT protocols for men and women[144].

In a study on the gender-specific effects of 8-week multi-modal strength and flexibility training on hamstring flexibility and strength, the researcher investigated the effects of multi-modal strength training or flexibility training on hamstring flexibility and strength in young males and females. A total of 20 male and 20 female college students (aged 18–24 years) participated in this study and were randomly assigned to either a multi-modal flexibility intervention group or a strength intervention group. Passive straight leg raises and isokinetic strength tests were performed before and after the intervention to determine the flexibility and strength of the participants. A multivariate repeated-measures ANOVA was used to determine the effect of training group and gender on hamstring strength and flexibility. Both male and female participants in the strength intervention group significantly increased peak torque, relative peak torque, and flexibility (all $p \leq 0.029$). Both male and female participants in the flexibility intervention group significantly increased flexibility (both $p \leq 0.001$). Female participants in the flexibility intervention group significantly increased peak torque and relative peak torque (both $p \leq 0.023$). However, no change was seen in peak torque or relative peak torque of male participants in the flexibility intervention group ($p \geq 0.676$). An 8-week strength training programmeme involving various training components can increase flexibility in both males and females, although the flexibility of male participants only increased slightly. While the hamstring flexibility training protocol consisted of different types of stretching and improved both flexibility and strength in female participants, male participants increased only flexibility but not strength, indicating such effects were gender-specific. For subjects with relatively low strength (e.g., older adults, sedentary women, postoperative rehabilitation population, etc.), strength training alone or flexibility training alone may increase both strength and flexibility[145].

In a study on high-intensity interval circuit training versus moderate-intensity continuous training on functional ability and body mass index in middle-aged and older women: a randomized controlled trial, the researcher determined what type of training (HIICT or MICT) induces greater adaptations in the functional ability and body mass index of middle-aged and older women. The study used a quasi-experimental randomised controlled trial with 54 participants (age = 67.8 ± 6.2 years). Participants were randomly allocated to HIICT (*n* = 18), MICT (*n* = 18), or a non-exercise control group (CG; *n* = 18). The participants in the HIICT or MICT groups trained twice a week (1 hour per session) for 18 weeks. Forty-one subjects were analysed (HIICT; *n* = 17, MICT; *n* = 12, CG; *n* = 12). Five subjects presented adverse events during the study. Strength, gait, cardiorespiratory fitness, balance, and body mass index were measured. A significant training-group interaction was found in the arm curl test, where HIICT was statistically better than MICT and CG. Likewise, HIICT was statistically better than the CG in the BMI interaction. In lower limb strength, gait/dynamic balance, and cardiorespiratory fitness, both HIICT and MICT were statistically better than the CG. In conclusion, HIICT generated better adaptations in upper limb strength than MICT. Likewise, HIICT generated better adaptations in body mass index than CG. Finally, both HIICT and MICT had a similar influence on strength, cardiorespiratory fitness, and gait/dynamic balance[146].

In a study on the acute and chronic effects of supervised flexibility training in older adults: A Comparison of Two Different Conditioning Programmemes, the researchers assessed acutely and after 12 weeks by means of the sit-and-reach test. Thirty-one healthy older adults were randomly divided into three groups: the Experiment I group (Exp) performed strength and static stretching exercises; the Experiment II group performed dynamic and static stretching exercises; and participants assigned to the control group maintained a sedentary lifestyle for the entire period of the study. Flexibility acutely increased in Exp I by the first ($\Delta T0 = 7.63 \pm 1.26\%$; ES = 0.36; $p = 0.002$) and second testing sessions ($\Delta T1 = 3.74 \pm 0.91\%$; ES = 0.20; $p = 0.002$). Similarly, it increased in Exp II significantly by the first ($\Delta T0 = 14.21 \pm 3.42\%$; ES = 0.20; $p = 0.011$) and second testing sessions ($\Delta T1 = 9.63 \pm 4.29\%$; ES = 0.13; $p = 0.005$). Flexibility significantly increased over the 12 weeks of training in Exp I ($\Delta T0 - T1 = 9.03 \pm 3.14\%$; ES = 0.41; $p = 0.020$) and Exp II ($\Delta T0 - T1 = 22.96 \pm 9.87\%$; ES = 0.35; $p = 0.005$). The acute and chronic differences between the two groups were not significant ($p > 0.05$). These results suggest the effectiveness of different exercise typologies in improving the flexibility of the posterior muscular chains in older adults[147].

In a study on the effects of circuit training programmemes on physical fitness in overweight older adults, the researcher aimed to study the effects of circuit training programmemes on the physical fitness of overweight adults. 30 elderlies with an average age of 63.46 ± 2.55 years were used as sample groups. The sample groups were divided into an experimental group of 15 participants joining the circuit training programmeme for 3 days a week for 12 weeks and a control group of 15 participants who did not join the circuit training programmeme. The analysis of basic statistics consisting of mean and standard deviation was implemented to compare the differences in the physical fitness of the adults before joining the programmeme, while attending the programmeme (6th week), and after completing the programmeme (12th week). An independent sample t-test was applied with statistical significance at the level of.05. The results demonstrated that the body mass index, weight, muscle strength, balance, and agility of the body, as well as the cardiorespiratory endurance of overweight seniors participating in the circuit training programmeme, were different from those who did not participate in the circuit training programmeme with statistical significance at the level of.05 after the 6th week of the training and the 12th week of the training. However, body flexibility was not statistically different at the level of 0.05[148].

In a study on the effects of a 12-week exercise training programmeme on physical function in institutionalised frail elderly, the researchers aimed to verify the effects of exercise training on biochemical, inflammatory, and anthropometric indices and functional performance in institutionalised frail elderly. The sample consisted of 37 elderly people of both genders, aged 76.1 ± 7.7 years, who were randomly allocated into 2 groups: 13 individuals in the exercise group (EG) and 24 in the control group (CG). Anthropometrics, clinical history, functional tests, and biochemical evaluation were measured before and after the completion of a physical exercise programmeme, which lasted for 12 weeks. The 12-week exercise programmeme for frail elderly residents in a long-term care facility was efficient in improving muscle strength, speed, agility, and biochemical variables, with reversal of the frailty condition in a considerable number. However, no effects on anthropometric and inflammatory parameters were noted[149].

In a study on the *e*ffects of aerobic dance circuit training programmeme on body composition and cardiorespiratory variables of obese female college students in Oyo Town, Nigeria, the researcher determine the effects of Aerobic Dance Circuit Training Programmeme (ADCT) on body composition variables [Percent body fat (%bf), Waist-to-hip ratio (WHR), Waist-to-height ratio (WHtR)] and cardiorespiratory variables [(Diastolic Blood Pressure (DBP), Systolic Blood Pressure (SBP), Mean Arterial Blood Pressure (Pmean), Vital Capacity (VC), Inspiratory Reserved Volume (IRV), Peak Expiratory Flow Rate (PEFR), Heart Rate Reserved (HRR) and Maximal Oxygen Uptakes (VO2 Max)] in obese female College of Education (COE) students. The study also examined the moderating effects of age and class on obesity. The study adopted Kinetography-Laban theory as a framework, while the pretest-posttest control group quasi-experimental design using a 2x2x4 factorial matrix was used. The two COEs in Oyo town, namely Emmanuel Alayande and Federal (Special), were selected. Obese female college students with a body mass index (BMI) of ≥25.0 were purposefully selected, ranging from obese class I-IV according to WHO standards. The participants were randomly assigned to the ADCT (Emmanuel Alayande COE-35) and control (Federal COE Special-35) groups. The treatment lasted 12 weeks. Instruments used were: a stadiametre, weighing scale, skinfold calliper, digital sphygmomanometre, spirometre, and peak flow metre. Data were analysed using descriptive statistics, the Cochran Q test, and the analysis of covariance at the 0.05 level of significance. Participants age was 21.10±2.46 years, while obesity percentage distribution was categorised as follows: class 1 (21.4%), class 2(60.0%), class 3 (17.1%) and class 4 (1.4%). There were significant mean differences in baseline and post-treatment values of body composition variables in terms of %bf (14.96±3.70; 16.89±4.10), WHR (0.77±0.02; 0.80±0.02) and WHtR (0.49±0.02; 0.52±0.02). There were significant mean differences in baseline and post-treatment values of cardiorespiratory variables in terms of SBP (130.83±9.25; 133.64±13.95), PEFR (295.57±82.35; 279.86±77.15), VC (2178.57±478.9; 2084.29±476.67) and IRV (2330.00±695.09; 2140.00±2=0.04) in favour of the age bracket 25η621.45). The main effect of age and class of obesity was not significant on body composition variables or cardiorespiratory variables. There were two-way interaction effects of treatment and age (F(1,57)=1.12; partial –2=0.03) in favour of obese class 4 participants from the ADCT group in the age bracket of 25η30 years in the ADCT group. The three-way effect was significant on cardiorespiratory variables (F(2,57)=4.02; partial –30 years. Aerobic dance circuit training was effective in reducing body composition and increasing maximal oxygen uptake among obese female students[150].

In a study on sex differences in resistance training: a systematic review and meta-analysis, t*he researchers* determined whether there are different responses to resistance training for strength or hypertrophy in young to middle-aged males and females using the same resistance training protocol. The protocol was pre-registered with PROSPERO (CRD42018094276). Meta-analyses were performed using robust variance random effects modelling for multilevel data structures, with adjustments for small samples using package regression in R. Statistical significance was set at $P < 0.05$. The analysis of hypertrophy comprised 12 outcomes from 10 studies with no significant difference between males and females (effect size [ES] = 0.07 ± 0.06; $P = 0.31$; $I^2 = 0$). The analysis of upper-body strength comprised 19 outcomes from 17 studies with a significant effect favouring females (ES = -0.60 ± 0.16; $P = 0.002$; $I^2 = 72.1$). The analysis of lower-body strength comprised 23 outcomes from 23 studies with no significant difference between sexes (ES = −0.21 ± 0.16; $P = 0.20$; $I^2 = 74.7$). The study found that males and females adapted to resistance training with similar effect sizes for hypertrophy and lower-body strength, but females had a larger effect for relative upper-body strength. Given the moderate effect size favouring females in the upper-body strength analysis, it is possible that untrained females display a higher capacity to increase upper-body strength than males. Further research was required to clarify why this difference occurred only in the upper body and whether the differences were due to neural, muscular, or motor learning or were an artefact of the short duration of the studies included[151].

In a study on the effects of sex and age on physical testing performance for law enforcement agency candidates: implications for academy training, the researchers investigated the influence of sex and age on candidate performance before academy training. A retrospective analysis of 516 candidates was performed. Data were stratified into men ($n = 432$) and women ($n = 84$), and the pooled (men and women combined) data were stratified into age groups (20–24; 24–29; 30–34; 35–39; and 40+ years). The tests included the following: maximal push-ups and sit-ups in 60 seconds; a 75-yard pursuit run (75PR); arm ergometer revolutions completed in 60 seconds; and a 2.4-km run. To compare the sex and age groups, a 2 × 5 analysis of variance (with Bonferroni post hoc for multiple between-age group comparisons) was used. Men performed significantly ($p < 0.001$) more push-ups, sit-ups, and arm ergometer revolutions and were faster in the 75PR and 2.4-km run. The 20–24, 25–29, and 35–39 year groups were faster in the 75PR compared with the 40+ year group; the 20–24 and 25–29 year groups were faster than the 35–39 year group; and the 20–24 year group was faster than the 30-34 year group ($p \leq 0.023$). The 20–24 year group was faster than the 40+ year group in the 2.4-km run ($p = 0.005$). Women and older candidates may have a lower physical capacity than men and younger candidates, respectively, in certain physical assessments. Women and older candidates, in particular, may benefit from dedicated training before the academy to better prepare for the demands of this period[152].

In a study on acute responses to resistance training on body composition, muscular fitness, and flexibility by sex and age in healthy war veterans aged 50–80 years, the researchers examined whether a 4-week resistance training programmeme would have similar effects on body composition, muscular fitness, and flexibility in men and women aged 50–80 years. Seven hundred and sixty-four participants were recruited and categorised into two groups, each of men and women aged 50–64 and 65–80 years. The training intervention lasted 4 weeks and consisted of three 60-minute sessions per week. All participants were tested for each of the following physical fitness components: body composition, push-ups in 30 seconds, chair-stands in 30 seconds, sit-ups in 30 seconds, and a sit-and-reach test. Over the intervention period of 4 weeks, body weight ($p = 0.002$) and the percent of fat mass ($p < 0.001$) decreased, while the percent of lean mass ($p < 0.001$) in push-ups in 30 s ($p < 0.001$), chair-stands in 30 s ($p < 0.001$), sit-ups in 30 s ($p < 0.001$), and sit-and-reach ($p < 0.001$) increased. Significant time*age interactions were shown for push-ups in 30 s ($F_{1,763} = 4.348$, $p = 0.038$) and chair-stands in 30 s ($F_{1,763} = 9.552$, $p = 0.002$), where men and women aged 50–64 years exhibited larger time-induced changes compared to their older (65–80 yr) counterparts. Effect sizes were similar between sex- and age-specific groups. The 4-week resistance training produced similar pronounced positive effects on body composition, muscular fitness, and flexibility, while men and women aged 50–64 years displayed significantly larger improvements in upper and lower muscular fitness compared with their 65–80-year-old counterparts[153].

In a study on sex differences in the impact of a 12-week high-intensity interval training intervention on sympathetic transduction, the researchers tested the hypothesis that 12-week of high-intensity interval training (HIIT) would improve aerobic fitness in young, healthy adults but only attenuate sympathetic transduction in males. Aerobic fitness ($\dot{V}O_2$peak, via indirect calorimetry), as well as peroneal MSNA (microneurography) and DBP (finger photoplethysmography), were recorded for ~10 minutes during supine rest. HIIT improved absolute $\dot{V}O_2$peak in both sexes (both, $P \leq 0.004$), with greater increases observed in males ($P = 0.004$). There was no change in sympathetic transduction following HIIT for either sex (both, $P \geq 0.523$). However, diastolic blood pressure (DBP) responses following cardiac cycles absent of MSNA bursts were enhanced (more negative) following HIIT in females (group $P = 0.019$, females $P = 0.016$, males $P = 0.345$). These results indicate that HIIT-mediated increases in aerobic fitness did not alter sympathetic transduction in a group of younger males and females[154].

In a study on how progressive circuit resistance training improves inflammatory biomarkers and insulin resistance in obese men, the researchers explored the reducing effects of progressive CRT on inflammatory biomarkers and cardiometabolic risk factors in obese young men. Thirty obese men (body mass index (BMI): 30.67 ± 3.06; age: 23 ± 3.2 years) were divided into CRT and control groups. The CRT was performed for eight weeks (3 times per week, 65–85% of 1 repetition maximum). Fasting blood samples were taken pre- and post-intervention for analysis of apelin, chemerin, serum amyloid A (SAA), C reactive protein concentrations (CRP), lipid profile, and insulin resistance index. The data were assessed by a two-way repeated measures ANOVA. Body mass, BMI, and waist-to-hip ratio (WHR) were significantly decreased after the training intervention ($P < .05$). Compared to the control group, the plasma concentrations of Chemrin ($P = .038$), SAA ($P = .004$), insulin ($P < .001$), insulin resistance index

(P < .001), total cholesterol (P = .033), triglyceride (P < .001), and low-density lipoprotein (P = .039) were significantly mitigated in the CRT group, but high-density lipoprotein plasma levels increased in the CRT group compared to those of the control group (P = .035). There was no significant difference between the two groups in apelin and CRP (P > .05). Moreover, insulin resistance was positively correlated with apelin (r = 0.56) and chemerin (*r* = 0.51). Also, chemerin had a positive correlation with SAA (*r* = 0.49) and WHR (*r* = 0.54). CRT caused an improvement in inflammation and cardiometabolic risk factors in young obese men, and this improvement was accompanied by decreased insulin resistance[155].

2.4 Conceptual Framework

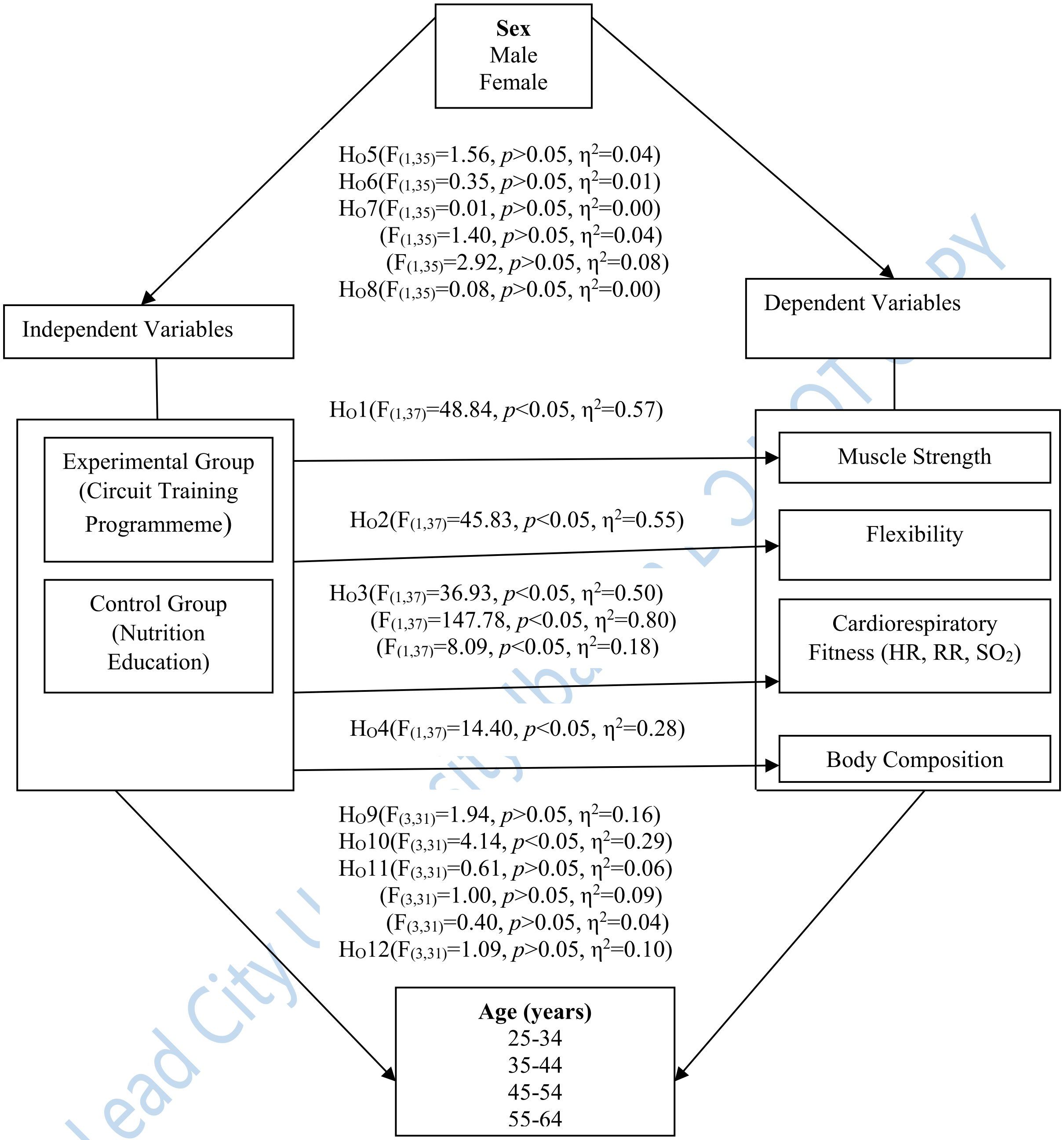

Fig. 2.12: Conceptual Framework Showing the Effect of an 8-Week Circuit Training Programmeme on Physical Fitness Parameters of Academic Staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

Source: Researcher's Fieldwork, 2024.

The conceptual framework for this study titled "effect of an 8-week circuit training programmeme on physical fitness parameters of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria" aims to assess the effect of an 8-week circuit training programmeme on physical fitness parameters of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria. The study intends to investigate the status of physical fitness parameters (muscle strength, flexibility, cardiorespiratory fitness, and body composition) of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

The first hypothesis suggest that there is no significant effect of an 8-weeks circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State. By exploring this hypothesis, the study contributes to the understanding of how circuit training affects muscle strength. The second hypothesis suggest that there is no significant effect an of 8-weeks circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State. By exploring this hypothesis, the study contributes to the understanding of how circuit training affects flexibility. The third hypothesis suggest that there is no significant effect of an 8-weeks circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State. By exploring this hypothesis, the study contributes to the understanding of how circuit training affects cardiorespiratory fitness. The fourth hypothesis suggest that there is no significant effect of an 8-weeks circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State. By exploring this hypothesis, the study contributes to the understanding of how circuit training affects body composition. The fifth to eighth hypothesis suggest that there is no significant effect of sex on the outcome of an 8-week circuit training programmeme on physical fitness parameters of academic staff of Bayelsa

Medical University, Yenagoa, Bayelsa State. It suggests that physical fitness parameters may vary depending on sex. The ninth to twelveth hypothesis suggest that there is no significant effect age on the outcome of an 8-week circuit training programmeme on physical fitness parameters of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State. It suggests that physical fitness parameters may vary depending on age. Findings of this study have the potential to inform fitness practitioners, educators, policy makers and individuals in developing alternative strategies to enhance physical fitness so as to enhance health and better living.

2.5 Summary of Gaps in Literature Reviewed

There are very scanty studies on the effect of circuit training programmeme on strength, flexibility, cardiorespiratory fitness, and body composition, particularly, among Academic Staff of Medical Universities in Nigeria, Bayelsa State inclusive. Most studies focus on students' physical fitness or the general population, leaving a huge gap in knowing academic staff's specialised demands and concerns.

Many research on physical fitness and exercise programmemes are undertaken in developed countries, which may fail to take into consideration the unique challenges and situations experienced by academic personnel in developing countries such as Nigeria. There is a need for research that takes into account the local context and resource restrictions that may affect fitness programmeme implementation.

Many studies believe that fitness programmemes are one-size-fits-all. There is a study void that investigates individual characteristics among academic staff, such as age, fitness levels, and pre-existing health issues, and how individualised circuit training programmemes can address these variables to maximise benefits.

There is a dearth of attention in the literature on how greater physical fitness among academic staff might lead to improved work performance, teaching effectiveness, research output, and overall job happiness. Understanding these links is critical for academic staff as well as the institutions they serve.

It is therefore the intension to bridge the gaps by evaluating the effect of an 8-week circuit training programmeme on strength, flexibility, cardiorespiratory fitness, and body composition of Academic Staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

Endnotes

1 S. Hardiansyah, *The Influence of Circuit Training Method on the Enhancement of Physical Fitness of Sports Education Department Students*, In: Proceedings The 1ST Yogyakarya International Seminar on Health, Physical Education, and Sports Science: Evidence-based Practice of Sports Science in Education Performance, and Health, Yogyakarta, 2017.

2 S. Hardiansyah, A. Zalindro, & F. Maifitri, *Effect of Circuit and Interval Training Method on the Improvement of Physical Fitness*, In 1st Progress in Social Science, Humanities and Education Research Symposium (PSSHERS 2019), Atlantis Press, 2020, 914-918).

3 F. Arjuna, N. Primasoni, & Y. Miftachurochmah, *The Effect of Circuit Training with Fixed and Decreasing Rest Intervals on the Ability of the Dominant Physical Component of Female Volleyball Players*, **Journal of Positive School Psychology**, 6 (8), 2022, 232-243.

4 I. A. Patah, H. Jumareng, E. Setiawan, M. Aryani, & R. A. Gani, *The Importance of Physical Fitness for Pencak Silat Athletes: Home-based Weight Training between Tabata and Circuit Can it Work?* **Journal Sport Area**, 6 (1), 2021, 108-122.

5 R. Festiawan, A. T. Raharja, J. B. K. Jusuf, & M. N. Mahardika, *The Effect of Oregon Circuit Training and Fartlek Training on the VO_2 max Level of Soedirman Expedition VII Athletes*, **Pendidikan Jasmani Olahraga**, 5 (1), 2020, 62-69.

6 T. Brijwasi, & P. Borkar, *To Study the Effect of Sports Specific Training Programme on Selective Physical and Physiological Variables in Basketball Players*, **International Journal of Physical Education, Sports and Health,** 9 (2), 2022, 25-30

7 B. L. Panetta, *Physical Fitness and Academic Achievement: The Relationship between Fitness and Academic Measures of Third and Fourth Grade Students*, Doctoral Dissertation, Centenary University, 2021.

8 J. M. Shimon, *Introduction to Teaching Physical Education: Principles and Strategies*, Human Kinetics, Incorporated, 2019.

9 M. Wewege, R. van den Berg, R. E. Ward, & A. Keech, *The Effects of High-Intensity Interval Training vs. Moderate-Intensity Continuous Training on Body Composition in Overweight and Obese Adults: A Systematic Review and Meta-Analysis*, **Obesity Reviews**, 18 (6), 2017, 635-646.

10 Kumar, & E. Jyothi, *Effect of Continous Training and Circuit Training for the Development of Aerobic Fitness among Long Distance Runners of Osmania University*, **International Journal of Health, Physical Education & Computer Science in Sports**, 39 (2), 2020, 105–107.

11 Y. S. Bhati, & J. N. Saini, *A Comparative Study of Cardiovascular Fitness of Bodybuilders and Atheletes During 50's Age*, ***Central Asian Journal of Medical and Natural Science***, 3 (5), 2022, 124-132.

12 E. de Souza Bezerra, F. Diefenthaeler, R. L. Sakugawa, E. L. Cadore, M. Izquierdo, & A. R. P. Moro, *Effects of Different Strength Training Volumes and Subsequent Detraining on Strength Performance in Aging Adults*, **Journal of Bodywork and Movement Therapies**, 23 (3), 2019, 466-472.

13 K. L. English, M. Downs, E. Goetchius, R. Buxton, J. W. Ryder, R. Ploutz-Snyder, M. Guilliams, J. M. Scott, & L. L. Ploutz-Snyder, *High Intensity Training During Spaceflight: Results from the NASA Sprint Study*, **NPJ Microgravity**, 6 (1), 2020, 1-9.

14 A. Batrakoulis, I. G. Fatouros, A. Chatzinikolaou, D. Draganidis, K. Georgakouli, K. Papanikolaou, C. K. Deli, P. Tsimeas, A. Avloniti, N. Syrou, & A. Z. Jamurtas, *Dose-response Effects of High-Intensity Interval Neuromuscular Exercise Training on Weight Loss, Performance, Health and Quality of Life in Inactive Obese Adults: Study Rationale, Design and Methods of the DoIT Trial*, **Contemporary Clinical Trials Communications**, 15, 2019, 100386.

15 I. Jukic, A. G. Ramos, E. R. Helms, M. R. McGuigan, & J. J. Tufano, *Acute Effects of Cluster and Rest Redistribution Set Structures on Mechanical, Metabolic, and Perceptual Fatigue during and after Resistance Training: A Systematic Review and Meta-Analysis*, **Sports Medicine**, 50, 2020, 2209-2236.

16 G. M. Duthie, E. J. Thomas, J. Bahnisch, H. R. Thornton, & K. Ball, *Using Small-sided Games in Field Hockey: Can they be used to reach Match Intensity*? **J Strength Cond Res**, 36 (2), 2022, 498-502.

17 N. Mohanta, S. Kalra, & S. Pawaria, *A Comparative Study of Circuit Training and Plyometric Training on Strength, Speed and Agility in State Level Lawn Tennis Players*, **Journal of Clinical & Diagnostic Research**, 13 (12), 2019.

18 Y. Campos, A. Casado, J. G. Vieira, M. Guimarães, L. Sant'Ana, L. Leitão, S. F. da Silva, P. H. S. M. de Azevedo, J. Vianna, & R. Domínguez, *Training-Intensity Distribution on Middle- and Long-Distance Runners: A Systematic Review*, **International Journal of Sports Medicine**, 43 (04), 2021, 305-316

19 A. Nasrulloh, Y. Prasetyo, S. Nugroho, R. Yuniana, & K. W. Pratama, *The Effect of Weight Training with Compound Set Method on Strength and Endurance among Archery Athletes*, **Journal of Physical Education and Sport**, 22 (6), 2022, 1457-1463.

20 C. S. Mackey, & J. M. DeFreitas, *A Longitudinal Analysis of the US Air Force Reserve Officers' Training Corps Physical Fitness Assessment*, **Military Medical Research**, 6 (1), 2019, 1-8.

21 V. M. Iversen, M. Norum, B. J. Schoenfeld, & M. S. Fimland, *No time to lift? Designing Time-Efficient Training Programmes for Strength and Hypertrophy: A Narrative Review*, **Sports Medicine**, 51 (10), 2021, 2079-2095.

22 G. Katsanis, D. Chatzopoulos, V. Barkoukis, A. C. Lola, C. Chatzelli, & I. Paraschos, *Effect of a School-based Resistance Training Programme Using a Suspension Training System on Strength Parameters in Adolescents*, **Journal of Physical Education and Sport**, 21 (5), 2021, 2607-2621.

23 H. Y. Ko, & S. Huh, *Extremity Kinematics and Muscles for Functional Training of Tetraplegics and Paraplegics*, **Handbook of Spinal Cord Injuries and Related Disorders: A Guide to Evaluation and Management**, 2021, 33-48.

24 A. Mrozek, M. Sopa, J. Myszkowski, A. Bakiera, P. Budzisz, A. Kuliberda, M. Białecka, T. Walczak, J. K. Grabski, & M. Grygorowicz, *Assessment of the Functional Movement Screen Test with the Use of Motion Capture System by the Example of Trunk Stability Push-Up Exercise among Adolescent Female Football Players*, **Vibrations in Physical Systems**, 31 (2), 2020.

25 A. Hazari, A. G. Maiya, T. V. Nagda, A. Hazari, A. G. Maiya, & T. V. Nagda, *Kinetics and Kinematics of Hip and Pelvis*, **Conceptual Biomechanics and Kinesiology**, 2021, 125-144.

26 Z. Wahl-Alexander, J. M. Jacobs, B. Kaeb, & K. Riley Jr, *No Gear? No Problem! Fitness Activities for Students with Limited Space and Equipment*, **Journal of Physical Education, Recreation & Dance**, 92 (6), 2021, 34-41.

27 I. Naureen, *Effect of Exercise and Obesity on Human Physiology*, **Sch Bull**, 8 (1), 2022, 17-24.

28 N. Hassanzadeh, R. Farzizadeh, M. Moharramzadeh, & B. Shoja Anzabi, *Designing a Dual-Purpose Device for Strengthening Pectoralis Major and Triceps Muscles*, **Journal of Advanced Sport Technology**, 6 (1), 2022, 96-102.

29 R. Woodruff, *Effectiveness of Exercise Intervention in Runners with and without Patellofemoral Pain Measured by Functional Movement Screening,* Doctoral Dissertation, University of Pittsburgh, 2022.

30 A. K. McKenzie, Z. J. Crowley-McHattan, R. Meir, J. W. Whitting, & W. Volschenk, *Glenohumeral Extension and the Dip: Considerations for the Strength and Conditioning Professional*, **Strength & Conditioning Journal**, 43 (1), 2021, 93-100.

31 B. Langton, & J. King, *Utilizing Body Weight Training with your Personal Training Clients*, **ACSM's Health & Fitness Journal**, 22 (6), 2018, 44-51.

32 Y. C. Joshi, & S. Jaykishan, *Effects of Selected Asana's on Back Extension of Female Students*, **IJPNPE**, 3 (2), 2018, 335-338.

33 S. Singh, & A. Gunjan Kumar, *Ultrasound-Guided Erector Spinae Plane Block for Postoperative Analgesia in Modified Radical Mastectomy: A Randomised Control Study*, **Indian Journal of Anaesthesia**, 63 (3), 2019, 200.

34 E. P. Lamers, J. C. Soltys, K. L. Scherpereel, A. J. Yang, & K. E. Zelik, *Low-Profile Elastic Exosuit Reduces Back Muscle Fatigue*, **Scientific Reports**, 10 (1), 2020, 15958.

35 D. J. Kim, I. R. Choi, & J. H. Lee, *Effect of Balance Taping on Trunk Stabilizer Muscles for Back Extensor Muscle Endurance: A Randomized Controlled Study*, **Journal of Musculoskeletal & Neuronal Interactions**, 20 (4), 2020, 541.

36 M. Tantot, V. Le Moal, É. Mévellec, I. Nouy-Trollé, E. Lemoine-Josse, F. Besnier, & T. Guiraud, *Effects of an Intensive 6-Week Rehabilitation Programme with the HUBER Platform in the Treatment of Non-specific Chronic Low Back Pain: A Pilot Study*, **Clinics and Practice**, 12 (4), 2022, 609-618.

37 J. Trout, *Postural Health in Physical Education*, **Journal of Physical Education, Recreation & Dance**, 93 (7), 2022, 4-11.

38 B. Winder, P. A. Keri, D. E. Weberg, & G. J. Beneck, *Postural Cueing Increases Multifidus Activation During Stabilization Exercise in Participants with Chronic and Recurrent Low Back Pain: An Electromyographic Study*, **Journal of Electromyography and Kinesiology**, *46*, 2019, 28-34.

39 B. Sánchez-Pinto-Pinto, C. Romero-Morales, D. López-López, C. de-Labra, & G. García-Pérez-de-Sevilla, *Efficacy of Bracing on Thoracic Kyphotic Angle and Functionality in Women with Osteoporosis: A Systematic Review*, **Medicina**, 58 (6), 2022, 693.

40 R. G. Lockie, M. R. Moreno, K. A. Rodas, J. M. Dulla, R. M. Orr, & J. J. Dawes, *With Great Power comes Great Ability: Extending Research on Fitness Characteristics that Influence Work Sample Test Battery Performance in Law Enforcement Recruits*, **Work**, 68 (4), 2021, 1069-1080.

41 A. D. Faigenbaum, & P. Mediate, *Medicine Ball Training for Kids: Benefits, Concerns, and Programme Design Considerations*, **ACSM's Health & Fitness Journal**, 12 (3), 2008, 7-12.

42 T. Suntharalingam, M. N. M. Jawis, A. A. Malik, & S. Sivanesan, *Effects of 8-Week Medicine Ball Training on Physical Performance among Basketball Players*, **Journal of Positive School Psychology**, 2022, 1307-1319.

43 R. Bandou, N. Idota, Y. Akasaka, & H. Ikegaya, *A Case of Fatal Asphyxia by a Barbell during a Bench Press*, **Forensic Sciences**, 2 (1), 2021, 1-6.

44 M. Krzysztofik, J. Jarosz, P. Matykiewicz, M. Wilk, M. Bialas, A. Zajac, & A. Golas, *A Comparison of Muscle Activity of the Dominant and Non-Dominant Side of the Body During Low Versus High Loaded Bench Press Exercise Performed to Muscular Failure*, **Journal of Electromyography and Kinesiology**, 56, 2021, 102513.

45 N. F. Hills, R. B. Graham, & L. McLean, *Comparison of Trunk Muscle Function between Women with and without Diastasis Recti Abdominis at 1 Year Postpartum*, **Physical Therapy**, 98 (10), 2018, 891-901.

46 A. N. Shiddiq, A. Kristiyanto, & M. Doewes, *Freeletics as Sports Activities Community Recreation (Phenomenological Study of Community Groups that carry out Recreational Sports in the City of Yogyakarta)*, **Journal of Education, Health and Sport**, 9 (4), 2019, 468-474.

47 B. Kim, & J. Yim, *Core Stability and Hip Exercises Improve Physical Function and Activity in Patients with Non-specific Low Back Pain: A Randomized Controlled Trial*, **The Tohoku Journal of Experimental Medicine**, 251 (3), 2020, 193-206.

48 N. Nimkar, T. K. Bera, A. Bagchi, & R. Narnolia, *Abdominal Muscular Strength Endurance: Normative Reference Values for Children 11 to 15 Years of Age*, **Indian Journal of Public Health Research & Development**, 11 (2), 2020.

49 N. J. Chang, I. H. Tsai, C. L. Lee, & C. H. Liang, *Effect of a Six-week Core Conditioning as a Warm-up Exercise in Physical Education Classes on Physical Fitness, Movement Capability, and Balance in School-aged Children*, **International Journal of Environmental Research and Public Health**, 17 (15), 2020, 5517.

50 Y. Song, L. Li, & B. Dai, *Trunk Neuromuscular Function and Anterior Cruciate Ligament Injuries: A Narrative Review of Trunk Strength, Endurance, and Dynamic Control*, **Strength and Conditioning Journal**, 44 (6), 2022, 82-93.

51 M. Haghighi, & A. Asgari, *Comparison of the Effects of Core Stability and Balance Exercise on Static and Dynamic Balance and Q-angle of the Students with Genu Varum*, **International Journal of Health Studies**, 9 (1), 2022.

52 H. Lee, C. Kim, S. An, & K. Jeon, *Effects of Core Stabilization Exercise Programmes on Changes in Erector Spinae Contractile Properties and Isokinetic Muscle Function of Adult Females with a Sedentary Lifestyle*, **Applied Sciences**, 12 (5), 2022, 2501.

53 M. Venegas-Carro, J. T. Herring, S. Riehle, & A. Kramer, *Jumping vs. Running: Effects of Exercise Modality on Aerobic Capacity and Neuromuscular Performance after a Six-week High-Intensity Interval Training*, **Plos one**, 18 (2), 2023, e0281737.

54 S. Zhao, Y. Yang, Y. Gao, Z. Zhang, T. Zheng, & Y. Zhu, *Development of a Soft Knee Exosuit with Twisted String Actuators for Stair Climbing Assistance*, **In *2019 IEEE International Conference on Robotics and Biomimetics (ROBIO)***, 2019, 2541-2546.

55 M. T. Curran, A. Bedi, C. L. Mendias, E. M. Wojtys, M. V. Kujawa, & R. M. Palmieri-Smith, *Blood Flow Restriction Training Applied with High-Intensity Exercise does not Improve Quadriceps Muscle Function after Anterior Cruciate Ligament Reconstruction: A Randomized Controlled Trial*, **The American Journal of Sports Medicine**, 48 (4), 2020, 825-837.

56 B. P. Shekhawat, & G. S. Chauhan, *Effect of Circuit Training on Speed and Agility of Adolescent Male Basketball Players*, **Int. J. Physiol. Nutr. Phys. Educ**, 6, 2021, 1-5.

57 J. Kang, N. A. Ratamess, J. Kuper, E. O'Grady, E. Nicole, I. Vought, J. A. Bush-Wallace, & A. D. Faigenbaum, *Cardiometabolic Responses of Body-Weight Exercises with and without Vibration*, **Kinesiology**, 51 (1), 2019, 83-91.

58 F. García-Pinillos, C. Lago-Fuentes, P. A. Latorre-Román, A. Pantoja-Vallejo, & R. Ramirez-Campillo, *Jump-Rope Training: Improved 3-km Time-trial Performance in Endurance Runners via Enhanced Lower-limb Reactivity and Foot-arch Stiffness*, **International Journal Of Sports Physiology And Performance**, 15 (7), 2020, 927-933.

59 X. Yang, J. Lee, X. Gu, X. Zhang, & T. Zhang, *Physical Fitness Promotion among Adolescents: Effects of a Jump Rope-Based Physical Activity Afterschool Programme*, **Children**, 7 (8), 2020, 95.

60 A. J. Robinson, R. P. Carter, J. D. Browne, J. Hu, M. T. Arnold, J. T. Baum, E. V. Neufeld, & B. A. Dolezal, *Energy Expenditure and Muscular Recruitment Patterns of Riding a Novel Electrically Powered Skateboard*, **International Journal of Exercise Science**, 13 (4), 2020, 1783.

61 Y. Yunidar, Y. Yaskur, R. Roslidar, & M. Syaryadhi, *Rancang Bangun Alat Pengukur Jarak Tempuh Lari Laun dengan Menggunakan Sensor Inertial Measurement Unit (IMU) Berbasis Mikrokontroler*, **Jurnal Rekayasa Elektrika**, 18 (1), 2022.

62 I. Ballesta-García, I. Martínez-González-Moro, D. J. Ramos-Campo, & M. Carrasco-Poyatos, *High-Intensity Interval Circuit Training Versus Moderate-intensity Continuous Training on Cardiorespiratory Fitness in Middle-aged and Older Women: A Randomized Controlled Trial*, **International Journal of Environmental Research and Public Health**, 17 (5), 2020, https://doi.org/10.3390/ijerph17051805.

63 L. M. Jones, L. Stoner, J. C. Baldi, & B. McLaren, *Circuit Resistance Training and Cardiovascular Health in Breast Cancer Survivors*, **European Journal of Cancer Care**, 29 (4), 2020, e13231.

64 N. Prvulovic, M. Hadzovic, & A. Lilic, *The Effects of Different Exercise Programmemes on Body Composition and Body Mass in Adults: A Review Article*, **Sport Mont**, 19 (3), 2021, 135-141.

65 S. Sakthivel, & K. Vaithiyanathan, *Impact of Circuit Training on Muscular Strength and Leg Explosive Power among Volleyball Players*, **Journal of Positive School Psychology**, 6 (10), 2022, 3937-3939.

66 K. Shimada, M. Nishitani-Yokoyma, T. Takahashi, & H. Daida, *Physical Activity and Long-Term Prognosis in Patients with Stable Coronary Artery Disease: How Often, How Intense, and How Long?,* European **Journal of Preventive Cardiology**, 27 (4), 2020, 422-425.

67 P. M. Kamble, A. P. Matondkar, & A. Paul, *An Investigation into Health Related Physical Fitness among Physiotherapists*, Website: www. ijpot. com, 15 (1), 2021, 112.

68 Y. Wang, B. Muthu, & C. B. Sivaparthipan, *Internet of things Driven Physical Activity Recognition System for Physical Education*, **Microprocessors and Microsystems**, 81, 2021, 103723.

69 A. Lohan, *Assorted Parameters with Elevation of Performance and Physical Fitness and Edurance with Exercise*, **Asian Journal of Research in Social Sciences and Humanities**, 11 (9), 2021, 10-16.

70 G. L. Blasquez Shigaki, C. C. Barbosa, M. B. Batista, C. L. Romanzini, E. M. Gonçalves, H. Serassuelo Junior, & E. R. Ronque, *Tracking of Health-related Physical Fitness between Childhood and Adulthood*, **American Journal of Human Biology**, 32 (4), 2020, e23381.

71 J. Mora-Gonzalez, I. Esteban-Cornejo, C. Cadenas-Sanchez, J. H. Migueles, P. Molina-Garcia, M. Rodriguez-Ayllon, P. Henriksson, M. B. Pontifex, A. Catena, & F. B. Ortega, *Physical Fitness, Physical Activity, and the Executive Function in Children with Overweight and Obesity*, **The Journal of Pediatrics**, 208, 2019, 50-56.

72 A. García-Hermoso, A. M. Alonso-Martinez, R. Ramírez-Vélez, & M. Izquierdo, *Effects of Exercise Intervention on Health-related Physical Fitness and Blood Pressure in Preschool Children: A Systematic Review and Meta-analysis of Randomized Controlled Trials*, **Sports Medicine**, 50 (1), 2020, 187-203.

73 C. M. Friedenreich, C. Ryder-Burbidge, & J. McNeil, *Physical Activity, Obesity and Sedentary Behavior in Cancer Etiology: Epidemiologic Evidence and Biologic Mechanisms*, **Molecular Oncology**, 15 (3), 2021, 790-800.

74 C. Weyh, K. Krüger, & B. Strasser, *Physical Activity and Diet Shape the Immune System during Aging*, **Nutrients**, 12 (3), 2020, 622.

75 D. Fernández-Lázaro, J. J. González-Bernal, N. Sánchez-Serrano, L. J. Navascués, A. Ascaso-del-Río, & J. Mielgo-Ayuso, *Physical Exercise as a Multimodal Tool for COVID-19: Could it be used as a Preventive Strategy?*, **International Journal of Environmental Research & Public Health**, 17 (22), 2020, 8496.

76 T. A. Wadden, J. S. Tronieri, & M. L. Butryn, *Lifestyle Modification Approaches for the Treatment of Obesity in Adults*, **American Psychologist**, 75 (2), 2020, 235.

77 S. Andermo, M. Hallgren, T. T. D. Nguyen, S. Jonsson, S. Petersen, M. Friberg, A. Romqvist, B. Stubbs, & L. S. Elinder, *School-Related Physical Activity Interventions and Mental Health among Children: A Systematic Review and Meta-analysis*, **Sports Medicine-Open**, 6 (1), 2020, 1-27.

78 B. Smits-Engelsman, E. Smit, R. X. Doe-Asinyo, S. E. Lawerteh, W. Aertssen, G. Ferguson, & D. L. Jelsma, *Inter-rater Reliability and Test-retest Reliability of the Performance and Fitness (PERF-FIT) Test Battery for Children: A Test for Motor Skill Related Fitness*, **BMC Pediatrics**, 21 (1), 2021, 1-11.

79 S. S. C. Hui, R. Zhang, K. Suzuki, H. Naito, G. Balasekaran, J. K. Song, S. Y. Park, Y. M. Liou, D. Lu, B. K. Poh, & K. Kijboonchoo, *Physical Activity and Health-related Fitness in Asian Adolescents: The Asia-Fit Study*, **Journal of Sports Sciences**, 38 (3), 2020, 273-279.

80 S. Y. Patel, A. Jadhav, T. Yadav, & K. Bathia, *Assessment of Physical Health among Security Guards Working in Krishna Hospital, Karad-A Cross-sectional Study*, **Website: www. ijpot. com**, 13 (3), 2019, 128.

81 V. Sember, J. Grošelj, & M. Pajek, *Balance Tests in Pre-adolescent Children: Retest Reliability, Construct Validity, and Relative Ability*, **International Journal of Environmental Research & Public Health**, 17 (15), 2020, 5474.

82 R. X. Doe-Asinyo, & B. C. Smits-Engelsman, *Ecological Validity of the PERF-FIT: Correlates of Active Play, Motor Performance and Motor Skill-related Physical Fitness*. **Heliyon**, 7 (8), 2021, 07901.

83 H. Zouhal, A. B. Abderrahman, G. Dupont, P. Truptin, R. Le Bris, E. Le Postec, Z. Sghaeir, M. Brughelli, U. Granacher, & B. Bideau, *Effects of Neuromuscular Training on Agility Performance in Elite Soccer Players*, **Frontiers in Physiology**, 10, 2019, 947.

84 P. Zamparo, M. Cortesi, & G. Gatta, *The Energy Cost of Swimming and its Determinants*, **European Journal of Applied Physiology**, 120, 2020, 41-66.

85 N. L. Bragazzi, M. Rouissi, S. Hermassi, & K. Chamari, *Resistance Training and Handball Players' Isokinetic, Isometric and Maximal Strength, Muscle Power and Throwing Ball Velocity: A Systematic Review and Meta-analysis*, **International Journal of Environmental Research & Public Health**, 17 (8), 2020, 2663.

86 B. Sökmen, R. L. Witchey, G. M. Adams, & W. C. Beam, *Effects of Sprint Interval Training with Active Recovery vs. Endurance Training on Aerobic and Anaerobic Power, Muscular Strength, and Sprint Ability*, **Journal of Strength & Conditioning Research**, 32 (3), 2018, 624–631.

87 V. Menz, N. Marterer, S. B. Amin, M. Faulhaber, A. B. Hansen, & J. S. Lawley, *Functional vs. Running Low-Volume High-Intensity Interval Training: Effects on VO2max and Muscular Endurance*, **Journal of Sports Science & Medicine**, 18 (3), 2019, 497–504.

88 M. J. Case, D. V. Knudson, & D. L. Downey, *Barbell Squat Relative Strength as an Identifier for Lower Extremity Injury in Collegiate Athletes*, **Journal of Strength & Conditioning Research**, 34 (5), 2020, 1249–1253.

89 M. Y. Fares, H. H. Khachfe, H. A. Salhab, A. Bdeir, J. Fares, & H. Baydoun, *Physical Testing in Sports Rehabilitation: Implications on a Potential Return to Sport*, **Arthroscopy, Sports Medicine, & Rehabilitation**, 4 (1), 2022, 189-198.

90 E. Iuliano, D. Cular, J. Padulo, A. Larion, I. Melenco, G. Kuvačić, W. Dhahbi, & G. M. Migliaccio, *Predictive Ability of Body Mass Parameter to Estimate 4-6 Repetition Maximum Of Upper and Lower Limb Muscles in Soccer Players*, **Acta Kinesiologica**, 15 (2), 2021, 120-124

91 J. A. Estrázulas, J. A. Estrázulas, K. de Jesus, K. de Jesus, R. A. da Silva, & J. O. L. Dos Santos, *Evaluation Isometric and Isokinetic of Trunk Flexor and Extensor Muscles with Isokinetic Dynamometer: A Systematic Review*, **Physical Therapy in Sport**, 45, 2020, 93-102.

92 S. S. Kumaran, & K. Ooraniyan, *Isotonic Strength Training for Basketball Players: A Short View*, **EPRA International Journal of Multidisciplinary Research (IJMR)**, 9 (1), 2023, 255-257.

93 I. Jukic, J. Calleja-González, F. Cos, F. Cuzzolin, J. Olmo, N. Terrados, N. Njaradi, R. Sassi, B. Requena, L. Milanovic, & I. Krakan, *Strategies and Solutions for Team Sports Athletes in Isolation due to COVID-19*, **Sports**, 8 (4), 2020, 56.

94 A. A. Gite, N. Mukkamala, & L. Parmar, *Relationship between Body Mass Index and Flexibility in Young Adults*, **Journal of Pharmaceutical Research International**, 33 (32A), 2021, 119-126.

95 S. Nazari, & B. H. Lim, *Effects of a 12-Week Core Training Programme on Physical Characteristics of Rhythmic Gymnastics: A Study In Kuala Lumpur, Malaysia*, **Malaysian Journal of Movement, Health & Exercise**, 8 (1), 2019, 157-174.

96 R. J. Wood, *Complete Guide to Fitness Testing. 2010,* Available at: https://www.topendsports.com/testing/.

97 S. Douka, V. I. Zilidou, O. Lilou, & V. Manou, *Traditional Dance Improves the Physical Fitness and Well-being of the Elderly*, **Frontiers in Aging Neuroscience**, 11, 2019, 75.

98 J. S. Jeevannavar, P. S. Jalamsingh, N. Misalankar, & K. P. Rajesh, *Variability in Flexibility of Dominant and Non-dominant Shoulder Joints among Healthy Young Adults*, **Indian Journal of Physiotherapy & Occupational Therapy**, 16 (4), 2022, 112-116.

99 E. McNabb, *Development of a Physical Movement Programme for Older Adults*, Doctoral Dissertation, California State University, Long Beach, 2022.

100D. Primasatya, E. Rimawan, & H. Herlambang, *Simulation of the Cardiovascular Mechanical System Based on Pressure-flow Model Rest Condition*, **International Journal of Innovative Science & Research Technology**, 5 (7), 2020, 104-115.

101I. Peate, *The Heart: An Amazing Organ*, **British Journal of Healthcare Assistants**, 15 (2), 2021, 72-77.

102K. Sato, & K. Sato, *Blood vessels-on-a-chip. In Principles of Human Organs-on-Chip,s*, Woodhead Publishing, 2023, 167-194.

103J. A. Zepp, & E. E. Morrisey, *Cellular Crosstalk in the Development and Regeneration of the Respiratory System*, **Nature Reviews Molecular Cell Biology**, 20 (9), 2019, 551-566.

104S. Vijayakumar Jain, M. R. Muthusekhar, M. F. Baig, P. Senthilnathan, S. Loganathan, P. U. Abdul Wahab, M. Madhulakshmi, & Y. Vohra, *Evaluation of Three-dimensional Changes in Pharyngeal Airway following Isolated Lefort one Osteotomy for the Correction of Vertical Maxillary Excess: A Prospective Study*, **Journal of Maxillofacial & Oral Surgery**, 18, 2019, 139-146.

105K. Ahookhosh, O. Pourmehran, H. Aminfar, M. Mohammadpourfard, M. M. Sarafraz, & H. Hamishehkar, *Development of Human Respiratory Airway Models: A Review*, **European Journal of Pharmaceutical Sciences**, 145, 2020, 105233.

106K. K. Buttar, N. Saboo, & S. Kacker, *A Review: Maximal Oxygen Uptake (VO2 Max) and its Estimation Methods*, **IJPESH**, 6, 2019, 24-32.

107V. M. Lukasik, *Anesthesia of the Dental Patient*, The Veterinary Dental Patient: A Multidisciplinary Approach, 2021, 169-187.

108K. S. Tang, E. D. Medeiros, & A. D. Shah, *Wide Pulse Pressure: A Clinical Review*, **The Journal of Clinical Hypertension**, 22 (11), 2020, 1960-1967.

109K. Sembulingam, P. Sembulingam, *Essentials of Medical Physiology*, JP Medical Ltd. 2012, 587-588.

110K. E. Barrett, S. M. Barman, S. Boitano, & H. Brooks, *Ganong's Review of Medical Physiology* (24 ed.), 2012, 619, ISBN 978-0071780032.

111P. Windisch, C. Schröder, R. Förster, N. Cihoric, D. R. Zwahlen, & P. Y. Windisch, *Accuracy of the Apple Watch Oxygen Saturation Measurement in Adults: A Systematic Review*, **Cureus**, 15 (2), 2023.

112H. W. You, P. L. Tan, & M. L. AF, *The Relationship between Physical Activity, Body Mass Index and Body Composition among Students at a Pre-University Centre in Malaysia*, **IIUM Medical Journal Malaysia**, 19 (2), 2020.

113Y. B. Usman, O. I. Shittu, M. T. Aloysius, A. O. Aliyu, & V. G. Igho, Performance Criteria of Modified Multihalver Technique for Detecting Outlying Values of Body Mass Index (BMI): A Higher Risk Factor and Prognosis ff COVID-19 Infections, 2022.

114D. Song, Q. Ge, M. Chen, S. Bai, X. Lai, G. Huang, M. Liu, M. Lin, J. Xu, & F. Dong, *Development and Validation of a Nomogram for Prediction of the Risk of MAFLD in an Overweight and Obese Population*, **Journal of Clinical and Translational Hepatology**, 10 (6), 2022,1027.

115O. A. Olutekunbi, A. U. Solarin, I. O. Senbanjo, E. A. Disu, & O. F. Njokanma, *Skinfold Thickness Measurement in Term Nigerian Neonates: Establishing Reference Values*, **International Journal of Pediatrics**, 2018, https://doi.org/10.1155/2018/3624548.

116N. A. Ujuagu, & T. N. Uzor, *Optimising Female Secondary School Teachers' body Composition and Muscular Endurance Using Circuit Training Exercise*, **South Eastern Journal of Research and Sustainable Development (SEJRSD)**, 5 (2), 2021, 31-49.

117R. F. Burton, *The Waist-Hip Ratio: A Flawed Index*, **Annals of Human Biology**, 47 (7-8), 2020, 629-631.

118G. B. Nepal, A. Bhaila, H. S. Shrestha, N. Maharjan, & B. Adhikari, *Estimation of Body Fat Percentage in Adult Population in Nepal and Assess its Correlation with Body Mass Index*, **Journal of Chitwan Medical College**, 12 (4), 2022, 99-102.

119H. Naeem, F. Qayyum, H. Qayyum, S. Murad, & Z. Khalid, *Association of Acute Coronary Syndrome with Waist Hip Ratio in Local Population of Islamabad Capital Territory, Pakistan*, **Journal of Islamic International Medical College (JIIMC)**, 14 (3), 2019, 111-115.

120B.A. Bushman, *Body Composition: Measurement Techniques to Increase Accuracy*, **ACSM's Health & Fitness Journal**, 26 (2), 2022, 6-12.

121R. P. Wilder, J. A. Greene, K. L. Winters, W. B. Long, K. Gubler, & R. F. Edlich, *Physical Fitness Assessment: An Update*, **J Long Term Eff Med Implants**, 16 (2), 2006, 193-204.

122R. Brand, & P. Ekkekakis, *Affective-reflective Theory of Physical Inactivity and Exercise: Foundations and Preliminary Evidence*, **German J. Exer Sport Res**, 48, 2018, 48–58.

123D. Eassey, H. K. Reddel, K. Ryan, & L. Smith, '*It is like Learning how to Live all Over Again'a Systematic Review of People's Experiences of Living with a Chronic Illness from a Self-determination Theory Perspective*, **Health Psychology & Behavioral Medicine**, 8 (1), 2020, 270-291.

124N. Ntoumanis, J. Y. Y. Ng, A. Prestwich, E. Quested, J. E. Hancox, C. Thøgersen-Ntoumani, & G. C. Williams, *A Meta-Analysis of Self-determination Theory-informed Intervention Studies in the Health Domain: Effects on Motivation, Health Behavior, Physical, and Psychological Health*, ***Health Psychology Review***, *15* (2), 2020, 214–244.

125S. Rathinakamalan, & G. Abraham, *Effect of Circuit Training on Strength endurance among Players of Different Team Games*, **Journal of Xi'an University of Architecture and Technology**, 13 (2), 2021, 364-371.

126L. I. Pietro, S. Gabriele, P. Maurizio, A. Giampietro, F. Damiano, & B. Andrea, *Circuit Training during Physical Education Classes to Prepare Cadets for Military Academies Tests: Analysis of an Educational Project,* **Sustainability**, 2020, 12, 5126.

127S. Nugroho, A. Nasrulloh, T. H. Karyono, R. Dwihandaka, & K. W. Pratama, *Effect of Intensity and Interval Levels of Trapping Circuit Training on the Physical Condition of Badminton Players*, **Journal of Physical Education & Sport**, 21, 2021, 1981-1987.

128P. J. Marcos-Pardo, F. J. Orquin-Castrillón, G. M. Gea-García, R. Menayo-Antúnez, N. González-Gálvez, R. G. D. S. Vale, & A. Martínez-Rodríguez, *Effects of a Moderate-to-High Intensity Resistance Circuit Training on Fat Mass, Functional Capacity, Muscular Strength, and Quality of Life in Elderly: A Randomized Controlled Trial*, **Scientific Reports**, 9 (1), 2019, 7830.

129I. Ullah, R. Gul, A. Muhammad, & K. Usman, *Effect of Circuit Training upon Flexibility among Non-athletes of College Students*, **Al-Qantara**, 8 (2), 2022, 227-241.

130J. Anitha, P. Kumaravelu, C. Lakshmanan, & K. Govindasamy, *Effect of Plyometric Training and Circuit Training on Selected Physical and Physiological Variables among Male Volleyball Players*, **International Journal of Yoga, Physiotherapy & Physical Education**, 3 (4), 2018, 26-32.

131R. Setyawan, H. Setijono, & N. W. Kusnanik, *The Effect of Floor and Swiss Ball Exercises Using Circuit Training Methods towards Balance, Strength, Flexibility and Muscle Endurance*, **Britain International of Humanities & Social Sciences (BIoHS) Journal**, 3 (2), 2021, 384-395.

132K. V. Shejin, & T. Vivekanandhan, *Effect of Circuit Training on Obesity, Vital Capacity and Flexibility among School Going Obese Children*, **International Journal of Sports Sciences & Fitness**, 10 (2), 2020.

133M. Salierno, R. Ceruso,, I. Sannicandro, & G. Altavilla, *Circuit Training as a Method of Adaptation and Prevention for People With Type 2 Diabetes*, **Journal of Human Sport and Exercise**, 16 (3), 2021, 1045-1054.

134U. C. Ikenna, O. G. Ngozichi, I. Ijeoma, N. Ijeoma, N. Ifeanyichukwu, & O. C. Martin, *Effect of Circuit Training on the Cardiovascular Endurance and Quality of Life: Findings from an Apparently Healthy Female Adult Population*, **JALSI**, 23 (3), 2020, 1-8.

135R. Ferraz, D. Marques, H. P. Neiva, M. C. Marques, D. A. Marinho, & L. Branquinho. *Effects of Applying a Circuit Training Programme During the Warm-up Phase of Practical Physical Education Classes*, **Orthop and Spo Med Op Acc J,** 4 (4), 2020, 439-444.

136L. P. T. A. Ariani, I. K. Sudiana, & K. C. A. Kusuma, *Continuous and Competitive Circuit Training: Methods to Increase VO2max on Young Badminton Player*, **Journal Sport Area**, 7 (2), 2022, 236-245.

137O. A. Ajayi, U. O. Suleiman, I. O. Oladipo, & N. C. M. Achikasim, *Effects of Aerobic Dance Circuit Training Programmeme on Blood Pressure Variables of Obese Female College Students in Oyo State, Nigeria*, **Journal of Physical Education Research**, 7 (3), 2020, 32-38.

138J. Ndayisenga, *Circuit Training Intervention for Adaptive Physical Activity to Improve Cardiorespiratory Fitness, Leg Muscle Strength Static and Balance of Intellectually Disabled Children*, **Sport Mont**, 17 (3), 2019, 97-100.

139W. S. Jung, Y. Y. Kim, & H. Y. Park, *Circuit Training Improvements in Korean Women with Sarcopenia*, **Perceptual & Motor Skills**, 126 (5), 2019, 828–842.

140J. John, U. Nnaji, O. Okezu, U. Nnadozie, D. John, A. Ezeukwu, U. Mgbeojedo, & I. Enyanwuma, *Effects of Circuit Exercise Training on Body Image, Cardiorespiratory Indices, and Body Composition of Obese Undergraduates in a Nigerian University*, **Physiotherapy Quarterly** (ISSN 2544-4395), doi: https://doi.org/10.5114/pq.2023.112744.

141J. W. Kim, Y. C. Ko, T. B. Seo, & Y. P. Kim, *Effect of Circuit Training on Body Composition, Physical Fitness, and Metabolic Syndrome Risk Factors in Obese Female College Students*, **Journal of Exercise Rehabilitation**, 14 (3), 2018, 460.

142S. Mehmood, A. Khan, S. Farooqui, A. W. Zahoor, Q. U. A. Adnan, & U. Khan, *High-intensity Circuit Training for Improving Anthropometric Parameters for Women from Low Socioeconomic Communities of Sikandarabad: A Clinical Trial*. **PLoS ONE**, 17 (10), 2022, e0275895. https://doi.org/10.1371/journal.pone.0275895.

143M. I. Aldhahi, M. M. Alshehri, F. Alqahtani, & A. S. Alqahtani, *A Pilot Study of the Moderating Effect of Gender on the Physical Activity and Fatigue Severity among Recovered COVID-19 Patients*, **Plos One**, 17 (7), 2022, 0269954.

144A. R. Ortego, D. K. Dantzler, A. Zaloudek, J. Tanner, T. Khan, R. Panwar, D. B. Hollander, & R. R. Kraemer, *Effects of Gender on Physiological Responses to Strenuous Circuit Resistance Exercise and Recovery*, **The Journal of Strength & Conditioning Research**, 23 (3), 2009, 932-938.

145S. Li, L. Wang, J. Xiong, & D. Xiao, *Gender-specific Effects of 8-Week Multi-modal Strength and Flexibility Training on Hamstring Flexibility and Strength*, **International Journal of Environmental Research and Public Health**, 19 (22), 2022, 15256.

146I. Ballesta-García, I. Martínez-González-Moro, J. Á. Rubio-Arias, & M. Carrasco-Poyatos, *High-intensity Interval Circuit Training Versus Moderate-intensity Continuous Training on Functional Ability and Body Mass Index in Middle-aged and Older Women: A Randomized Controlled Trial*, **International Journal of Environmental Research and Public Health**, 16 (21), 2019, 4205.

147S. La Greca, M. Rapali, G. Ciaprini, L. Russo, M. G. Vinciguerra, & R. Di Giminiani, *Acute and Chronic Effects of Supervised Flexibility Training in Older Adults: A Comparison of Two Different Conditioning Programmes*, **International Journal of Environmental Research and Public Health**, 19 (24), 2022, 16974.

148N. Jaronsukwimal, *Effects of Circuit Training Programme on Physical Fitness in Overweight Older Adults*, **Academic Journal of Thailand National Sports University**, 13(3), 2021, 57–68.

149C. B. Ferreira, P. D. S. Teixeira, G. Alves Dos Santos, A. T. Dantas Maya, P. Americano Do Brasil, V. C. Souza, C. Córdova, A. P. Ferreira, R. M. Lima, & O. D. T. Nóbrega, *Effects of a12-Week Exercise Training Programme on Physical Function in Institutionalized Frail Elderly*, **Journal of Aging Research**, 2018.

150O. A. Ajayi, Effects of Aerobic Dance Circuit Training Programmeme on Body Composition and Cardiorespiratory Variables of Obese Female College Students in Oyo Town, Nigeria (Doctoral Dissertation), 2018.

151B. M. Roberts, G. Nuckols, & J. W. Krieger, *Sex Differences in Resistance Training: A Systematic Review and Meta-analysis*, ***J Strength Cond Res,*** 34 (5), 2020, 1448-1460.

152A. M. Bloodgood, J. J. Dawes, R. M. Orr, M. Stierli, K. A. Cesario, M. R. Moreno, J. M. Dulla, & R. G. Lockie, *Effects of Sex and Age on Physical Testing Performance for Law Enforcement Agency Candidates: Implications for Academy Training*, ***J Strength Cond Res,*** 35 (9), 2021, 2629-2635.

153M. Kasović, L. Štefan, & Z. Kalčik, *Acute Responses to Resistance Training on Body Composition, Muscular Fitness and Flexibility by Sex and Age in Healthy War Veterans Aged 50-80 Years*, **Nutrients**, 14 (16), 2022, 3436.

154B. Schwartz, *Sex Differences in the Impact of A 12-Week High Intensity Interval Training Intervention on Sympathetic Transduction,* (Doctoral Dissertation), 2023.

155S. Kolahdouzi, M. Baghadam, F. A. Kani-Golzar, A. Saeidi, G. Jabbour, A. Ayadi, M. De Sousa, A. Zouita, A. B. Abderrahmane, & H. Zouhal, *Progressive Circuit Resistance Training Improves Inflammatory Biomarkers and Insulin Resistance in Obese Men*, **Physiology & Behavior**, *205*, 2019, 15-21.

Chapter Three

Methodology

This chapter describes methodology. It is organized to cover the following:

3.1 Research Design

3.2 Population of the Study

3.1 Research Design

This study adopted a pretest-posttest, control group quasi-experimental design using a 2×2×4 factorial matrix. The design employed two groups of participants: the control group and the experimental group. The control group was placed on placebo without their knowledge, while the experimental group was involved in the intervention programmeme of circuit training.

3.2 Population of the Study

The population of this study consisted of all academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

3.3 Sample and Sampling Techniques

The sample size for this study was forty (40) academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State. The purposive sampling technique was used to select forty (40) academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State[1]. The selected male and female participants were randomly assigned equally into two groups: the control (nutrition education) and experimental (circuit training programmeme) groups using the fish bowl method. However, participation was voluntary in the study. The research focused on securing volunteers' interest by providing clear information about the research purpose, methodology, and potential benefits. Built trust and interest by emphasising the benefits of participation, offering flexible scheduling, and providing transportation or childcare assistance. Ethical considerations were explained, and a feedback mechanism was established to address concerns. Regular communication was maintained, providing updates on progress, acknowledging contributions, and expressing gratitude for the volunteers' participation.

Inclusion and Exclusion Criteria

The academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, that completed the consent form and physical fitness readiness questionnaire, ages 25 to 64, were generally healthy individuals without any known cardiovascular or respiratory conditions that might interfere with their ability to perform physical exercise safely. The resting heart rate and Cooper's 12-minute run test were used to determine the medical fitness of participants. Participants with a heart rate ranging between 60 and 80 beats per minute and scores above 1100 metres in the Cooper 12-minute run test were included. Participants who do not fall into the academic staff category, did not complete the consent form or physical fitness readiness questionnaire, were not between the ages of 25 and 64 years old; individuals with physical limitations or disabilities that would prevent them from safely participating in the Cooper 12-minute run test or could confound heart rate measurements; and individuals who are taking medications that could affect heart rate or exercise tolerance unless they have medical clearance from a healthcare provider were excluded.

3.4 Description of the Research Instruments

Physical Activity Readiness Questionnaire (PAR-Q): The Physical Activity Readiness Questionnaire was used to assess risk factors during moderate physical exercise, family history, and disease severity.

PAAS Blood Pressure Monitor: SKU: GE779SE0MMBL2NAFAMZ, Product Line: PAAS Diagnostics Ltd, Model: BSP-12, Size (L x W x H cm): 14.8 x 10 x 5.6 cm, Weight (kg): 382 were used to measure blood pressure in millimeter of mercury (mmHg).

Stopwatch: The Heuer Track mate stopwatch was used to determine running time, respiratory rate and muscular strength tests.

Pulse Oximeter: SKU: CO989SE0SYCO0NAFAMZ, Product Line: JAVISTA, Model: CMS50D1, Production Country: China, Size (L x W x H cm): 8.1 x 6.8 x 4.9 was used to measure the percentage of oxygen saturation level.

Step Bench: A thick, sturdy-step bench 50.8cm high made with plywood was used for the step up exercise for the circuit training programmeme.

Gym Mats: The sit and reach test and sit-up were performed on 3D model rubber gym mats. Also all the circuits that require lying down were done on gym mats.

Measuring Tape: A HANSMAYA non-elastic fiber measuring tape measuring 60 INCH/ 150 CM was used for back scratch flexibility. It had measurement accuracy of 0.003MM.

Seat and Reach Box: A fabricated seat and reach box was used to measure flexibility of the lower back and hamstring musculature. The length of top of the box was 53.3 centimeter and the height at 32.5 centimeter.

Cones: SKLZ 2-Inch Mini Cones were used to mark distances during coopers run test.

3.5 Validity of Research Instruments

Validity is the ability of a test result to reflect the accuracy of the parameters being measured. Standardised scientific tests and instruments were used for this study. There was a cross-check of the workability of instruments before use. Also, the instruments that were used for testing in this study had been used by other researchers to test different fitness components and had been found to be valid[2, 3, 4].

3.5 Reliability of Research Instruments

Reliability of an instrument is the consistence of an instrument to measure what it is purported to measure. Reliability of pulse oximeter, blood pressure monitor, measuring tape and sit and reach box were 0.91, 0.96, 0.90, and 0.92 respectively, hence their reliability[2, 3, 4].

3.7 Method of Data Collection

A letter of introduction from the Head, Department of Kinesiology, Sports Science, and Health Education, Lead City University, Ibadan, was used by the researcher to obtain permission from the Vice Chancellor, Bayelsa State Medical University, Yenagoa, Bayelsa State, Nigeria. This facilitated access for the collection of data from the sample for the study.

Physical Activity Readiness Questionnaire (PAR-Q): Prior to the physical activity exercise, the participants were given a physical activity readiness questionnaire to fill out, which was used to determine their physical activity [5].

Training of Research Assistant: Five (5) research assistants, who are medical students, were selected from the school. They assisted in the coordination, testing, and training of the participants. They attended a one-day training of trainers (TOT) programmeme, which was organised by the researcher.

Test Administration: Data was collected by first administering the pre-test to both the control and experimental groups by the researcher with the help of the research assistants, who helped to record and observe the participants. The tests were spread and conducted such that the preceding test did not influence the subsequent one. The pre-test was followed by the training session (circuit training) that was done for eight weeks, given only to the experimental group. After the training session, the researcher finally conducted the post-test with both experimental and control groups in order to know how the training affected the variables of interest for the study. Scores were collected and recorded. The researcher and the research assistants conducted the pre- and post-tests on all the participants as follows:

1. Cardiorespiratory fitness (resting heart rate, respiratory rate, oxygen saturation level).
2. Flexibility (sit and reach test).
3. Body composition (Waist to Hip Ratio).
4. Muscle Strength (Push-ups).

Participants and research assistants where blinded to avoid performance and data collection bias. Participants were informed about the nature and the purpose of the test before commencement. The researcher demonstrated the exercise where necessary. The procedures for the collection of data during testing were done as follows:

Cardiorespiratory Fitness

Heart Rate: The heart rate of the participants was determined using the PAAS Blood Pressure Monitor with the participant seated, placed the arm cuff just above the elbow at about 2cm above the elbow to make sure it can detect the artery in the arm, just under the skin, **keep participants still and quiet while taking reading, took readings,** recorded all readings in beats per minute.

Respiratory Rate: The respiratory rate was measured when the participant were at rest by counting the number of breaths for one minute (how many times the chest rises) with the aid of a stopwatch[6]. Recorded number of breathes per minute.

Oxygen Saturation Level: The percentage of oxygen saturation level was measured using the pulse oximeter. After confirming the right implantation site, position the pulse oximeter such that the light can pass through the tissue and be detected by the detector. When using a pulse oximeter on a fingertip, the probe fitted snugly. It was not be very tight or overly loose. Special care was taken to ensure that the probe does not restrict circulation to the digit, as this could result in an erroneous reading[7].

Flexibility

Sit and Reach Test: Sit and reach test measures flexibility of the lower back and hamstring musculature. A fabricated box (the length of top of the box at 53.3 centimeter and the height at 32.5 centimeter) was placed against a wall and the participant sits on the floor with the knees and upper body straight, and their heels against the box[8]. The test was completed without shoes on. The participants reached forward as far as possible along the measuring tape atop of the box, with one hand on top of the other, slides along the box and with the back and legs straight. The furthest the participant managed to stretch the hands along the measuring tape and hold for two sec, was recorded to the nearest half centimeter (point zero), the point where the feet met the box.

Body Composition

Waist-Hip Ratio: The waist-hip ratio (WHR) is the dimensionless ratio of the circumference of the waist to that of the hips[9]. The test consists of measuring the circumference of the waist and hip of participants using non-elastic measuring tape. Each participant was asked to:

- Stanf upright during measurement.

- The circumference of the waist was measured and recorded in centimeters around the narrowest portion of the stomach, near or just above the belly button.
- The circumference of the hip was measured and recorded in centimeters over the broadest region of the hips and buttocks.
- WHR was calculated by dividing the waist size by the hip size.

Muscle Strength:

Push-Up/ 30 Sec: The push-up test is a popular way to assess upper body strength. It is a quick and easy approach to evaluate strength and endurance. The test consists of doing as many push-ups as possible in 30 seconds. Muscular strength was measured by the number of pushups accomplished in the period. Each participant was asked to:

- Get down on all fours, placing the hands slightly wider than the shoulders.
- Straighten the arms and legs.
- Lower the body until the chest nearly touches the floor.
- Pause, then push the body back up.
- Continue the exercise until you can no longer continue, with timing starting when participants get down on all fours.

Training Procedure: The circuit training programme was a self-developed, structured programme titled "Ogbara Freedom Festus Circuit Training Programme". The training programmeme was an eight week circuit training exercise. The exercise was carried out three times per week. The exercise training was done in a circuit with instructions and supervision by the researcher and trained assistants. The training session started with warm-up activities, followed by circuit training and ended with a cool down stretch.

Circuit Training Protocol: A ten (10) minute warm up exercise was carried out before the commencement of the circuit training. The circuit training sesion was conducted 3 times per week within a duration of 24 minutes, 9 stations, 4 sets per station (Weeks 1 and 2), 30 minutes 9 stations, 5 sets per station (Weeks 3 and 4), 41 minutes 67 seconds, 10 stations, 5 sets per station (Weeks 5 and 6), and 50 minutes, 10 stations, 5 sets per station (Weeks 7 and 8). The circuit exercise was accompanied by a ten (10) minutes cool down exercise.Pictoral presentations of the typical training session is shown in appendix II.

3.8 Method of Data Analysis

Descriptive and inferential statistical procedures were used to analyse the data. The descriptive statistics of frequency, percentage (%), mean, and standard error of mean were used to analyse the demographic data. Null hypotheses were tested at the 0.05 significance level using the analysis of covariance (ancova). All data were analysed using IBM SPSS version 22 (IBM Co., Armonk, NY, USA).

3.9 Ethical Approval

Ethical approval (LCU-REC/23/226) was obtained from the Lead City University Health Research Committee (LCU-HREC) by the researcher. This was done by making copies of the proposal available to the committee. After approval by the committee, the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, was approached through the Vice Chancellor, Bayelsa Medical University, Yenagoa, Bayelsa State. The researcher informed them of the aim and benefits of the programmeme and also solicited compliance. Participation was made voluntary. Consent forms were given to participants to affirm their willingness to participate.

Endnotes

1 M. J. Fontelles, M. G. Simões, J. C. Almeida, & R. G. S. Fontelles, *Research Methodology: Guidelines for Calculating the Sample Size*, **Rev Para Med**, 24 (2), 2010, 57-64.

2 N. H. Parker; A. Ngo-Huang; R. E. Lee; D. P. O'Connor; K. M. Basen-Engquist; M. Q. Petzel; X. Wang; L. Xiao; D. R. Fogelman; K. L. Schadler; & R. J. Simpson, *Physical Activity and Exercise during Preoperative Pancreatic Cancer Treatment*, **Supportive Care in Cancer**, *27*, 2019, 2275-2284.

3 R. E. Harskamp, L. Bekker, J. C. Himmelreich, L. De Clercq, E. P. Karregat, M. E. Sleeswijk, & W. A. Lucassen, *Performance of Popular Pulse Oximeters Compared with Simultaneous Arterial Oxygen Saturation or Clinical-grade Pulse Oximetry: A Cross-sectional Validation Study in Intensive Care Patients*, **BMJ Open Respiratory Research**, 8 (1), 2021, 000939.

4 J. A. Hodgkinson, M. M. Lee, S. Milner, P. Bradburn, R. Stevens, F. R. Hobbs, C. Koshiaris, S. Grant, J. Mant, & R. J. Mcmanus, *Accuracy of Blood-pressure Monitors Owned by Patients with Hypertension (ACCU-RATE Study): A Cross-sectional, Observational StudyiIn Central England*, **British Journal of General Practice**, 70 (697), 2020, 548-554.

5 A. Chotipanich, & N. Kongpit, *Precision and Reliability of Tape Measurements in the Assessment of Head and Neck Lymphedema*, **Plos One**, 15 (5), 2020, 0233395.

6 P. Bhutia, & A. Tiwari, *A Study on Physiological Aspects of Ellite Middle-And Long-Distance Runners*, **Think India Journal**, 22 (10), 2019, 9609-9622.

7 B. B. Hafen, & S. Sharma, *Oxygen Saturation*, [Updated 2022 Nov 23]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK525974/

8 A. Martínez-Rodríguez; M. R. Alejandro; J. C. C. Bernardo; M. G. de F. José; Y. S. Rodrigo, & J. M. P. Pablo, *Body Composition Assessment Techniques in Clinical and Epidemiological Settings: Development, Validation and Use in Dietary Programmes,* **Physical Training and Sports**, *16648714*, 2023, 226.

9 A. G. Rundle; P. Factor-Litvak; S. F. Suglia; E. S. Susser; K. L. Kezios; G. S. Lovasi; P. M. Cirillo; B. A. Cohn; B. G. & Link, *Tracking of Obesity in Childhood into Adulthood: Effects on Body Mass Index and Fat Mass Index at age 50*, **Childhood Obesity**, 16 (3), 2020, 226-233.

Chapter Four

Results and Discussion of Findings

This chapter presents results of the analyses and discussion of findings. The results and discussion of findings are organized to cover the following: demographic characteristics of the participants, research question and hypotheses testing and discussion of findings.

4.1 Demographic Data Analysis

The analysis of socio-demographic characteristics of the participants is presented in table 4.1, 4.2, 4.3.

Table 4.1: Distribution of Participants by Sex

Sex	Frequency	Percent	Valid Percent	Cumulative Percent
Male	30	75.0	75.0	75.0
Female	10	25.0	25.0	100.0
Total	40	100.0	100.0	

Source: Researcher's Fieldwork, 2024.

Table 4.1 reveals that 30 (75.0%) of the participants were males, while 10 (25.0%) were females.

Table 4.2: Distribution of Participants by Age

Age Range (Years)	Frequency	Percent	Valid Percent	Cumulative Percent
25-34	5	12.5	12.5	12.5
35-44	17	42.5	42.5	55.0
45-54	10	25.0	25.0	80.0
55-64	8	20.0	20.0	100.0
Total	40	100.0	100.0	

Source: Researcher's Fieldwork, 2024.

Table 4.2 reveals that 5 (12.5%) of the participants were in the age range of 25-34 years, 17 (42.5%) were between 35-44 years, 10 (25.0%) were between 45-54 years, while 8 (20.0%) were 50 years and above.

Table 4.3: Distribution of Participants by Group

Treatment Groups	Frequency	Percent	Valid Percent	Cumulative Percent
Control	20	50.0	50.0	50.0
Experimental	20	50.0	50.0	100.0
Total	40	100.0	100.0	

Source: Researcher's Fieldwork, 2024.

Table 4.3 reveals that 20 (50.0%) of the participants were used as control and experimental.

4.2 **Presentation of Data**

4.2.1 **Research Question**

The research question below was answered:

Research Question One: What is the pre-field status of physical fitness parameters (Muscle strength, flexibility, cardiorespiratory fitness, and body composition) of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State?

The pre-field status of physical fitness parameters (muscle strength, flexibility, cardiorespiratory fitness, and body composition) of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State is presented in table 4.4.

Table 4.4: Summary of the Pre-field Physical Fitness Parameters of Participants

	Muscle Strength (sec)	**Flexibility (cm)**	**Heart Rate (bpm)**	**Respiratory Rate (bpm)**	**Oxygen Saturation (%)**	**Body Composition**
N	40	40	40	40	40	40
Missing	0	0	0	0	0	0
Mean	15.93	1.56	77.65	18.18	97.10	0.87
Std. Error of Mean	0.91	0.22	0.58	0.33	0.14	0.01

Source: Researcher’s Fieldwork, 2024.

Table 4.4 reveals that participants had mean muscle strength of 15.93 ± 0.91, flexibility of 1.56 ± 0.22, heart rate (bpm) of 77.65 ± 0.58, respiratory rate (bpm) of 18.18 ± 0.33, oxygen Saturation (%) of 97.10 ± 0.14, and body composition of 0.87 ± 0.01.

Table 4.5: Result of the Pre-field Muscle Strength of Participants

Push-ups	Frequency	Percent	Valid Percent	Cumulative Percent
5.00	3	7.5	7.5	7.5
6.00	1	2.5	2.5	10.0
7.00	1	2.5	2.5	12.5
8.00	1	2.5	2.5	15.0
9.00	1	2.5	2.5	17.5
10.00	2	5.0	5.0	22.5
11.00	1	2.5	2.5	25.0
12.00	2	5.0	5.0	30.0

13.00	2	5.0	5.0	35.0
14.00	1	2.5	2.5	37.5
15.00	1	2.5	2.5	40.0
16.00	1	2.5	2.5	42.5
17.00	2	5.0	5.0	47.5
18.00	2	5.0	5.0	52.5
19.00	2	5.0	5.0	57.5
20.00	8	20.0	20.0	77.5
21.00	3	7.5	7.5	85.0
22.00	4	10.0	10.0	95.0
23.00	1	2.5	2.5	97.5
24.00	1	2.5	2.5	100.0
Total	**40**	**100.0**	**100.0**	

Source: Researcher's Fieldwork, 2024.

Table 4.5 shows that 8 participants (20%) had twenty (20) push-ups in 30 seconds, 1 participant each (2.5%) had 6, 7, 8, 9, 11, 14, 15, 16, 23 and 24 push-ups in 30 seconds. Participants had average push-up of 15.93 in 30 seconds.

Table 4.6: Result of the Pre-field Flexibility of Participants

Flexibility	Frequency	Percent	Valid Percent	Cumulative Percent
0.10	8	20.0	20.0	20.0
0.20	4	10.0	10.0	30.0
0.30	1	2.5	2.5	32.5
0.40	1	2.5	2.5	35.0
1.00	2	5.0	5.0	40.0
1.10	2	5.0	5.0	45.0
1.20	3	7.5	7.5	52.5
1.60	1	2.5	2.5	55.0

1.80	1	2.5	2.5	57.5
2.20	3	7.5	7.5	65.0
2.30	3	7.5	7.5	72.5
2.40	4	10.0	10.0	82.5
2.60	1	2.5	2.5	85.0
3.00	1	2.5	2.5	87.5
3.40	1	2.5	2.5	90.0
3.60	1	2.5	2.5	92.5
3.80	1	2.5	2.5	95.0
4.00	1	2.5	2.5	97.5
5.50	1	2.5	2.5	100.0
Total	**40**	**100.0**	**100.0**	

Source: Researcher's Fieldwork, 2024.

Table 4.6 shows that 8 participants (20%) had a pre-field flexibility score of 0.10cm, 1 participant each (2.5%) had pre-field flexibility score of 0.30cm, 0.40cm, 1.60cm, 1.80cm, 2.60cm, 3.00cm, 3.40cm, 3.60cm, 3.80cm, 4.00cm, 5.50cm respectively. Average pre-field flexibility score was 1.56cm.

Table 4.7: Result of the Pre-field Heart Rate of Participants

Heart Rate	Frequency	Percent	Valid Percent	Cumulative Percent
68.00	1	2.5	2.5	2.5
69.00	1	2.5	2.5	5.0
70.00	1	2.5	2.5	7.5

73.00	2	5.0	5.0	12.5
74.00	3	7.5	7.5	20.0
75.00	2	5.0	5.0	25.0
76.00	2	5.0	5.0	30.0
77.00	1	2.5	2.5	32.5
78.00	11	27.5	27.5	60.0
79.00	4	10.0	10.0	70.0
80.00	3	7.5	7.5	77.5
81.00	2	5.0	5.0	82.5
82.00	5	12.5	12.5	95.0
83.00	2	5.0	5.0	100.0
Total	**40**	**100.0**	**100.0**	

Source: Researcher's Fieldwork, 2024.

Table 4.7 shows that 11 participants (27.5%) had a pre-field heart rate of 78bpm, four levels had 1 participant each (2.5%) with a pre-field heart rate of 68, 69, 70, and 77bpm respectively. Average pre-field heart rate was 77.65bpm.

Table 4.8: Result of the Pre-field Respiratory Rate of Participants

Respiratory Rate	Frequency	Percent	Valid Percent	Cumulative Percent
13.00	1	2.5	2.5	2.5
14.00	2	5.0	5.0	7.5
15.00	3	7.5	7.5	15.0
16.00	2	5.0	5.0	20.0
17.00	5	12.5	12.5	32.5
18.00	5	12.5	12.5	45.0

19.00	9	22.5	22.5	67.5
20.00	11	27.5	27.5	95.0
21.00	1	2.5	2.5	97.5
22.00	1	2.5	2.5	100.0
Total	**40**	**100.0**	**100.0**	

Source: Researcher's Fieldwork, 2024.

Table 4.8 shows that 11 participants (27.5%) had a pre-field respiratory rate (RR) of 20bpm, three levels had 1 participant each (2.5%) with a pre-field RR of 13, 21 and 22bpm respectively. Average RR was 18.18bpm.

Table 4.9: Result of the Pre-Field Oxygen Saturation of Participants

Oxygen Saturation	Frequency	Percent	Valid Percent	Cumulative Percent
95.00	2	5.0	5.0	5.0
96.00	6	15.0	15.0	20.0
97.00	20	50.0	50.0	70.0
98.00	10	25.0	25.0	95.0
99.00	2	5.0	5.0	100.0
Total	**40**	**100.0**	**100.0**	

Source: Researcher's Fieldwork, 2024.

Table 4.9 shows that 20 participants (50%) had a pre-field oxygen saturation (OS) of 97%, 2 participants each (5%) had OS of 95% and 99% respectively. Average OS score was 97.10%.

Table 4.10: Result of the Pre-field Body Composition of Participants

Body Composition	Frequency	Percent	Valid Percent	Cumulative Percent
0.81	1	2.5	2.5	2.5
0.82	4	10.0	10.0	12.5
0.83	2	5.0	5.0	17.5
0.84	6	15.0	15.0	32.5
0.85	2	5.0	5.0	37.5
0.86	3	7.5	7.5	45.0
0.87	3	7.5	7.5	52.5

0.88	3	7.5	7.5	60.0
0.89	4	10.0	10.0	70.0
0.90	4	10.0	10.0	80.0
0.91	2	5.0	5.0	85.0
0.92	5	12.5	12.5	97.5
0.95	1	2.5	2.5	100.0
Total	**40**	**100.0**	**100.0**	

Source: Researcher's Fieldwork, 2024.

Table 4.10 shows that 6 participants (15%) had a pre-field body composition of 0.84, 1participant each (2.5%) had a pre-field body composition of 0.81 and 0.95 respectively. Average body composition score of participants was 0.87.

4.2.2 **Hypotheses**

The following hypotheses were tested in this study.

Ho1: There is no significant effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

Table 4.11: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Muscle Strength

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1355.90	2	677.95	144.41	.00	.89
Intercept	19.18	1	19.18	4.08	.05	.10
Pretest	1253.50	1	1253.50	267.01	.00	.88

Treatment	229.29	1	229.29	48.84	.00	.57
Error	173.70	37	4.70			
Total	14346.00	40				
Corrected Total	1529.60	39				

Source: Researcher's Fieldwork, 2024.

Table 4.11 shows a significant effect of the 8-week circuit training programmeme on muscle strength as measured by push-up of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,37)}$=48.84, p<0.05, η^2=0.57). The null hypothesis was therefore rejected. This implies that the 8-week circuit training programmeme significantly increased muscle strength of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.57 shows the contributing effect size of treatment was 57%.

Table 4.12: Estimated Marginal Means of Treatment on Muscle Strength

			95% Confidence Interval	
Treatment	Mean	Std. Error	Lower Bound	Upper Bound
Control	15.48	0.49	14.49	16.47
Experimental	20.32	0.49	19.33	21.31

Source: Researcher's Fieldwork, 2024.

Table 4.12 shows the estimated marginal means of the effect of the 8-week circuit training programmeme on muscle strength of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. Table 4.12 reveals that the participants exposed to the 8-week circuit training programmeme had a higher muscle strength mean score (20.32) compared to the control (15.48). This implies that the 8-week circuit training programmeme was effective in improving the muscle strength of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State.

H_O2: There is no significant effect of an 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

Table 4.13: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Flexibility

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	130.61	2	65.30	73.35	.00	.80
Intercept	14.22	1	14.22	15.98	.00	.30
Pretest	85.45	1	85.45	95.98	.00	.72
Treatment	40.80	1	40.80	45.83	.00	.55
Error	32.94	37	.89			
Total	438.65	40				
Corrected Total	163.55	39				

Source: Researcher's Fieldwork, 2024.

Table 4.13 shows a significant effect of an 8-week circuit training programmeme on flexibility of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,37)}$=45.83, p<0.05, η^2=0.55). The null hypothesis was therefore rejected. This implied that the 8-week circuit training programmeme significantly increased flexibility of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.55 shows the contributing effect size of treatment was 55%.

Table 4.14: Estimated Marginal Means of Treatment on Flexibility

Treatment	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	1.61	0.21	1.18	2.04
Experimental	3.63	0.21	3.21	4.06

Source: Researcher's Fieldwork, 2024.

Table 4.14 shows the estimated marginal means of the effect of an 8-week circuit training programmeme on flexibility of the academic staff of Bayelsa Medical University, Yenagoa

Bayelsa State. The table reveals that the participants exposed to the 8-week circuit training programmeme had a higher flexibility mean score (3.63) compared to the control (1.63). This implies that the 8-week circuit training programmeme was effective in enhancing the flexibility of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State.

H_O3: There is no significant effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

Table 4.15: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Heart Rate

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	740.62	2	370.31	20.78	.00	.53
Intercept	38.02	1	38.02	2.13	.15	.06
Pretest	229.39	1	229.39	12.87	.00	.26
Treatment	658.18	1	658.18	36.93	.00	.50
Error	659.36	37	17.82			
Total	222071.00	40				
Corrected Total	1399.98	39				

Source: Researcher's Fieldwork, 2024.

Table 4.15 shows a significant effect of an 8-week circuit training programmeme on heart rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,37)}$=36.93, p<0.05, η^2=0.50). The null hypothesis was therefore rejected. This implied that the 8-week circuit training programmeme significantly decreased heart rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.50 shows the contributing effect size of treatment was 50%.

Table 4.16: Estimated Marginal Means of Treatment on Heart Rate

Treatment	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	78.46	.96	76.2	80.41
Experimental	70.09	.96	68.15	72.03

Source: Researcher's Fieldwork, 2024.

Table 4.16 shows the estimated marginal means of the effect of 8-week circuit training programmeme on heart rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The table reveals that the participants exposed to the 8-week circuit training programmeme had a lower heart rate mean score (70.09) compared to the control (78.46). This implies that 8-week circuit training programmeme was effective in lowering the heart rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State.

Table 4.17: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Respiratory Rate

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	256.13	2	128.06	140.30	.00	.88
Intercept	6.25	1	6.25	6.85	.01	.16
Pretest	88.03	1	88.03	96.44	.00	.72
Treatment	134.89	1	134.89	147.78	.00	.80
Error	33.77	37	.91			
Total	11246.00	40				
Corrected Total	289.90	39				

Source: Researcher's Fieldwork, 2024.

Table 4.17 shows a significant effect of an 8-week circuit training programmeme on respiratory rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,37)}$=147.78, p<0.05, η^2=0.80). The null hypothesis was therefore rejected. This implies that the 8-week circuit training programmeme significantly decreased respiratory rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.80 shows the contributing effect size of treatment was 80%.

Table 4.18: Estimated Marginal Means of Treatment on Respiratory Rate

Treatment	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	18.40	0.22	17.9	18.84
Experimental	14.70	0.22	14.263	15.13

Source: Researcher's Fieldwork, 2024.

Table 4.18 shows the estimated marginal means of the effect of 8-week circuit training programmeme on respiratory rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The table reveals that the participants exposed to the 8-week circuit training programmeme had a lower respiratory rate mean score (14.70) compared to the control (18.40). This implies that 8-week circuit training programmeme was effective in lowering the respiratory rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State.

Table 4.19: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Oxygen Saturation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	29.38	2	14.69	131.96	.00	.88
Intercept	.09	1	.09	.77	.39	.02
Pretest	28.48	1	28.48	255.84	.00	.87
Treatment	.90	1	.90	8.09	.01	.18
Error	4.12	37	.11			
Total	378336.00	40				

Corrected Total	33.50	39

Source: Researcher's Fieldwork, 2024.

Table 4.19 shows a significant effect of an 8-week circuit training programmeme on oxygen saturation of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,37)}$=8.09, p<0.05, η^2=0.18). The null hypothesis was therefore rejected. This implies that the 8-week circuit training programmeme significantly influenced oxygen saturation rate of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.18 shows the contributing effect size of treatment was 18%.

Table 4.20: Estimated Marginal Means of Treatment on Oxygen Saturation

			95% Confidence Interval	
Treatment	Mean	Std. Error	Lower Bound	Upper Bound
Control	97.10	.075	96.95	97.25
Experimental	97.40	.075	97.25	97.55

Source: Researcher's Fieldwork, 2024.

Table 4.20 shows the estimated marginal means of the effect of 8-week circuit training programmeme on oxygen saturation of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The table reveals that the participants exposed to the 8-week circuit training programmeme had a higher oxygen saturation mean score (97.40) compared to the control (97.10). This implies that the 8-week circuit training programmeme was effective in improing oxygen saturation level of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State.

H_O4: There is no significant effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State.

Table 4.21: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Body Composition

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.051	2	.026	175.62	.00	.91
Intercept	1.16E-6	1	1.16E-6	.01	.93	.00
Pretest	.049	1	.05	339.63	.00	.90
Treatment	.00	1	.00	14.40	.00	.28
Error	.01	37	.00			
Total	29.88	40				
Corrected Total	.057	39				

Source: Researcher's Fieldwork, 2024.

Table 4.21 shows a significant effect of an 8-week circuit training programmeme on body composition of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,37)}$=14.40, p<0.05, η^2=0.28). The null hypothesis was therefore rejected. This implies that the 8-week circuit training programmeme significantly influenced body composition of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.28 shows the contributing effect size of treatment was 28%.

Table 4.22: Estimated Marginal Means of Treatment on Body Composition

Treatment	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	.87	.00	.8	.88
Experimental	.86	.00	.851	.86

Source: Researcher's Fieldwork, 2024.

Table 4.22 shows the estimated marginal means of the effect of an 8-week circuit training programmeme on body composition of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The table reveals that the participants exposed to the 8-week circuit training programmeme had a lower body composition mean score (0.86) compared to the control (0.87). This implies that 8-week circuit training programmeme was effective in improving the body composition of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State.

H_O5: There is no significant effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

Table 4.23: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Muscle Strength Based on Sex

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1376.39	4	344.10	78.61	.00	.90
Intercept	34.92	1	34.92	7.98	.01	.19
Pretest	634.3	1	634.39	144.93	.00	.81
Treatment	199.62	1	199.62	45.60	.00	.57
Sex	15.82	1	15.82	3.61	.07	.09
Treatment * Sex	6.84	1	6.84	1.56	.22	.04
Error	153.21	35	4.38			
Total	14346.00	40				
Corrected Total	1529.60	39				

Source: Researcher's Fieldwork, 2024.

Table 4.23 shows a no significant interaction effect of an 8-week circuit training programmeme on muscle strength based on sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,35)}$=1.56, p>0.05, η^2=0.04). The null hypothesis was considered tenable. This implies that there is no significant interaction between muscle strength and sex. The eta square value of 0.04 shows the contributing effect size of treatment was 4%.

Table 4.24: Estimated Marginal Means of Treatment on Muscle Strength Based on Sex

Treatment	Sex	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	Male	16.26	0.59	15.05	17.46

	Female	13.46	1.06	11.32	15.60
Experimental	Male	20.45	0.54	19.35	21.55
	Female	19.60	1.01	17.55	21.66

Source: Researcher's Fieldwork, 2024.

Table 4.24 shows that the male participants in the control group had a higher muscle strength mean score (16.26) compared to their female (13.46) counterpart. In the experimental group, the male participant had a higher muscle strength mean score (20.45) compared to their female (19.60) counterpart, though the value did not attain significant level based on sex.

HO6: There is no significant effect an of an 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

Table 4.25: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Flexibility Based on Sex

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	130.97	4	32.74	35.18	.00	.80
Intercept	13.77	1	13.77	14.79	.00	.30
Pretest	71.88	1	71.88	77.22	.00	.69
Treatment	27.43	1	27.43	29.47	.00	.46
Sex	.03	1	.0	.03	.86	.00
Treatment * Sex	.33	1	.33	.35	.56	.01
Error	32.58	35	.93			
Total	438.65	40				
Corrected Total	163.55	39				

Source: Researcher's Fieldwork, 2024.

Table 4.25 shows a no significant interaction effect of an 8-week circuit training programmeme on flexibility based on sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,35)}$=0.35, p>0.05, η^2=0.01). The null hypothesis was tenable. This implies that there is no significant interaction between flexibility and sex. The eta square value of 0.01 shows the contributing effect size of treatment was 1%.

Table 4.26: Estimated Marginal Means of Treatment on Flexibility Based on Sex

Treatment	Sex	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	Male	1.58	.25	1.07	2.09
	Female	1.72	.45	.80	2.63
Experimental	Male	3.70	.25	3.19	4.21
	Female	3.42	.44	2.53	4.32

Source: Researcher's Fieldwork, 2024.

Table 4.26 shows that the male participants in the control group had a lower mean score (1.58) compared to their female (1.72) counterpart. In the experimental group, the male participants had a higher mean score (3.70) and compared to their female (3.42) counterpart, though the value did not attain significant level based on sex.

H$_O$7: There is no significant effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

Table 4.27: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Heart Rate Based on Sex

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	766.01	4	191.50	10.57	.00	.55
Intercept	59.61	1	59.61	3.29	.08	.09
Pretest	140.04	1	140.04	7.73	.01	.18
Treatment	488.12	1	488.12	26.95	.00	.44
Sex	25.29	1	25.29	1.40	.25	.04

Treatment * Sex	.16	1	.16	.01	.93	.00
Error	633.96	35	18.11			
Total	222071.00	40				
Corrected Total	1399.98	39				

Source: Researcher’s Fieldwork, 2024.

Table 4.27 shows a no significant interraction effect of 8-week circuit training programmeme on heart rate based on sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,35)}$=0.01, p>0.05, η^2=0.00). The null hypothesis was tenable. This implies that there is no significant interaction between heart rate and sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.00 shows the contributing effect size of treatment was 0%.

Table 4.28: Estimated Marginal Means of Treatment on Heart Rate Based on Sex

Treatment	Sex	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	Male	77.84	1.16	75.48	80.19
	Female	79.99	1.94	76.05	83.92
Experimental	Male	69.71	1.10	67.48	71.95
	Female	71.57	2.01	67.49	75.66

Source: Researcher’s Fieldwork, 2024.

Table 4.28 shows that the male participants in the control group had a lower mean score (77.84) compared to their female (79.99) counterpart. In the experimental group, the male participants had a lower mean score (69.71) compared to their female (71.57) counterpart.

Table 4.29: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Respiratory Rate Based on Sex

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	258.56	4	64.64	72.20	.00	.89
Intercept	3.25	1	3.25	3.63	.07	.09
Pretest	87.73	1	87.73	97.98	.00	.74

Treatment	113.21	1	113.21	126.45	.00	.78
Sex	1.29	1	1.29	1.44	.24	.04
Treatment * Sex	1.25	1	1.25	1.40	.25	.04
Error	31.34	35	.90			
Total	11246.00	40				
Corrected Total	289.90	39				

Source: Researcher's Fieldwork, 2024.

Table 4.29 shows a no significant interaction effect of 8-week circuit training programmeme on respiratory rate based on sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,35)}$=1.40, p>0.05, η^2=0.04). The null hypothesis was tenable. This implies that there is no significant interaction between respiratory rate and sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.04 shows the contributing effect size of treatment was 4%.

Table 4.30: Estimated Marginal Means of Treatment on Respiratory Rate Based on Sex

Treatment	Sex	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	Male	18.40	.24	17.90	18.90
	Female	18.38	.43	17.51	19.25
Experimental	Male	14.92	.25	14.41	15.43
	Female	14.08	.43	13.20	14.95

Source: Researcher's Fieldwork, 2024.

Table 4.30 shows that the male participants in the control group had a higher respiratory rate mean score (18.40) compared to their female (18.38) counterpart. In the experimental group, the male participants had a higher mean score (14.92) compared to their female (14.08) counterpart.

Table 4.31: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Oxygen Saturation Based on Sex

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	29.90	4	7.48	72.71	.00	.89
Intercept	.00	1	.00	.01	.91	.00

Pretest	24.94	1	24.94	242.53	.00	.87
Treatment	.30	1	.30	2.87	.10	.08
Sex	.26	1	.26	2.48	.12	.07
Treatment * Sex	.30	1	.30	2.92	.10	.08
Error	3.60	35	.10			
Total	378336.00	40				
Corrected Total	33.50	39				

Source: Researcher's Fieldwork, 2024.

Table 4.31 shows a no significant interaction effect of 8-week circuit training programmeme on oxygen saturation based on sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,35)}$=2.92, p>0.05, η^2=0.08). The null hypothesis was tenable. This implies that there is no significant interaction between oxygen saturation and sex of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.08 shows the contributing effect size of treatment was 8%.

Table 4.32: Estimated Marginal Means of Treatment on Oxygen Saturation Based on Sex

				95% Confidence Interval	
Treatment	Sex	Mean	Std. Error	Lower Bound	Upper Bound
Control	Male	97.10	.08	96.93	97.27
	Female	97.10	.15	96.80	97.39
Experimental	Male	97.50	.09	97.33	97.68
	Female	97.09	.16	96.78	97.41

Source: Researcher's Fieldwork, 2024.

Table 4.32 shows that the male and female participants in the control group had equal oxygen saturation mean score (97.10). In the experimental group, the male participants had a higher oxygen saturation mean score (97.50) compared to their female (97.09) counterpart.

H_O8: There is no significant effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on sex.

Table 4.33: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Body Composition Based on Sex

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.05	4	.01	87.41	.00	.91
Intercept	6.34E-5	1	6.34E-5	.43	.52	.01
Pretest	.03	1	.03	217.20	.00	.86
Treatment	.0	1	.00	9.78	.00	.22
Sex	.00	1	.00	1.49	.23	.04
Treatment * Sex	1.22E-5	1	1.22E-5	.08	.78	.00
Error	.01	35	.00			
Total	29.88	40				
Corrected Total	.06	39				

Source: Researcher's Fieldwork, 2024.

Table 4.33 shows a no significant interaction effect of 8-week circuit training programmeme on body composition based on sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(1,35)}$=0.08, p>0.05, η^2=0.00). The null hypothesis was tenable. This implies that there is no significant interaction between body composition and sex of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.00 shows the contributing effect size of treatment was 0%.

Table 4.34: Estimated Marginal Means of Treatment on Body Composition Based on Sex

Treatment	Sex	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	Male	.87	.00	.86	.88
	Female	.88	.01	.86	.89
Experimental	Male	.85	.00	.85	.86
	Female	.86	.01	.85	.87

Source: Researcher's Fieldwork, 2024.

Table 4.34 shows that both the male participants in the control group had lower body composition mean score of 0.87 compared to their female counterparts (0.88). In the experimental group, the male participants had a lower body composition mean score (0.85) compared to their female (0.86) counterpart.

H$_O$9: There is no significant effect of an 8-week circuit training programmeme on muscle strength of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

Table 4.35: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Muscle Strength Based on Age

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1405.33	8	175.67	43.82	.00	.92
Intercept	11.44	1	11.44	2.85	.10	.08
Pretest	561.90	1	561.90	140.17	.00	.82
Treatment	168.62	1	168.62	42.06	.00	.58
Age	28.11	3	9.37	2.34	.09	.18
Treatment * Age	23.31	3	7.77	1.94	.14	.16

Error	124.27	31	4.01
Total	14346.00	40	
Corrected Total	1529.60	39	

Source: Researcher's Fieldwork, 2024.

Table 4.35 shows a no significant interaction effect of 8-week circuit training programmeme on muscle strength based on age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(3,31)}$=1.94, p>0.05, η^2=0.16). The null hypothesis was tenable. This implies that there is no significant interaction between muscle strength and age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.16 shows the contributing effect size of treatment was 16%.

Table 4.36: Estimated Marginal Means of Treatment on Muscle Strength Based on Age

				95% Confidence Interval	
Treatment	Age (Years)	Mean	Std. Error	Lower Bound	Upper Bound
Control	25-34	14.06	1.20	11.60	16.51
	35-44	15.93	.78	14.33	17.53
	45-54	15.56	.82	13.89	17.24
	55-64	15.68	1.31	13.01	18.36
Experimental	25-34	20.49	1.43	17.58	23.40
	35-44	21.55	.69	20.14	22.96
	45-54	17.65	1.00	15.61	19.70
	55-64	20.09	1.09	17.87	22.30

Source: Researcher's Fieldwork, 2024.

Table 4.36 shows that the participants in age group 25-34, 35-44, 45- 54, 55-64 had mean muscle strength score of 14.06, 15.93, 15.56 and 15.68 respectively in the control group. In the experimental group, participants in age group 25-34, 35-44, 45- 54, 55-64 had mean muscle strength score mean score of 20.49, 21.55, 17.65 and 20.09 respectively. Table 4.3.26 shows that the participants in the control group between ages 25-34 had the lowest mean muscle strength score (14.06), while those in the experimental group between ages 35-44 had the highest mean muscle strength score (21.55).

H_O10: There is no significant effect an of 8-week circuit training programmeme on flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

Table 4.37: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Flexibility Based on Age

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	146.17	8	18.27	32.59	.00	.89
Intercept	15.84	1	15.84	28.26	.00	.48
Pretest	20.33	1	20.33	36.26	.00	.54
Treatment	38.25	1	38.25	68.23	.00	.69
Age	7.28	3	2.43	4.33	.01	.30
Treatment * Age	6.96	3	2.32	4.14	.01	.29
Error	17.38	31	.56			
Total	438.65	40				
Corrected Total	163.55	39				

Source: Researcher's Fieldwork, 2024.

Table 4.37 shows a significant interaction effect of 8-week circuit training programmeme on flexibility based on age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(3,31)}$=4.14, p<0.05, η^2=0.29). The null hypothesis was therefore rejected. This implies that there is a significant interaction between flexibility and age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.29 shows the contributing effect size of treatment was 29%.

Table 4.38: Estimated Marginal Means of Treatment on Flexibility Based on Age

Treatment	Age (Years)	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	25-34	1.63	.44	.74	2.52

	35-44	1.71	.31	1.09	2.33
	45-54	1.52	.34	.82	2.22
	55-64	1.46	.48	.49	2.42
Experimental	25-34	4.66	.53	3.57	5.75
	35-44	3.93	.31	3.31	4.55
	45-54	4.47	.40	3.66	5.28
	55-64	2.05	.40	1.25	2.86

Source: Researcher's Fieldwork, 2024.

Table 4.38 shows that the participants in age group 25-34, 35-44, 45- 54, 55-64 had mean score of 1.63, 1.71, 1.52 and 1.46 respectively in the control group. In the experimental group, participants in age group 25-34, 35-44, 45- 54, 55-64 had mean score mean score of 4.66, 3.93, 4.47 and 2.05 respectively. Table 4.3.28 shows that the participants in the control group between ages 55-64 had the lowest mean flexibility score (1.46), while those in the experimental group between ages 25-34 had the highest mean flexibility score (4.66).

H$_O$11: There is no significant effect of an 8-week circuit training programmeme on cardiorespiratory fitness of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

Table 4.39: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Heart Rate Based on Age

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	854.07	8	106.76	6.06	.00	.61
Intercept	53.39	1	53.39	3.03	.09	.09
Pretest	67.35	1	67.35	3.83	.06	.11
Treatment	481.48	1	481.48	27.34	.00	.46

Age	73.56	3	24.52	1.39	.26	.12
Treatment * Age	32.1	3	10.71	.61	.62	.06
Error	545.906	31	17.61			
Total	222071.00	40				
Corrected Total	1399.98	39				

Source: Researcher's Fieldwork, 2024.

Table 4.39 shows a no significant interaction effect of 8-week circuit training programmememe on heart rate based on age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(3,31)}$=0.61, p>0.05, η^2=0.06). The null hypothesis was tenable. This implies that there is no significant interaction between heart rate and age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.06 shows the contributing effect size of treatment was 6%.

Table 4.40: Estimated Marginal Means of Treatment on Heart Rate Based on Age

				95% Confidence Interval	
Treatment	Age (Years)	Mean	Std. Error	Lower Bound	Upper Bound
Control	25-34	75.21	3.02	69.04	81.37
	35-44	78.21	1.53	75.09	81.32
	45-54	78.90	1.76	75.31	82.48
	55-64	80.48	2.46	75.46	85.50
Experimental	25-34	69.60	3.16	63.17	76.04
	35-44	69.71	1.41	66.83	72.59
	45-54	67.68	2.20	63.19	72.18
	55-64	73.51	1.93	69.58	77.45

Source: Researcher's Fieldwork, 2024.

Table 4.40 shows that the participants in age group 25-34, 35-44, 45- 54, 55-64 had mean heart rate score of 75.21, 78.21, 78.90 and 80.48 respectively in the control group. In the experimental group, participants in age group 25-34, 35-44, 45- 54, 55-64 had mean heart rate score of 69.60, 69.71, 67.68 and 73.51 respectively. Table 4.3.30 shows that the participants in the control group between ages 55-64 had the highest mean heart rate score (80.48), while those in the experimental group between ages 25-34 had the lowest mean heart rate score (69.60).

Table 4.41: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Respiratory Rate Based on Age

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	264.10	8	33.01	39.67	.00	.91
Intercept	9.93	1	9.93	11.93	.00	.28
Pretest	28.39	1	28.39	34.12	.00	.52
Treatment	109.21	1	109.21	131.23	.00	.81
Age	5.04	3	1.68	2.02	.13	.16
Treatment * Age	2.51	3	.84	1.00	.40	.09
Error	25.80	31	.83			
Total	11246.00	40				
Corrected Total	289.90	39				

Source: Researcher's Fieldwork, 2024.

Table 4.41 shows a no significant interaction effect of 8-week circuit training programmeme on respiratory rate based on age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(3,31)}$=1.00, p>0.05, η^2=0.09). The null hypothesis was tenable. This implies that there is no significant interaction between respiratory rate and age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.09 shows the contributing effect size of treatment was 9%.

Table 4.42: Estimated Marginal Means of Treatment on Respiratory Rate Based on Age

Treatment	Age (Years)	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	25-34	17.39	.56	16.25	18.52
	35-44	18.28	.32	17.62	18.94
	45-54	18.77	.39	17.98	19.55

	55-64	19.29	.56	18.16	20.42
Experimental	25-34	14.53	.70	13.11	15.95
	35-44	14.42	.34	13.73	15.11
	45-54	14.17	.46	13.23	15.11
	55-64	15.53	.46	14.58	16.47

Source: Researcher's Fieldwork, 2024.

Table 4.42 shows that the participants in age group 25-34, 35-44, 45- 54, 55-64 had mean respiratory rate score of 17.39, 18.28, 18.77 and 19.29 respectively in the control group. In the experimental group, participants in age group 25-34, 35-44, 45- 54, 55-64 had mean respiratory rate score of 14.53, 14.42, 14.17 and 15.53 respectively. Table 4.3.32 shows that the participants in the control group between ages 55-64 had the highest mean respiratory rate score (19.29), while those in the experimental group between ages 25-34 had the lowest mean respiratory rate score (14.17).

Table 4.43: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Oxygen Saturation Based on Age

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	29.58	8	3.70	29.27	.00	.88
Intercept	.04	1	.04	.28	.60	.01

Pretest	14.59	1	14.59	115.48	.00	.79
Treatment	.49	1	.49	3.87	.06	.11
Age	.07	3	.02	.18	.91	.02
Treatment * Age	.15	3	.05	.40	.76	.04
Error	3.92	31	.13			
Total	378336.00	40				
Corrected Total	33.50	39				

Source: Researcher's Fieldwork, 2024.

Table 4.43 shows a no significant interaction effect of 8-week circuit training programmeme on oxygen saturation based on age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(3,31)}$=0.40, p>0.05, η^2=0.04). The null hypothesis was tenable. This implies that there is no significant interaction between oxygen saturation and age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.04 shows the contributing effect size of treatment was 4%.

Table 4.44: Estimated Marginal Means of Treatment on Oxygen Saturation Based on Age

				95% Confidence Interval	
Treatment	Age (Years)	Mean	Std. Error	Lower Bound	Upper Bound
Control	25-34	97.16	.23	96.68	97.63
	35-44	97.11	.13	96.85	97.37
	45-54	97.09	.15	96.79	97.39
	55-64	97.05	.23	96.59	97.51
Experimental	25-34	97.14	.26	96.60	97.68
	35-44	97.45	.12	97.20	97.70
	45-54	97.35	.18	96.98	97.71
	55-64	97.46	.18	97.10	97.82

Source: Researcher's Fieldwork, 2024.

Table 4.44 shows that the participants in age group 25-34, 35-44, 45- 54, 55-64 had mean oxygen saturation score of 97.16, 97.11, 97.09 and 97.05 respectively in the control group. In the experimental group, participants in age group 25-34, 35-44, 45- 54, 55-64 had mean oxygen saturation score of 97.14, 97.45, 97.35 and 97.46 respectively. Table 4.3.34 shows that the participants in the control group between ages 55-64 had the lowest mean oxygen saturation score (97.05), also those in the experimental group between ages 55-64 had the highest mean oxygen saturation score (97.46).

H_O12: There is no significant effect of an 8-week circuit training programmeme on body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State based on age.

Table 4.45: Summary of Analysis of Covariance of Effect of an 8-week Circuit Training Programmeme on Body Composition Based on Age

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.05[a]	8	.01	49.24	.00	.93
Intercept	6.92E-6	1	6.92E-6	.05	.82	.00
Pretest	.05	1	.05	358.55	.00	.92
Treatment	.00	1	.00	15.81	.00	.34
Age	.00	3	.00	2.46	.08	.19
Treatment * Age	.00	3	.00	1.09	.37	.10
Error	.00	31	.00			
Total	29.88	40				
Corrected Total	.06	39				

Source: Researcher's Fieldwork, 2024.

Table 4.45 shows a no significant interractioneffect of 8-week circuit training programmeme on body composition based on age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State ($F_{(3,31)}$=1.09, p>0.05, η^2=0.10). The null hypothesis was tenable. This implies that there is no significant interaction between body composition and age of the academic staff of Bayelsa Medical University, Yenagoa Bayelsa State. The eta square value of 0.10 shows the contributing effect size of treatment was 10%.

Table 4.46: Estimated Marginal Means of Treatment on Body Composition Based on Age

Treatment	Age (Years)	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Control	25-34	.88	.007	.861	.888
	35-44	.87	.004	.862	.878
	45-54	.87	.005	.858	.878
	55-64	.88	.007	.861	.888
Experimental	25-34	.86	.008	.844	.878
	35-44	.86	.004	.852	.868
	45-54	.84	.006	.829	.853
	55-64	.86	.005	.849	.870

Source: Researcher's Fieldwork, 2024.

Table 4.46 shows that the participants in age group 25-34, 35-44, 45- 54, 55-64 had mean body composition score of 90.88, 0.87, 0.87 and 0.88 respectively in the control group. In the experimental group, participants in age group 25-34, 35-44, 45- 54, 55-64 had mean body composition score of 0.86, 0.86, 0.84 and 0.86 respectively. Table 4.3.36 shows that the participants in the control group between ages 25-34 and 55-64 had the highest mean body composition score (0.88), while those in the experimental group between ages 45-54 had the lowest mean body composition score (0.84).

4.3 Discussion of Findings

The findings of this study on socio-demographic characteristics revealed that most (75.0%) of the participants were male. Similarly, it was shown that, most (42.5%) of the participants were in the age range of 35-44 years. This study reveals that academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria had pre-field mean muscle strength of 15.93±0.91, with 8 participant (20.0%) muscle strength of 20.00 per 30 seconds. The study also shows mean flexibility of 1.56±0.22 with majority (20.0%) of the participants having flexibility of 1.56±0.10cm, heart rate (bpm) of 77.65±0.58 with majority (27.5%) of the participants having heart rate of 78bpm, respiratory rate (bpm) of 18.18±0.33 with majority (27.5%) of the participants having respiratory rate of 20bpm, oxygen Saturation (%) of 97.1±

0.14 with majority (50.0%) of the participants having oxygen saturation of 97%, and body composition of 0.87±0.01 with majority (15.0%) of the participants having body composition of 0.84. The findings of the study is in agreement with similarstudies which reported similar values for muscle strength, flexibility, heart rate, respiratory rate, oxygen saturation, and body compostion[1, 2, 3, 4].

The result from this study revealed a significant effect of circuit training on muscle strength of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria. The significant increase in muscle strength in experimental group when compared to control group shows that circuit training might have caused hypertrophy or enlargement of cells as a result of enhanced muscle protein synthesis and incorporation of proteins into cells enabling muscles to exhibit greater strength. It may also be due to neural adaptations that enhance nerve muscle interaction which aids the recruitment of more muscle fibres and power strokes in a simultaneous manner[5, 6].The finding of this study is in agreement with previous studies, which reported a significant increase in muscle strength following circuit training[7, 8, 9].

The result from this study revealed a significant effect of circuit training on flexibility of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria. This indicates that circuit training may have resulted in an increased range of motion of the harmstrings, increased elasticity of the non-contractile viscoelastic component of muscles and joints, improved hamstring muscle strength, resulting in improved performance and reduced injury risk[10, 11, 12].The finding of this study is in agreement with previous studies, which reported a significant increase in flexibility following circuit training[13, 14, 15, 16].

The result from this study revealed a significant effect of circuit training on heart rate of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria. The significant decrease in heart rate in experimental group when compared to control group shows that circuit training might have caused stronger heart, aiding pumping of blood with less effort. Or by increasing contractile strength and the length of time the heart fills with blood which results from an increase in the activity of the parasympathetic nervous system and decrease in activity of sympathetic nervous system[17, 18]. The finding of this study is in agreement with a previous study, which reported a significant decrease in heart rate following circuit training[19]. The result from this study revealed a significant effect of circuit training on respiratory rate of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria. The significant reduction in respiratory rate in the experimental group compared to the control group suggests that circuit training may have generated mitochondrial energy adaptation via changing mitochondrial respiratory capacity, protein translation, and protein complex formation[20].The finding of this study is in agreement with a previous study, which reported a significant decrease in respiratory rate following circuit training[19]. The result from this study revealed a significant effect of circuit training on oxygen saturation of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria. The significant increase in oxygen saturation in experimental group when compared to control group might have been caused by the maintenance of haemoglobin in arterial blood, as well as its passage through the capillaries[21]. The finding of this study is in agreement with previous study, which reported a significant improvement in oxygen saturation following circuit training[19].

The result from this study revealed a significant effect of circuit training on body composition of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria. The significant decrease in body composition in experimental group when compared to control group might have been caused by the the reduction of percentage of fat mass following circuit training[22, 23, 24, 25]. The finding of this study is in agreement with previous study, which reported a significant decrease in body composition following circuit training[22, 23, 24, 25].

This study found no significant effect of the circuit training programmeme on muscle strength of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex, implying that males and females adapted to the 8-week circuit training with similar effect sizes for hypertrophy and upper-body strength[26]. The findings of this study are in agreement with previous studies that found no significant interaction of treatment and sex on muscle strength[26]. This study found that the male participants in the control group had a higher mean score compared to their female counterparts, implying that the interaction of treatment and sex had a better effect on the muscle strength of the male participants exposed to an 8-week circuit training programmeme than their female counterparts. In the experimental group, the male participants had a higher mean score compared to their female counterparts, implying that the interaction of treatment and sex had a better effect on the muscle strength of the male participants in the experimental group than their female counterpart. The comparison shows that male participants in the experimental group had the highest mean score, signifying a better effect of the 8-week circuit training programmeme[27, 28]. The higher muscle strength mean score in males in the experimental group could be due to development of larger fast-twitch fibres[26]. The finding of this study is in agreement with previous study that reported higher improved muscle strength following exercise in both males and females, but with the highest improvement in females[26].

This study found no significant effect of circuit training programmeme on flexibility of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex, implying that males and females adapted to the 8-week circuit training with similar effect sizes for flexibility[29]. The findings of this study are in agreement with previous studies that found no significant interaction of treatment and sex on flexibility[29]. This study found that the male participants in the control group had a lower mean flexibility score compared to their female counterpart, implying that the interaction of treatment and sex had a better effect on the flexibility of the female participants exposed to treatment than their male counterpart. In the experimental group, the male participants had a higher mean score and compared to their female counterparts, implying that the interaction of treatment and sex had a better effect on the flexibility of the male participants in the experimental group than their female counterpart. The comparison shows that male participants in the experimental group had the highest mean score, signifying a better effect of 8-week circuit training programmeme. The increased mean flexibility score of males in the experimental group could be due to improvement in the makeup of connective tissues of the participants following the circuit training programmeme[28]. The findings of this study are in agreement with similar studies which reported an improvement in the flexibility of males and females, with a higher improvement in males[28, 29].

This study found no significant effect of circuit training programmeme on heart rate of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex, implying that males and females adapted to the 8-week circuit training with similar effect sizes for heart rate[30]. The findings of this study are in agreement with similar studies that found no significant interaction of treatment and sex on cardiorespiratory fitness[30]. This study found that the male participants in the control group had a lower mean heart rate score compared to their female counterpart, implying that the interaction of treatment and sex had a better effect on the heart rate of the male participants exposed to treatment than their female counterpart. In the experimental group, the male participants had a lower mean score compared to their female counterparts, implying that the interaction of treatment and sex had a better effect on the heart rate of the male participants in the experimental group than their female counterparts. The comparison shows that male participants in the experimental group had the lowest mean score, signifying a better interaction effect of treatment. This could be possible because men have larger hearts, greater stroke volumes, higher haemoglobin levels, and increased vagal tone compared to women, possibly due to variations in body size and composition, hormone differences, and increased vagal tone[31]. The findings of this study are in agreement with similar studies which reported a decrease in the heart rate of males and females following exercise programmemes[28, 32]. This study found no significant effect of circuit training programmeme on respiratory rate of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex, implying that males and females adapted to the 8-week circuit training with similar effect sizes for respiratory rate. The findings of this study are in agreement with previous studies that found no significant interaction of treatment and sex on cardiorespiratory fitness[30]. This study found that the male participants in the control group had a higher mean score compared to their female counterparts, implying that the interaction of treatment and sex had a better effect on the respiratory rate of the female participants exposed to treatment than their male counterparts. In the experimental group, the male participants had a higher mean score compared to their female counterparts, implying that the interaction of treatment and sex had a better effect on the respiratory rate of the female participants in the experimental group than their male counterparts. The comparison shows that female participants in the experimental group had the lowest mean score, signifying a better effect of 8-week circuit training programmeme. This could be due to women's reliance on fat metabolism during exercise which may result in smaller lungs due to reduced carbon dioxide production. They may also exhibit different breathing patterns, favoring slower, deeper breaths to meet oxygen demands, potentially reducing their respiratory rate[33, 34].

The finding of this study is consistent with previous study that reported a decrease in male and female cardiorespiratory variables[35]. This study found no significant effect of circuit training programmeme on oxygen saturation of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex, implying that males and females adapted to 8-week circuit training with similar effect sizes for oxygen saturation. The findings of this study are in agreement with previous studies that found no significant interaction of treatment and sex on cardiorespiratory fitness[30]. This study found that the male and female participants in the control group had an equal mean score (97.10), implying that the interaction of treatment and sex had an equal effect on the oxygen saturation of the male and female participants. In the experimental group, the male participants had a higher mean score (97.50) compared to their female (97.09) counterpart. This implies that the interaction of treatment and sex had a better effect on the oxygen saturation of the male participants in the experimental group than their male counterpart. The comparison shows that male participants in the experimental group had the highest mean score, signifying a better effect of 8-week circuit training programmeme followed by female participants in the same group. This may be due to men having higher hemoglobin levels, larger lung volumes, and better matching of ventilation and perfusion due to differences in body size and anatomy compared to women[36]. The finding of this study is consistent with similar study that reported increase in cardiorespiratory variables such as maximum oxygen uptake[35].

This study found no significant effect of circuit training programmeme on body composition of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex, implying that males and females adapted to the 8-week circuit training with similar effect sizes for body composition[29]. The findings of this study are in agreement with previous studies that found no significant interaction of treatment and sex on body composition[29]. This study found that the male participants in the control group had lower mean body composition score compared to their female counterpart, implying that the interaction of treatment and sex had a greater effect on the body composition of the male participants than female participants. In the experimental group, the male participants had a lower mean body composition score compared to their female counterpart. This implies that the interaction of treatment and sex had a better effect on the body composition of the male participants in the experimental group than their female counterpart. This may be due to men having a higher proportion of muscle mass than women, which can be increased through sub-chronic exercise training. This can lead to increased metabolic rate, which can reduce body fat percentage. Hormonal variations, like higher testosterone levels in men, can also influence body composition, promoting lean muscle mass and reducing body fat[37]. The finding of this study is consistent with previous study that reported decrease in body composition in males and females[35].

This study found no significant effect of circuit training programmeme on muscle strength of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age, implying that all age groups adapted to the 8-week circuit training with similar effect sizes for muscle strength. The findings of this study are in agreement with previous studies that found no significant interaction of treatment and sex on muscle strength. The study shows that the participants in age group 35-44 had the highest muscle strength mean score (15.93) in the control group. In the experimental group, participants in age group 35-44 had the highest muscle strength mean score (21.55). The overall comparison showed that the participants in the experimental group had a better muscle strength mean score in age range 35-44. The finding of this study is consistent with similar study that reported an improvement in muscle strength regardless of age group[29].

This study found a significant effect of the circuit training programmeme on flexibility of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age, implying that age groups adapted to the 8-week circuit training with different effect sizes for flexibility. The findings of this study are in contrast with similar studies that found no significant interaction between treatment and age on flexibility[29]. The result of this study shows that the participants in the age group 35-44 had the highest mean flexibility score (1.71) in the control group. In the experimental group, participants in the age group 45-54 had the highest mean flexibility score (4.47). The overall comparison showed that the participants in the experimental group had an improved mean flexibility score in the age range of 45-54. The findings of this study are consistent with similar studies that reported an improvement in muscle strength regardless of age group[29].

This study found no significant effect of the circuit training programmeme on heart rate of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age, implying that age groups adapted to the 8-week circuit training with similar effect sizes for heart rate. Insufficient evidence was available to ascertain the interaction effect of treatment and age on heart rate. The result of this study shows that the participants in the age group 25-34 had the lowest mean score (75.21) in the control group. In the experimental group, participants in the age group 25-34 had the lowest mean score (69.60). The overall comparison showed that the participants in the experimental group had a better mean score in age range 25-34. The findings of this study are consistent with similar studies that reported a decrease in heart rate regardless of age group[38]. This study found no significant effect of the circuit training programmeme on respiratory rate of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age, implying that age groups adapted to the 8-week circuit training with similar effect sizes for respiratory rate. There was insufficient evidence to determine the interaction effect of treatment and age on respiratory rate. The result of this study shows that the participants in the age group 25-34 had the lowest mean respiratory rate score (17.39) in the control group. In the experimental group, participants in the age group (45-54) had the lowest mean score (14.17). The overall comparison showed that the participants in the experimental group had a better mean respiratory rate score in the age range 45-54. The findings of this study are consistent with similar studies that reported a decrease in cardiorespiratory fitness regardless of age group[38]. This study found no significant effect of circuit training programmeme on oxygen saturation of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age, implying that age groups adapted to the 8-week circuit training with similar effect sizes for oxygen saturation. There was insufficient evidence to determine the interaction effect of treatment and age on oxygen saturation. The results of this study show that the participants in the age group 25-34 had the highest mean oxygen saturation score (97.16) in the control group. In the experimental group, participants in age group 55-64 had the highest mean oxygen saturation score (97.46). The overall comparison showed that the participants in the experimental group had a better mean oxygen saturation score in the age range of 55-64. The findings of this study are consistent with similar studies that reported an improvement in cardiorespiratory fitness regardless of age group[30].

This study found no significant effect of the circuit training programmeme on body composition of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age, implying that age groups adapted to the 8-week circuit training with similar effect sizes for body composition. There was insufficient evidence to determine the interaction effect of treatment and age on body composition. The results of this study show that the participants in age groups 35-44 and 45-54 had the lowest mean body composition score (0.87) in the control group. In the experimental group, participants in the age group 45-54 had the lowest mean body composition score (0.84). The overall comparison showed that the participants in the experimental group had a better mean body composition score in the age range of 45-54. The findings of this study are consistent with similar studies that reported a decrease in body composition regardless of age group[29, 39].

Endnotes

1 V. A. Mohammed, M. A. Mohammed, M. A. Mohammed, J. Logeshwaran, & N. Jiwani, *Machine Learning-based Evaluation of Heart Rate Variability Response in Children with Autism Spectrum Disorder*, ***In 2023 Third International Conference on Artificial Intelligence and Smart Energy (ICAIS)***, 2023, 1022-1028.

2 N. Rashid, M. M. Rahman, T. Ahmed, J. Kuang, & J. A. Gao, *Breathie: Estimating Breathing Inhale Exhale Ratio using Motion Sensor Data from Consumer Earbuds*, ***In ICASSP 2023-***

2023 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2023, 1-5.

3 M. M. Khan, T. M. Alanazi, A. A. Albraikan, & F. A. Almalki, *IoT-based Health Monitoring System Development and Analysis*, **Security and Communication Networks**, 2022.

4 C. Perez-Rodrigo, M. G. Citores, G. H. Bárbara, & J. Aranceta-Bartrina, *Prevalence of Obesity and Abdominal Obesity in Spanish Population Aged 65 Years and Over: ENPE Study*, **Medicina Clínica**,158 (2), 2022, 49-57.

5 J. Park, V. Mcllvain, J. Rosenberg, L. Donovan, P. Desai, & J. Y. Kim, *From Barbells to Brawns: The Physiology of Resistance Exercise and Skeletal Muscle Growth*, **The Korean Journal of Sports Medicine**, 40 (3), 2022, 151-169.

6 R. Furrer, J. A. Hawley, & C. Handschin, *The Molecular Athlete: Exercise Physiology from Mechanisms to Medals*, **Physiological Reviews**, 2023.

7 S. Rathinakamalan, & G. Abraham, *Effect of Circuit Training on Strength endurance among Players of Different Team Games*, **Journal of Xi'an University of Architecture and Technology**, 13 (2), 2021, 364-371.

8 S. Nugroho, A. Nasrulloh, T. H. Karyono, R. Dwihandaka, & K. W. Pratama, *Effect of Intensity and Interval Levels of Trapping Circuit Training on the Physical Condition of Badminton Players*, **Journal of Physical Education & Sport**, 21, 2021, 1981-1987.

9 P. J. Marcos-Pardo, F. J. Orquin-Castrillón, G. M. Gea-García, R. Menayo-Antúnez, N. González-Gálvez, R. G. D. S. Vale, & A. Martínez-Rodríguez, *Effects of a Moderate-to-High Intensity Resistance Circuit Training on Fat Mass, Functional Capacity, Muscular Strength, and Quality of Life in Elderly: A Randomized Controlled Trial*, **Scientific Reports**, 9 (1), 2019, 7830.

10 F. Ballantyne, G. Fryer, & P. McLaughlin, *The Effect of Muscle Energy Technique on Hamstring Extensibility: The Mechanism of Altered Flexibility*, **Journal of Osteopathic Medicine**, 6 (2), 2003, 59-63.

11 R. Kompal, S. Ul-Islam, U. Bhatti, K. Tahir, R. Noor, & M. Kashif, *Effects of Static Stretch Versus Hold Relax in Improving Flexibility of Tight Hamstrings*, **Rehman Journal of Health Sciences**, 4 (1), 2022, 36-40.

12 A. F. Widodo, C. W. Tien, C. W. Chen, & S. C. Lai, *Isotonic and Isometric Exercise Interventions Improve the Hamstring Muscles' Strength and Flexibility: A Narrative Review*, **In Healthcare**, 10 (5), 2022, 811).

13 I. Ullah, R. Gul, A. Muhammad, & K. Usman, *Effect of Circuit Training upon Flexibility among Non-athletes of College Students*, **Al-Qantara**, 8 (2), 2022, 227-241.

14 J. Anitha, P. Kumaravelu, C. Lakshmanan, & K. Govindasamy, *Effect of Plyometric Training and Circuit Training on Selected Physical and Physiological Variables among Male Volleyball Players*, **International Journal of Yoga, Physiotherapy & Physical Education**, 3 (4), 2018, 26-32.

15 R. Setyawan, H. Setijono, & N. W. Kusnanik, *The Effect of Floor and Swiss Ball Exercises Using Circuit Training Methods towards Balance, Strength, Flexibility and Muscle Endurance*, **Britain International of Humanities & Social Sciences (BIoHS) Journal**, 3 (2), 2021, 384-395.

16 K. V. Shejin, & T. Vivekanandhan, *Effect of Circuit Training on Obesity, Vital Capacity and Flexibility among School Going Obese Children*, **International Journal of Sports Sciences & Fitness**, 10 (2), 2020.

17 I. Naureen, A. Saleem, & M. Naeem, *Effect of Exercise and Obesity on Human Physiology*, **Sch Bull**, 8 (1), 2022, 17-24.

18 D. M. Khalif, & H. A. Abdulkadhim, *The Effect of Aerobic Exercise Hypo Plank on Some Functional Variables in the Exercise of Physical Fitness Aged 35-40 Years*, **International Journal of Early Childhood Special Education**, 14 (3), 2022.

19 U. C. Ikenna, O. G. Ngozichi, I. Ijeoma, N. Ijeoma, N. Ifeanyichukwu, & O. C. Martin, *Effect of Circuit Training on the Cardiovascular Endurance and Quality of Life: Findings from an Apparently Healthy Female Adult Population*, **JALSI**, 23 (3), 2020, 1-8.

20 C. F. Bennett, P. Latorre-Muro, & P. Puigserver, *Mechanisms of Mitochondrial Respiratory Adaptation*, **Nature Reviews Molecular Cell Biology**, 23 (12), 2022, 817-835.

22 W. S. Jung, Y. Y. Kim, & H. Y. Park, *Circuit Training Improvements in Korean Women with Sarcopenia*, **Perceptual & Motor Skills**, 126 (5), 2019, 828-842.

23 J. John, U. Nnaji, O. Okezu, U. Nnadozie, D. John, A. Ezeukwu, U. Mgbeojedo, & I. Enyanwuma, *Effects of Circuit Exercise Training on Body Image, Cardiorespiratory Indices, and Body Composition of Obese Undergraduates in a Nigerian University*, **Physiotherapy Quarterly** (ISSN 2544-4395), doi: https://doi.org/10.5114/pq.2023.112744.

24 J. W. Kim, Y. C. Ko, T. B. Seo, & Y. P. Kim, *Effect of Circuit Training on Body Composition, Physical Fitness, and Metabolic Syndrome Risk Factors in Obese Female College Students*, **Journal of Exercise Rehabilitation**, 14 (3), 2018, 460.

25 S. Mehmood, A. Khan, S. Farooqui, A. W. Zahoor, Q. U. A. Adnan, & U. Khan, *High-intensity Circuit Training for Improving Anthropometric Parameters for Women from Low Socioeconomic Communities of Sikandarabad: A Clinical Trial*. **PLoS ONE**, 17 (10), 2022, e0275895. https://doi.org/10.1371/journal.pone.0275895.

26 B. M. Roberts, G. Nuckols, & J. W. Krieger, *Sex Differences in Resistance Training: A Systematic Review and Meta-analysis*, ***J Strength Cond Res**,* 34 (5), 2020, 1448-1460.

27 A. M. Bloodgood, J. J. Dawes, R. M. Orr, M. Stierli, K. A. Cesario, M. R. Moreno, J. M. Dulla, & R. G. Lockie, *Effects of Sex and Age on Physical Testing Performance for Law Enforcement Agency Candidates: Implications for Academy Training*, ***J Strength Cond Res**,* 35 (9), 2021, 2629-2635.

28 S. Li, L. Wang, J. Xiong, & D. Xiao, *Gender-specific Effects of 8-Week Multi-modal Strength and Flexibility Training on Hamstring Flexibility and Strength*, **International Journal of Environmental Research and Public Health**, 19 (22), 2022, 15256.

29 M. Kasović, L. Štefan, & Z. Kalčik, *Acute Responses to Resistance Training on Body Composition, Muscular Fitness and Flexibility by Sex and Age in Healthy War Veterans Aged 50-80 Years*, **Nutrients**, 14 (16), 2022, 3436.

30 B. Schwartz, *Sex Differences in the Impact of A 12-Week High Intensity Interval Training Intervention on Sympathetic Transduction,* (Doctoral Dissertation), 2023.

31 B. J. Petek, E. H. Chung, J. H. Kim, R. Lampert, B. D. Levine, D. Phelan, A. Danielian, P. N. Dean, E. H. Dineen, A. B. Fernandez, & M. Husaini, *Impact of Sex on Cardiovascular Adaptations to Exercise: JACC Review Topic of the Week*, **Journal of the American College of Cardiology**, 82 (10), 2023, 1030-1038.

32 M. Picard, I. Tauveron, S. Magdasy, T. Benichou, R. Bagheri, U. C. Ugbolue, V. Navel, & F. Dutheil, *Effect of Exercise Training on Heart Rate Variability in Type 2 Diabetes Mellitus Patients: A Systematic Review and Meta-analysis*, **PLoS One**, 16 (5), 2021, 0251863.

33 A. Raberin, J. Burtscher, T. Citherlet, G. Manferdelli, B. Krumm, N. Bourdillon, J. Antero, L. Rasica, D. Malatesta, F. Brocherie, & M. Burtscher, *Women at Altitude: Sex-Related Physiological Responses to Exercise in Hypoxia*, **Sports Medicine**, 2023, 1-17.

34 I. Witvrouwen, E. M. Van Craenenbroeck, A. Abreu, T. Moholdt, & N. Kränkel, *Exercise Training in Women with Cardiovascular Disease: Differential Response and Barriers–Review and Perspective*, **European Journal of Preventive Cardiology**, 28 (7), 2021, 779-790.

35 O. A. Ajayi, *Effects of Aerobic Dance Circuit Training Programmeme on Body Composition and Cardiorespiratory Variables of Obese Female College Students in Oyo Town, Nigeria* (Doctoral Dissertation), 2018.

36 P. B. Dominelli, & Y. Molgat-Seon, *Sex, Gender and the Pulmonary Physiology of Exercise*, **European Respiratory Review**, 31(163), 2022.

37 B. J. Schoenfeld, A. Alto, J. Grgic, G. Tinsley, C. T. Haun, B. I. Campbell, G. Escalante, G. T. Sonmez, G. Cote, A. Francis, & E. T. Trexler, *Alterations in Body Composition, Resting Metabolic Rate, Muscular Strength, and Eating Behavior in Response to Natural Bodybuilding Competition Preparation: A Case Study*, **The Journal of Strength & Conditioning Research**, *34*(11), 2020, 3124-3138.

38 Z. Milanović, S. Pantelić, N. Čović, G. Sporiš, M. Mohr, & P. Krustrup, *Broad-spectrum Physical Fitness Benefits of Recreational Football: A Systematic Review and Meta-analysis*, **British Journal of Sports Medicine**, 53(15), 2019, 926-939.

39 S. Kolahdouzi, M. Baghadam, F. A. Kani-Golzar, A. Saeidi, G. Jabbour, A. Ayadi, M. De Sousa, A. Zouita, A. B. Abderrahmane, & H. Zouhal, *Progressive Circuit Resistance Training*

Improves Inflammatory Biomarkers and Insulin Resistance in Obese Men, **Physiology & Behavior**, *205*, 2019, 15-21.

Chapter Five

Conclusion

This chapter presents the conclusion of the study. The conclusion is organized to cover the following: summary of findings, conclusion, recommendations, contribution to knowledge, and suggested areas for further research.

5.1 Summary of Findings

The findings of this study on socio-demographic characteristics revealed that, most of the participants are male. Similarly, it was shown that, most of the participants were in the age range of 35-44 years. This study reveals that academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria had pre-field mean muscle strength of 15.93 ± 0.91, flexibility of 1.56 ± 0.22cm, heart rate of 77.65 ± 0.58bpm, respiratory rate of 18.18 ± 0.33bpm, oxygen Saturation of 97.10 ± 0.14% and body composition of 0.87 ± 0.01.

The findings of this study revealed a significant effect of circuit training on muscle strength of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

The findings of this study revealed a significant effect of circuit training on flexibility of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

The findings of this study revealed a significant effect of circuit training on cardiorespiratory fitness such as heart rate, respiratory rate and oxygen saturation of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

The findings of this study revealed a significant effect of circuit training on body composition of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria.

This study found no significant effect of circuit training programmeme on muscle strength of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex.

This study found no significant effect of circuit training programmeme on flexibility of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex.

This study found no significant effect of circuit training programmeme on cardiorespiratory fitness such as heart rate, respiratory rate and oxygen saturation of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria, based on sex

This study found no significant effect of circuit training programmeme on body composition of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on sex.

This study found no significant effect of circuit training programmeme on muscle strength of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age.

This study found a significant effect of circuit training programmeme on flexibility of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age.

This study found no significant effect of circuit training programmeme on cardiorespiratory fitness such as heart rate, respiratory rate and oxygen saturation of the academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria, based on age.

This study found no significant effect of circuit training programmeme on body composition of academic staff at Bayelsa Medical University in Yenagoa, Bayelsa State, based on age.

5.2 Conclusion

The observed significant effect in muscle strength, flexibility, heart rate, respiratory rate, oxygen saturation and body composition could be due to circuit training programmeme. Based on the findings of this study, 8-weeks circuit training programmeme influences muscle strength, flexibility, cardiorespiratory fitness and body composition of academic staff of Bayelsa Medical

University, Yenagoa, Bayelsa State, Nigeria. 8-weeks circuit training programmeme do not influence muscle strength, flexibility, cardiorespiratory fitness and body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria based on sex. 8-weeks circuit training programmeme influences flexibility of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria based on age. 8-weeks circuit training programmeme do not influence muscle strength, cardiorespiratory fitness and body composition of academic staff of Bayelsa Medical University, Yenagoa, Bayelsa State, Nigeria based on age.

5.3 Recommendations

Based on the findings of this study, the following recommendations were made:

1. Academic staff should be encouraged to participate in circuit exercise because they are at risk of acquiring metabolic illnesses and are prone to sedentary lifestyle. Furthermore, because circuit exercise can be self-administered, the economic/financial burden of registering in a traditional gym setting is decreased.
2. Future research should account for nutritional consumption and daily energy expenditure, as these factors may be more relevant for body composition and lipid profile.
3. Academic institutions and government should prioritize sensitization on exercise and physical activity, and also consider implementation of regular aerobic exercise for staff.

5.4 Contributions to Knowledge

This study contributed to knowledge in the following ways:

1. The Ogbara Freedom Festus circuit training programmeme can be used to improve physical fitness parameters irrespective of age and sex.

2. The study's findings indicate that an 8-week circuit training programmeme can be used to improve muscle strength.
3. The study's findings indicate that an 8-week circuit training programmeme can be used to improve flexibility.
4. The study's findings indicate that an 8-week circuit training programmeme can be used to improve cardiorespiratory fitness.
5. The study's findings indicate that an 8-week circuit training programmeme can be used to improve body composition.
6. The study's findings indicate that an 8-week circuit training programmeme can be used to improve physical fitness parameters irrespective of age and sex.

5.5 Suggested Areas for Further Research

The following suggestions were made for further research based on the findings of the study.

1. This type of research can be duplicated among academic staff at other tertiary institutions in Nigeria.
2. This type of study can be reproduced among non-academic staff at Nigerian tertiary institutions.
3. Other researchers can focus on other fitness components that were not investigated in this study in future investigations.
4. Exercise duration, frequency, and intensity can be varied from those used in this study to examine the effect of circuit training on physical fitness markers.

Bibliography

Journals

Adeloye, D. Ige-Elegbede, J. O. Auta, A. Ale, B. M. Ezeigwe, N. Omoyele, C. Dewan, M. T. Mpazanje, R. G. Agogo, E. Alem, W. Gadany, M. A. Harhay, M. O. & Adebiyi, A. O. *Epidemiology of Physical Inactivity in Nigeria: A Systematic Review and Meta-analysis*, **Journal of Public Health**, 2021, 1-11.

Ahookhosh, K. Pourmehran, O. Aminfar, H. Mohammadpourfard, M. Sarafraz, M. M. & Hamishehkar, H. *Development of Human Respiratory Airway Models: A Review*, **European Journal of Pharmaceutical Sciences**, 145, 2020, 105233.

Ajayi, O. A. Suleiman, U. O. Oladipo, I. O. & Achikasim, N. C. M. *Effects of Aerobic Dance Circuit Training Programmeme on Blood Pressure Variables of Obese Female College Students in Oyo State, Nigeria*, **Journal of Physical Education Research**, 7 (3), 2020, 32-38.

Akodu, A. K. Owoeye, O. B. A. & Raufu, A. I. *Exercise, Recreation and Sport Participation among Lecturers in University of Lagos*, **University of Lagos Journal of Basic Medical Sciences**, 4 (8), 2022, 26-32.

Aldhahi, M. I. Alshehri, M. M. Alqahtani, F. & Alqahtani, A. S. *A Pilot Study of the Moderating Effect of Gender on the Physical Activity and Fatigue Severity among Recovered COVID-19 Patients*, **Plos One**, 17 (7), 2022, 0269954.

Andermo, S. Hallgren, M. Nguyen, T. T. D. Jonsson, S. Petersen, S. Friberg, M. Romqvist, A. Stubbs, B. & Elinder, L. S. *School-related Physical Activity Interventions and Mental Health among Children: A Systematic Review and Meta-analysis*, **Sports Medicine-Open**, 6 (1), 2020, 1-27.

Anitha, J. Kumaravelu, P. Lakshmanan, C. & Govindasamy, K. *Effect of Plyometric Training and Circuit Training on Selected Physical and Physiological Variables among Male Volleyball Players*, **International Journal of Yoga, Physiotherapy & Physical Education**, 3 (4), 2018, 26-32.

Ariani, L. P. T. A. Sudiana, I. K. & Kusuma, K. C. A. *Continuous and Competitive Circuit Training: Methods to Increase VO_2max on Young Badminton Player*, **Journal Sport Area**, 7 (2), 2022, 236-245.

Arjuna, F. Primasoni, N. & Miftachurochmah, Y. *The Effect of Circuit Training with Fixed and Decreasing Rest Intervals on the Ability of the Dominant Physical Component of Female Volleyball Players*, **Journal of Positive School Psychology**, 6 (8), 2022, 232-243.

Ballantyne, F., Fryer, G. & McLaughlin, P., *The Effect of Muscle Energy Technique on Hamstring Extensibility: The Mechanism of Altered Flexibility*, **Journal of Osteopathic Medicine**, 6 (2), 2003, 59-63.

Ballesta-García, I. Martínez-González-Moro, I. Ramos-Campo, D. J. & Carrasco-Poyatos, M. *High-intensity Interval Circuit Training Versus Moderate-intensity Continuous Training on Cardiorespiratory Fitness in Middle-aged and Older Women: A Randomized Controlled Trial*, **International Journal of Environmental Research and Public Health**, 17 (5), 2020, https://doi.org/10.3390/ijerph17051805.

Ballesta-García, I. Martínez-González-Moro, I. Rubio-Arias, J. Á. & Carrasco-Poyatos, M. *High-intensity Interval Circuit Training Versus Moderate-intensity Continuous Training on Functional Ability and Body Mass Index in Middle-aged and Older Women: A Randomized Controlled Trial*, **International Journal of Environmental Research and Public Health**, 16 (21), 2019, 4205.

Bandou, R. Idota, N. Akasaka, Y. & Ikegaya, H. *A Case of Fatal Asphyxia by a Barbell during a Bench Press*, **Forensic Sciences**, 2 (1), 2021, 1-6.

Batrakoulis, A. Fatouros, I. G. Chatzinikolaou, A. Draganidis, D. Georgakouli, K. Papanikolaou, K. Deli, C. K. Tsimeas, P. Avloniti, A. Syrou, N. & Jamurtas, A. Z. *Dose-response Effects of High-Intensity Interval Neuromuscular Exercise Training on Weight Loss, Performance, Health and Quality of Life in Inactive Obese Adults: Study Rationale, Design and Methods of the DoIT Trial*, **Contemporary Clinical Trials Communications**, 15, 2019, 100386.

Bennett, C. F., Latorre-Muro, P. & Puigserver, P., *Mechanisms of Mitochondrial Respiratory Adaptation*, **Nature Reviews Molecular Cell Biology**, 23 (12), 2022, 817-835.

Bhati, Y. S. & Saini, J. N. *A Comparative Study of Cardiovascular Fitness of Bodybuilders and Atheletes During 50's Age*, **Central Asian Journal of Medical and Natural Science**, 3 (5), 2022, 124-132.

Bhutia, P. & Tiwari, A. *A Study on Physiological Aspects of Ellite Middle-and Long-distance Runners*, **Think India Journal**, 22 (10), 2019, 9609-9622.

Blasquez Shigaki, G. L. Barbosa, C. C. Batista, M. B. Romanzini, C. L. Gonçalves, E. M. Serassuelo Junior, H. & Ronque, E. R. *Tracking of Health‐related Physical Fitness between Childhood and Adulthood*, **American Journal of Human Biology**, 32 (4), 2020, e23381.

Bloodgood, A. M. Dawes, J. J. Orr, R. M. Stierli, M. Cesario, K. A. Moreno, M. R. Dulla, J. M. & Lockie, R. G, *Effects of Sex and Age on Physical Testing Performance for Law*

Enforcement Agency Candidates: Implications for Academy Training, ***J Strength Cond Res****,* 35 (9), 2021, 2629-2635.

Braaksma, P. Stuive, I. Garst, R. M. E. Wesselink, C. F. van der Sluis, C. K. & Dekker, R. *Characteristics of Physical Activity Interventions and Effects on Cardiorespiratory Fitness in Children Aged 6-12 Years-A Systematic Review*, **J Sci Med Sport**, 21, 2018, 296-306.

Bragazzi, N. L. Rouissi, M. Hermassi, S. & Chamari, K. *Resistance Training and Handball Players' Isokinetic, Isometric and Maximal Strength, Muscle Power and Throwing Ball Velocity: A Systematic Review and Meta-analysis*, **International Journal of Environmental Research & Public Health**, 17 (8), 2020, 2663.

Brand, R. & Cheval, B. *Theories to Explain Exercise Motivation and Physical Inactivity: Ways of Expanding Our Current Theoretical Perspective*, **Front. Psychol**, 10, 2019, 1147.

Brand, R. & Ekkekakis, P. *Affective-reflective Theory of Physical Inactivity and Exercise: Foundations and Preliminary Evidence*, **German J. Exer Sport Res**, 48, 2018, 48–58.

Brijwasi, T. & Borkar, P. *To Study the Effect of Sports Specific Training Programme on Selective Physical and Physiological Variables in Basketball Players*, **International Journal of Physical Education, Sports and Health,** 9 (2), 2022, 25-30

Burton, R. F. *The Waist-hip Ratio: A Flawed Index*, **Annals of Human Biology**, 47 (7-8), 2020, 629-631.

Bushman, B. A. *Body Composition: Measurement Techniques to Increase Accuracy*, **ACSM's Health & Fitness Journal**, 26 (2), 2022, 6-12.

Buttar, K. K. Saboo, N. & Kacker, S. *A Review: Maximal Oxygen Uptake (VO_2 Max) and its Estimation Methods*, **IJPESH**, 6, 2019, 24-32.

Campos, Y. Casado, A. Vieira, J. G. Guimarães, M. Sant'Ana, L. Leitão, L. da Silva, S. F. de Azevedo, P. H. S. M. Vianna, J. & Domínguez, R. *Training-intensity Distribution on Middle-and Long-distance Runners: A Systematic Review*, **International Journal of Sports Medicine**, 43 (04), 2021, 305-316

Case, M. J. Knudson, D. V. & Downey, D. L. *Barbell Squat Relative Strength as an Identifier for Lower Extremity Injury in Collegiate Athletes*, **Journal of Strength & Conditioning Research**, 34 (5), 2020, 1249–1253.

Chang, N. J. Tsai, I. H. Lee, C. L. & Liang, C. H. *Effect of a Six-week Core Conditioning as a Warm-up Exercise in Physical Education Classes on Physical Fitness, Movement Capability, and Balance in School-aged Children*, **International Journal of Environmental Research and Public Health**, 17 (15), 2020, 5517.

Chen, W. Hammond-Bennet, A. Hypnar, A. & Mason, S. *Health-related Physical Fitness and Physical Activity in Elementary School Students*, **BMC Public Health**, 18, 2018, 195.

Chotipanich, A. & Kongpit, N. *Precision and Reliability of Tape Measurements in the Assessment of Head and Neck Lymphedema*, **Plos One**, 15 (5), 2020, 0233395.

Comeras-Chueca, C. Marin-Puyalto, J. Matute-Llorente, A. Vicente-Rodriguez, G. Casajus, J. A. & Gonzalez-Aguero, A. *The Effects of Active Video Games on Health-Related Physical Fitness and Motor Competence in Children and Adolescents with Healthy Weight: A Systematic Review and Meta-analysis*, ***Int. J. Environ. Res. Public Health**, 18,* 2021, 6965.

Curran, M. T. Bedi, A. Mendias, C. L. Wojtys, E. M. Kujawa, M. V. & Palmieri-Smith, R. M. *Blood Flow Restriction Training Applied with High-intensity Exercise does not Improve Quadriceps Muscle Function after Anterior Cruciate Ligament Reconstruction: A Randomized Controlled Trial*, **The American Journal of Sports Medicine**, 48 (4), 2020, 825-837.

Darikwa, T. B. & Manda, S. O. *Spatial Co-clustering of Cardiovascular Diseases and Select Risk Factors among Adults in South Africa*, **International Journal of Environmental Research and Public Health**, 17 (10), 2020, 3583.

de Souza Bezerra, E. Diefenthaeler, F. Sakugawa, R. L. Cadore, E. L. Izquierdo, M. & Moro, A. R. P. *Effects of Different Strength Training Volumes and Subsequent Detraining on Strength Performance in Aging Adults*, **Journal of Bodywork and Movement Therapies**, 23 (3), 2019, 466-472.

DeFina, L. F. William, L. H. Benjamin, W. L. Carolyn, B. E. Carrie, F. E. & Benjamin, L. D. *Physical Activity versus Cardiorespiratory Fitness: Two (Partly) Distinct Components of Cardiovascular Health*, **Prog Cardiovasc Dis**, 57, 2015, 324-29.

Doe-Asinyo, R. X. & Smits-Engelsman, B. C. *Ecological Validity of the PERF-FIT: Correlates of Active Play, Motor Performance and Motor Skill-related Physical Fitness*. **Heliyon**, 7 (8), 2021, 07901.

Dominelli, P. B. & Molgat-Seon, Y. *Sex, Gender and the Pulmonary Physiology of Exercise*, **European Respiratory Review**, 31(163), 2022.

Douka, S. Zilidou, V. I. Lilou, O. & Manou, V. *Traditional Dance Improves the Physical Fitness and Well-being of the Elderly*, **Frontiers in Aging Neuroscience**, 11, 2019, 75.

Duthie, G. M. Thomas, E. J. Bahnisch, J. Thornton, H. R. & Ball, K. *Using Small-sided Games in Field Hockey: Can they be used to reach Match Intensity*? **J Strength Cond Res**, 36 (2), 2022, 498-502.

Eassey, D. Reddel, H. K. Ryan, K. & Smith, L. '*It is like Learning how to Live all Over Again'a Systematic Review of People's Experiences of Living with a Chronic Illness from a Self-determination Theory Perspective*, **Health Psychology & Behavioral Medicine**, 8 (1), 2020, 270-291.

Eddolls, W. T. B. McNarry, M. A. Stratton, G. Winn, C. O. N. & Mackintosh, K. A. *High-intensity Interval Training Interventions in Children and Adolescents: A Systematic Review*, **Sports Med**, 47, 2017, 2363–2374.

Engel, F.A. Ackermann, A. Chtourou, H. & Sperlich, B. *High-intensity Interval Training Performed by Young Athletes: A Systematic Review and Meta-analysis*, **Front Physiol**, 9, 2018, 1012.

English, K. L. Downs, M. Goetchius, E. Buxton, R. Ryder, J. W. Ploutz-Snyder, R. Guilliams, M. Scott, J. M. & Ploutz-Snyder, L. L. *High Intensity Training During Spaceflight: Results from the NASA Sprint Study*, **NPJ Microgravity**, 6 (1), 2020, 1-9.

Estrázulas, J. A. de Jesus, K. da Silva, R. A. & Dos Santos, J. O. L. *Evaluation Isometric and Isokinetic of Trunk Flexor and Extensor Muscles with Isokinetic Dynamometer: A Systematic Review*, **Physical Therapy in Sport**, 45, 2020, 93-102.

Faigenbaum, A. D. & Mediate, P. *Medicine Ball Training for Kids: Benefits, Concerns, and Programme Design Considerations*, **ACSM's Health & Fitness Journal**, 12 (3), 2008, 7-12.

Fares, M. Y. Khachfe, H. H. Salhab, H. A. Bdeir, A. Fares, J. & Baydoun, H. *Physical Testing in Sports Rehabilitation: Implications on a Potential Return to Sport*, **Arthroscopy, Sports Medicine, & Rehabilitation**, 4 (1), 2022, 189-198.

Fernández-Lázaro, D. González-Bernal, J. J. Sánchez-Serrano, N. Navascués, L. J. Ascaso-del-Río, A. & Mielgo-Ayuso, J. *Physical Exercise as a Multimodal Tool for COVID-19: Could it be used as a Preventive Strategy?*, **International Journal of Environmental Research & Public Health**, 17 (22), 2020, 8496.

Ferraz, R. Marques, D. Neiva, H. P. Marques, M. C. Marinho, D. A. & Branquinho. L. *Effects of Applying a Circuit Training Programme During the Warm-up Phase of Practical Physical Education Classes*, **Orthop and Spo Med Op Acc J,** 4 (4), 2020, 439-444.

Ferreira, C. B. Teixeira, P. D. S. Alves Dos Santos, G. Dantas Maya, A. T. Americano Do Brasil, P. Souza, V. C. Córdova, C. Ferreira, A. P. Lima, R. M. & Nóbrega, O. D. T. *Effects of a12-Week Exercise Training Programme on Physical Function in Institutionalized Frail Elderly*, **Journal of Aging Research**, 2018.

Festiawan, R. Raharja, A. T. Jusuf, J. B. K. & Mahardika, M. N. *The Effect of Oregon Circuit Training and Fartlek Training on the VO_2 max Level of Soedirman Expedition VII Athletes*, **Pendidikan Jasmani Olahraga**, 5 (1), 2020, 62-69.

Fontelles, M. J. Simões, M. G. Almeida, J. C. &Fontelles, R. G. S. *Research Methodology: Guidelines for Calculating the Sample Size*, **Rev Para Med**, 24 (2), 2010, 57-64.

Friedenreich, C. M. Ryder-Burbidge, C. & McNeil, J. *Physical Activity, Obesity and Sedentary Behavior in Cancer Etiology: Epidemiologic Evidence and Biologic Mechanisms*, **Molecular Oncology**, 15 (3), 2021, 790-800.

Furrer, R., Hawley, J. A. & Handschin, C., *The Molecular Athlete: Exercise Physiology from Mechanisms to Medals*, **Physiological Reviews**, 2023.

García-Hermoso, A. Alonso-Martinez, A. M. Ramírez-Vélez, R. & Izquierdo, M. *Effects of Exercise Intervention on Health-related Physical Fitness and Blood Pressure in Preschool Children: A Systematic Review and Meta-analysis of Randomized Controlled Trials*, **Sports Medicine**, 50 (1), 2020, 187-203.

García-Hermoso, A. Cerrillo-Urbina, A. Herrera-Valenzuela, J. T. Cristi- Montero, C. Saavedra, J. M. & Martínez-Vizcaíno, V. *Is High-intensity Interval Training more Effective on Improving Cardiometabolic Risk and Aerobic Capacity than other forms of Exercise in Overweight and Obese Youth?* **A Meta-analysis, Obes Rev**, 17, 2016, 531–540.

García-Pinillos, F. Lago-Fuentes, C. Latorre-Román, P. A. Pantoja-Vallejo, A. & Ramirez-Campillo, R. *Jump-rope Training: Improved 3-km Time-trial Performance in Endurance Runners via Enhanced Lower-limb Reactivity and Foot-arch Stiffness*, **International Journal of Sports Physiology and Performance**, 15 (7), 2020, 927-933.

Gite, A. A. Mukkamala, N. & Parmar, L. *Relationship between Body Mass Index and Flexibility in Young Adults*, **Journal of Pharmaceutical Research International**, 33 (32A), 2021, 119-126.

Haghighi, M. & Asgari, A. *Comparison of the Effects of Core Stability and Balance Exercise on Static and Dynamic Balance and Q-angle of the Students with Genu Varum*, **International Journal of Health Studies**, 9 (1), 2022.

Hammami, A. Harrabi, B. Mohr, M. & Krustrup, P. *Physical Activity and Coronavirus Disease 2019 (COVID-19): Specific Recommendations for Home-based Physical Training*, **Managing Sport and Leisure**, 27 (1-2), 2022, 26-31.

Harskamp, R. E. Bekker, L. Himmelreich, J. C. De Clercq, L. Karregat, E. P. Sleeswijk, M. E. & Lucassen, W. A. *Performance of Popular Pulse Oximeters Compared with Simultaneous Arterial Oxygen Saturation or Clinical-grade Pulse Oximetry: A Cross-sectional Validation Study in Intensive Care Patients*, **BMJ Open Respiratory Research**, 8 (1), 2021, 000939.

Hassanzadeh, N. Farzizadeh, R. Moharramzadeh, M. & Shoja Anzabi, B. *Designing a Dual-Purpose Device for Strengthening Pectoralis Major and Triceps Muscles*, **Journal of Advanced Sport Technology**, 6 (1), 2022, 96-102.

Hazari, A. Maiya, A. G. Nagda, T. V. Hazari, A. Maiya, A. G. & Nagda, T. V. *Kinetics and Kinematics of Hip and Pelvis*, **Conceptual Biomechanics and Kinesiology**, 2021, 125-144.

Herbert, C. *Enhancing Mental Health, Well-being and Active Lifestyles of University Students by Means of Physical Activity and Exercise Research Programmes*, **Frontiers In Public Health**, 10, 2022, 849093.

Hills, N. F. Graham, R. B. & McLean, L. *Comparison of Trunk Muscle Function between Women with and without Diastasis Recti Abdominis at 1 Year Postpartum*, **Physical Therapy**, 98 (10), 2018, 891-901.

Hodgkinson, J. A. Lee, M. M. Milner, S. Bradburn, P. Stevens, R. Hobbs, F. R. Koshiaris, C. Grant, S. Mant, J. & Mcmanus, R. J. *Accuracy of Blood-pressure Monitors Owned by Patients with Hypertension (ACCU-RATE Study): A Cross-sectional, Observational StudyiIn Central England*, **British Journal of General Practice**, 70 (697), 2020, 548-554.

Hui, S. S. C. Zhang, R. Suzuki, K. Naito, H. Balasekaran, G. Song, J. K. Park, S. Y. Liou, Y. M. Lu, D. Poh, B. K. & Kijboonchoo, K. *Physical Activity and Health-related Fitness in Asian Adolescents: The Asia-fit Study*, **Journal of Sports Sciences**, 38 (3), 2020, 273-279.

Ikenna, U. C. Ngozichi, O. G. Ijeoma, I. Ijeoma, N. Ifeanyichukwu, N. & Martin, O. C. *Effect of Circuit Training on the Cardiovascular Endurance and Quality of Life: Findings from an Apparently Healthy Female Adult Population*, **JALSI**, 23 (3), 2020, 1-8.

Iuliano, E. Cular, D. Padulo, J. Larion, A. Melenco, I. Kuvačić, G. Dhahbi, W. & Migliaccio, G. M. *Predictive Ability of Body Mass Parameter to Estimate 4-6 Repetition Maximum of Upper and Lower Limb Muscles in Soccer Players*, **Acta Kinesiologica**, 15 (2), 2021, 120-124

Iversen, V. M. Norum, M. Schoenfeld, B. J. & Fimland, M. S. *No time to lift? Designing Time-Efficient Training Programmes for Strength and Hypertrophy: A Narrative Review*, **Sports Medicine**, 51 (10), 2021, 2079-2095.

Jaronsukwimal, N. *Effects of Circuit Training Programme on Physical Fitness in Overweight Older Adults*, **Academic Journal of Thailand National Sports University**, 13(3), 2021, 57–68.

Jeevannavar, J. S. Jalamsingh, P. S. Misalankar, N. & Rajesh, K. P. *Variability in Flexibility of Dominant and Non-dominant Shoulder Joints among Healthy Young Adults*, **Indian Journal of Physiotherapy & Occupational Therapy**, 16 (4), 2022, 112-116.

John, J. Nnaji, U. Okezu, O. Nnadozie, U. John, D. Ezeukwu, A. Mgbeojedo, U. & Enyanwuma, I. *Effects of Circuit Exercise Training on Body Image, Cardiorespiratory Indices, and Body Composition of Obese Undergraduates in a Nigerian University*, **Physiotherapy Quarterly** (ISSN 2544-4395), doi: https://doi.org/10.5114/pq.2023.112744.

Jones, L. M. Stoner, L. Baldi, J. C. & McLaren, B. *Circuit Resistance Training and Cardiovascular Health in Breast Cancer Survivors*, **European Journal of Cancer Care**, 29 (4), 2020, e13231.

Joshi, Y. C. & Jaykishan, S. *Effects of Selected Asana's on Back Extension of Female Students*, **IJPNPE**, 3 (2), 2018, 335-338.

Jukic, I. Calleja-González, J. Cos, F. Cuzzolin, F. Olmo, J. Terrados, N. Njaradi, N. Sassi, R. Requena, B. Milanovic, L. & Krakan, I. *Strategies and Solutions for Team Sports Athletes in Isolation due to COVID-19*, **Sports**, 8 (4), 2020, 56.

Jukic, I. Ramos, A. G. Helms, E. R. McGuigan, M. R. & Tufano, J. J. *Acute Effects of Cluster and Rest Redistribution Set Structures on Mechanical, Metabolic, and Perceptual Fatigue during and after Resistance Training: A Systematic Review and Meta-analysis*, **Sports Medicine**, 50, 2020, 2209-2236.

Jung, W. S. Kim, Y. Y. & Park, H. Y. *Circuit Training Improvements in Korean Women with Sarcopenia*, **Perceptual & Motor Skills**, 126 (5), 2019, 828–842.

Kang, J. Ratamess, N. A. Kuper, J. O'Grady, E. Nicole, E. Vought, I. Bush-Wallace, J. A. & Faigenbaum, A. D. *Cardiometabolic Responses of Body-weight Exercises with and without Vibration*, **Kinesiology**, 51 (1), 2019, 83-91.

Kasović, M. Štefan, L. & Kalčik, Z, *Acute Responses to Resistance Training on Body Composition, Muscular Fitness and Flexibility by Sex and Age in Healthy War Veterans Aged 50-80 Years*, **Nutrients**, 14 (16), 2022, 3436.

Katsanis, G. Chatzopoulos, D. Barkoukis, V. Lola, A. C. Chatzelli, C. & Paraschos, I. *Effect of a School-based Resistance Training Programme Using a Suspension Training System on Strength Parameters in Adolescents*, **Journal of Physical Education and Sport**, 21 (5), 2021, 2607-2621.

Khalif, D. M. & Abdulkadhim, H. A., *The Effect of Aerobic Exercise Hypo Plank on Some Functional Variables in the Exercise of Physical Fitness Aged 35-40 Years*, **International Journal of Early Childhood Special Education**, 14 (3), 2022.

Khan, M. M. Alanazi, T. M. Albraikan, A. A. & Almalki, F. A, *IoT-based Health Monitoring System Development and Analysis*, **Security and Communication Networks**, 2022.

Kim, B. & Yim, J. *Core Stability and Hip Exercises Improve Physical Function and Activity in Patients with Non-specific Low Back Pain: A Randomized Controlled Trial*, **The Tohoku Journal of Experimental Medicine**, 251 (3), 2020, 193-206.

Kim, D. J. Choi, I. R. & Lee, J. H. *Effect of Balance Taping on Trunk Stabilizer Muscles for Back Extensor Muscle Endurance: A Randomized Controlled Study*, **Journal of Musculoskeletal & Neuronal Interactions**, 20 (4), 2020, 541.

Kim, J. W. Ko, Y. C. Seo, T. B. & Kim, Y. P. *Effect of Circuit Training on Body Composition, Physical Fitness, and Metabolic Syndrome Risk Factors in Obese Female College Students*, **Journal of Exercise Rehabilitation**, 14 (3), 2018, 460.

Ko, H. Y. & Huh, S. *Extremity Kinematics and Muscles for Functional Training of Tetraplegics and Paraplegics*, **Handbook of Spinal Cord Injuries and Related Disorders: A Guide to Evaluation and Management**, 2021, 33-48.

Kolahdouzi, S. Baghadam, M. Kani-Golzar, F. A. Saeidi, A. Jabbour, G. Ayadi, A. De Sousa, M. Zouita, A. Abderrahmane, A. B. & Zouhal, H, *Progressive Circuit Resistance Training Improves Inflammatory Biomarkers and Insulin Resistance in Obese Men*, **Physiology & Behavior**, *205*, 2019, 15-21.

Kompal, R., Ul-Islam, S., Bhatti, U., Tahir, K., Noor, R. & Kashif, M., *Effects of Static Stretch Versus Hold Relax in Improving Flexibility of Tight Hamstrings*, **Rehman Journal of Health Sciences**, 4 (1), 2022, 36-40.

Krzysztofik, M. Jarosz, J. Matykiewicz, P. Wilk, M. Bialas, M. Zajac, A. & Golas, A. *A Comparison of Muscle Activity of the Dominant and Non-dominant Side of the Body During Low Versus High Loaded Bench Press Exercise Performed to Muscular Failure*, **Journal of Electromyography and Kinesiology**, 56, 2021, 102513.

Kumar, & Jyothi, E. *Effect of Continous Training and Circuit Training for the Development of Aerobic Fitness among Long Distance Runners of Osmania University*, **International Journal of Health, Physical Education & Computer Science in Sports**, 39 (2), 2020, 105–107.

Kumaran, S. S. & Ooraniyan, K. *Isotonic Strength Training for Basketball Players: A Short View*, **EPRA International Journal of Multidisciplinary Research (IJMR)**, 9 (1), 2023, 255-257.

La Greca, S. Rapali, M. Ciaprini, G., Russo, L. Vinciguerra, M. G. & Di Giminiani, R. *Acute and Chronic Effects of Supervised Flexibility Training in Older Adults: A Comparison of Two*

Different Conditioning Programmes, **International Journal of Environmental Research and Public Health**, 19 (24), 2022, 16974.

Lamers, E. P. Soltys, J. C. Scherpereel, K. L. Yang, A. J. & Zelik, K. E. *Low-profile Elastic Exosuit Reduces Back Muscle Fatigue*, **Scientific Reports**, 10 (1), 2020, 15958.

Langton, B. & King, J. *Utilizing Body Weight Training with your Personal Training Clients*, **ACSM's Health & Fitness Journal**, 22 (6), 2018, 44-51.

Lee, B. S. Shin, S. Y. & Han, Y. O. *Comparison of Male Adolescents' Physical Fitness Using Physical Activity Promotion System and Circuit Exercise Programme*, ***Int. J. Environ. Res. Public Health****, 18*, 2021, 7519.

Lee, H. Kim, C. An, S. & Jeon, K. *Effects of Core Stabilization Exercise Programmes on Changes in Erector Spinae Contractile Properties and Isokinetic Muscle Function of Adult Females with a Sedentary Lifestyle*, **Applied Sciences**, 12 (5), 2022, 2501.

Li, S. Wang, L. Xiong, J. & Xiao, D. *Gender-specific Effects of 8-Week Multi-modal Strength and Flexibility Training on Hamstring Flexibility and Strength*, **International Journal of Environmental Research and Public Health**, 19 (22), 2022, 15256.

Litwin, S. E., Komtebedde, J., Hu, M., Burkhoff, D., Hasenfuß, G., Borlaug, B. A., Solomon, S. D., Zile, M. R., Mohan, R. C., Khawash, R. & Sverdlov, A. L., *Exercise-induced Left Atrial Hypertension in Heart Failure with Preserved Ejection Fraction*, **Heart Failure**, *11* (8): 2, 2023, 1103-1117.

Lockie, R. G. Moreno, M. R. Rodas, K. A. Dulla, J. M. Orr, R. M. & Dawes, J. J. *With Great Power comes Great Ability: Extending Research on Fitness Characteristics that Influence Work Sample Test Battery Performance in Law Enforcement Recruits*, **Work**, 68 (4), 2021, 1069-1080.

Lohan, A. *Assorted Parameters with Elevation of Performance and Physical Fitness and Edurance with Exercise*, **Asian Journal of Research in Social Sciences and Humanities**, 11 (9), 2021, 10-16.

Lukasik, V. M. *Anesthesia of the Dental Patient*, **The Veterinary Dental Patient: A Multidisciplinary Approach**, 2021, 169-187.

Mackey, C. S. & DeFreitas, J. M. *A Longitudinal Analysis of the US Air Force Reserve Officers' Training Corps Physical Fitness Assessment*, **Military Medical Research**, 6 (1), 2019, 1-8.

Marcos-Pardo, P. J. Orquin-Castrillón, F. J. Gea-García, G. M. Menayo-Antúnez, R. González-Gálvez, N. Vale, R. G. D. S. & Martínez-Rodríguez, A. *Effects of a Moderate-to-High Intensity Resistance Circuit Training on Fat Mass, Functional Capacity, Muscular*

Strength, and Quality of Life in Elderly: A Randomized Controlled Trial, **Scientific Reports**, 9 (1), 2019, 7830.

Marino, F. E. *Adaptations, Safety Factors, Limitations and Trade-Offs in Human Exercise Performance*, **Adaptive Human Behavior and Physiology,** 8, 2022, 98–113.

Martínez-Rodríguez, A. Alejandro, M. R. Bernardo, J. C. C. de F. José, M. G. Rodrigo, Y. S. & Pablo, J. M. P. *Body Composition Assessment Techniques in Clinical and Epidemiological Settings: Development, Validation and Use in Dietary Programmes,* **Physical Training and Sports**, *16648714*, 2023, 226.

McKenzie, A. K. Crowley-McHattan, Z. J. Meir, R. Whitting, J. W. & Volschenk, W. *Glenohumeral Extension and the Dip: Considerations for the Strength and Conditioning Professional*, **Strength & Conditioning Journal**, 43 (1), 2021, 93-100.

McKenzie, T. L. *Physical Activity within School Contexts: The Bigger Bang Theory*, **Kinesiol Rev**, 8 (1), 2019, 48-53.

Medrano, M. Cadenas-Sánchez, C. Oses, M. Villanuev, A. Cabeza, R. Idoate, F. Sanz, A. Rodríguez-Vigil, B.Ortega, F. B.Ruiz J. R. & Labayen, I. *Associations of Fitness and Physical Activity with Specific Abdominal Fat Depots in Children with Overweight/Obesity,* **SJMS**, 32 **(1),** 2022, 211-222.

Mehmood, S. Khan, A. Farooqui, S. Zahoor, A. W. Adnan, Q. U. A. & Khan, U. *High-intensity Circuit Training for Improving Anthropometric Parameters for Women from Low Socioeconomic Communities of Sikandarabad: A Clinical Trial*. **PLoS ONE**, 17 (10), 2022, e0275895. https://doi.org/10.1371/journal.pone.0275895.

Menz, V. Marterer, N. Amin, S. B. Faulhaber, M. Hansen, A. B. & Lawley, J. S. *Functional vs. Running Low-volume High-intensity Interval Training: Effects on VO_2max and Muscular Endurance*, **Journal of Sports Science & Medicine**, 18 (3), 2019, 497–504.

Mohanta, N. Kalra, S. & Pawaria, S. *A Comparative Study of Circuit Training and Plyometric Training on Strength, Speed and Agility in State Level Lawn Tennis Players*, **Journal of Clinical & Diagnostic Research**, 13 (12), 2019.

Mora-Gonzalez, J. Esteban-Cornejo, I. Cadenas-Sanchez, C. Migueles, J. H. Molina-Garcia, P. Rodriguez-Ayllon, M. Henriksson, P. Pontifex, M. B. Catena, A. & Ortega, F. B. *Physical Fitness, Physical Activity, and the Executive Function in Children with Overweight and Obesity*, **The Journal of Pediatrics**, 208, 2019, 50-56.

Mrozek, A. Sopa, M. Myszkowski, J. Bakiera, A. Budzisz, P. Kuliberda, A. Białecka, M. Walczak, T. Grabski, J. K. & Grygorowicz, M. *Assessment of the Functional Movement Screen Test with the Use of Motion Capture System by the Example of Trunk Stability Push-up Exercise among Adolescent Female Football Players*, **Vibrations in Physical Systems**, 31 (2), 2020.

Milanović, Z. Pantelić, S. Čović, N. Sporiš, G. Mohr, M. & Krustrup, P, *Broad-spectrum Physical Fitness Benefits of Recreational Football: A Systematic Review and Meta-analysis*, **British Journal of Sports Medicine**, 53(15), 2019, 926-939.

Naeem, H. Qayyum, F. Qayyum, H. Murad, S. & Khalid, Z. *Association of Acute Coronary Syndrome with Waist Hip Ratio in Local Population of Islamabad Capital Territory, Pakistan*, **Journal of Islamic International Medical College (JIIMC)**, 14 (3), 2019, 111-115.

Nasrulloh, A. Prasetyo, Y. Nugroho, S. Yuniana, R. & Pratama, K. W. *The Effect of Weight Training with Compound Set Method on Strength and Endurance among Archery Athletes*, **Journal of Physical Education and Sport**, 22 (6), 2022, 1457-1463.

Naureen, I., Saleem, A. & Naeem, M., *Effect of Exercise and Obesity on Human Physiology*, **Sch Bull**, 8 (1), 2022, 17-24.

Nazari, S. & Lim, B. H. *Effects of a 12-Week Core Training Programme on Physical Characteristics of Rhythmic Gymnastics: A Study In Kuala Lumpur, Malaysia*, **Malaysian Journal of Movement, Health & Exercise**, 8 (1), 2019, 157-174.

Ndayisenga, J. *Circuit Training Intervention for Adaptive Physical Activity to Improve Cardiorespiratory Fitness, Leg Muscle Strength Static and Balance of Intellectually Disabled Children*, **Sport Mont**, 17 (3), 2019, 97-100.

Nepal, G. B. Bhaila, A. Shrestha, H. S. Maharjan, N. & Adhikari, B. *Estimation of Body Fat Percentage in Adult Population in Nepal and Assess its Correlation with Body Mass Index*, **Journal of Chitwan Medical College**, 12 (4), 2022, 99-102.

Nimkar, N. Bera, T. K. Bagchi, A. & Narnolia, R. *Abdominal Muscular Strength Endurance: Normative Reference Values for Children 11 to 15 Years of Age*, **Indian Journal of Public Health Research & Development**, 11 (2), 2020.

Nordzro, C. Sorkpo, R. S. & Tsorhe, B. *Comparison of Health-Related Physical Fitness Levels of Girls in Day and Boarding Senior High Schools in Cape Coast*, **International Journal of Scientific Research and Management (IJSRM),** 6 (7), 2018, 31-40.

Ntoumanis, N. Ng, J. Y. Y. Prestwich, A. Quested, E. Hancox, J. E. Thøgersen-Ntoumani, C. & Williams, G. C. *A Meta-analysis of Self-determination Theory-informed Intervention Studies in the Health Domain: Effects on Motivation, Health Behavior, Physical, and Psychological Health*, **Health *Psychology Review***, *15* (2), 2020, 214–244.

Nugroho, S. Nasrulloh, A. Karyono, T. H. Dwihandaka, R. & Pratama, K. W. *Effect of Intensity and Interval Levels of Trapping Circuit Training on the Physical Condition of Badminton Players*, **Journal of Physical Education & Sport**, 21, 2021, 1981-1987.

Nuñez, T. P. Amorim, F. T. Beltz, N. M. Mermier, C. M. Moriarty, T. A. Nava, R. C. VanDusseldorp, T. A. & Kravitz, L. *Metabolic Effects of Two High-intensity Circuit Training Protocols: Does Sequence Matter*? **J. Exerc. Sci**. **Fit**, 18, 2020, 14–20. https:// doi. org/ 10. 1016/j. jesf. 2019. 08. 001

Olutekunbi, O. A. Solarin, A. U. Senbanjo, I. O. Disu, E. A. & Njokanma, O. F. *Skinfold Thickness Measurement in Term Nigerian Neonates: Establishing Reference Values*, **International Journal of Pediatrics**, 2018, https://doi.org/10.1155/2018/3624548.

Ortego, A. R. Dantzler, D. K. Zaloudek, A. Tanner, J. Khan, T. Panwar, R. Hollander, D. B. & Kraemer, R. R. *Effects of Gender on Physiological Responses to Strenuous Circuit Resistance Exercise and Recovery*, **The Journal of Strength & Conditioning Research**, 23 (3), 2009, 932-938.

Ortolan, S. Neunhaeuserer, D. Quinto, G. Barra, B. Centanini, A. Battista, F. Vecchiato, M. De Marchi, V. Celidoni, M. Rebba, V. & Ermolao, A. *Potential Cost Savings for the Healthcare System by Physical Activity in Different Chronic Diseases: A Pilot Study in the Veneto Region of Italy*, ***Int. J. Environ. Res. Public Health***, *19*, 2022, 7375.

Osifila, G. I. & Abimbola, A. T. *Workload and Lecturers' Job Satisfaction in Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria*, **Journal of Education and Learning (EduLearn)**, 14 (3), 2020, 416-423.

Oyeyemi, A. L. Conway, T. L. & Adedoyin, R. A. *Construct Validity of the Neighborhood Environment Walkability Scale for Africa*, **Med Sci Sports Exerc**, 49 (3), 2017, 482-491.

Park, J., Mcllvain, V., Rosenberg, J., Donovan, L., Desai, P. & Kim, J. Y., *From Barbells to Brawns: The Physiology of Resistance Exercise and Skeletal Muscle Growth*, **The Korean Journal of Sports Medicine**, 40 (3), 2022, 151-169.

Parker, N. H. Ngo-Huang, A. Lee, R. E. O'Connor, D. P. Basen-Engquist, K. M. Petzel, M. Q. Wang, X. Xiao, L. Fogelman, D. R. Schadler, K. L. & Simpson, R. J. *Physical Activity and Exercise during Preoperative Pancreatic Cancer Treatment*, **Supportive Care in Cancer**, 27, 2019, 2275-2284.

Patah, I. A. Jumareng, H. Setiawan, E. Aryani, M. & Gani, R. A. *The Importance of Physical Fitness for Pencak Silat Athletes: Home-based Weight Training between Tabata and Circuit Can it Work?* **Journal Sport Area**, 6 (1), 2021, 108-122.

Peate, I. *The Heart: An Amazing Organ*, **British Journal of Healthcare Assistants**, 15 (2), 2021, 72-77.

Perone, F., Pingitore, A., Conte, E., Halasz, G., Ambrosetti, M., Peruzzi, M. & Cavarretta, E., *Obesity and Cardiovascular Risk: Systematic Intervention is the Key for Prevention*, **In Healthcare**, 11(6), 2023, 902.

Perez-Rodrigo, C. Citores, M. G. Bárbara, G. H. & Aranceta-Bartrina, J, *Prevalence of Obesity and Abdominal Obesity in Spanish Population Aged 65 Years and Over: ENPE Study*, **Medicina Clínica***,*158 (2), 2022, 49-57.

Petek, B. J. Chung, E. H. Kim, J. H. Lampert, R. Levine, B. D. Phelan, D. Danielian, A. Dean, P. N. Dineen, E. H. Fernandez, A. B. & Husaini, M. *Impact of Sex on Cardiovascular Adaptations to Exercise: JACC Review Topic of the Week*, **Journal of the American College of Cardiology**, 82 (10), 2023, 1030-1038.

Picard, M. Tauveron, I. Magdasy, S. Benichou, T. Bagheri, R. Ugbolue, U. C. Navel, V. & Dutheil, F. *Effect of Exercise Training on Heart Rate Variability in Type 2 Diabetes Mellitus Patients: A Systematic Review and Meta-analysis*, **PLoS One**, 16 (5), 2021, 0251863.

Pietro, L. I. Gabriele, S. Maurizio, P. Giampietro, A. Damiano, F. & Andrea, B. *Circuit Training during Physical Education Classes to Prepare Cadets for Military Academies Tests: Analysis of an Educational Project,* **Sustainability**, 2020, 12, 5126.

Primasatya, D. Rimawan, E. & Herlambang, H. *Simulation of the Cardiovascular Mechanical System Based on Pressure-flow Model Rest Condition*, **International Journal of Innovative Science & Research Technology**, 5 (7), 2020, 104-115.

Pojednic, R., D'Arpino, E., Halliday, I. & Bantham, A., *The Benefits of Physical Activity for People with Obesity, Independent of Weight Loss: A Systematic Review*, **International Journal of Environmental Research and Public Health**, 19 (9), 2022, 4981.

Prvulovic, N. Hadzovic, M. & Lilic, A. *The Effects of Different Exercise Programmemes on Body Composition and Body Mass in Adults: A Review Article*, **Sport Mont**, 19 (3), 2021, 135-141.

Raberin, A. Burtscher, J. Citherlet, T. Manferdelli, G. Krumm, B. Bourdillon, N. Antero, J. Rasica, L. Malatesta, D. Brocherie, F. & Burtscher, M. *Women at Altitude: Sex-Related Physiological Responses to Exercise in Hypoxia*, **Sports Medicine**, 2023, 1-17.

Rathinakamalan, S. & Abraham, G. *Effect of Circuit Training on Strength Endurance among Players of Different Team Games*, **Journal of Xi'an University of Architecture and Technology**, 13 (2), 2021, 364-371.

Rhodes, R. E. McEwan, D. & Rebar, A. L. *Theories of Physical Activity and Behavior Change: A History and Synthesis of Approaches*, **Psychol. Sport Exer**, 42, 2019, 100–109.

Roberts, B. M. Nuckols, G. & Krieger, J. W, *Sex Differences in Resistance Training: A Systematic Review and Meta-analysis*, ***J Strength Cond Res,*** 34 (5), 2020, 1448-1460.

Robinson, A. J. Carter, R. P. Browne, J. D. Hu, J. Arnold, M. T. Baum, J. T. Neufeld, E. V. & Dolezal, B. A. *Energy Expenditure and Muscular Recruitment Patterns of Riding a Novel Electrically Powered Skateboard*, **International Journal of Exercise Science**, 13 (4), 2020, 1783.

Rundle, A. G. Factor-Litvak, P. Suglia, S. F. Susser, E. S. Kezios, K. L. Lovasi, G. S. Cirillo, P. M. Cohn, B. A & Link, B. G. *Tracking of Obesity in Childhood into Adulthood: Effects on Body Mass Index and Fat Mass Index at age 50*, **Childhood Obesity**, 16 (3), 2020, 226-233.

Ruzmatovich, U. S. & Shohbozjon G'Ayratjon O'G, Q., *Uzbekistan's General Education School Physical Education Programmeme: A Curriculum Analysis*, **Best Journal of Innovation in Science, Research and Development**, 2 (5), 2023, 184-193.

Sakthivel, S. & Vaithiyanathan, K. *Impact of Circuit Training on Muscular Strength and Leg Explosive Power among Volleyball Players*, **Journal of Positive School Psychology**, 6 (10), 2022, 3937-3939.

Salierno, M. Ceruso, R. Sannicandro, I. & Altavilla, G. *Circuit Training as a Method of Adaptation and Prevention for People With Type 2 Diabetes*, **Journal of Human Sport and Exercise***,* 16 (3), 2021, 1045-1054.

Sánchez-Pinto-Pinto, B. Romero-Morales, C. López-López, D. de-Labra, C. & García-Pérez-de-Sevilla, G. *Efficacy of Bracing on Thoracic Kyphotic Angle and Functionality in Women with Osteoporosis: A Systematic Review*, **Medicina**, 58 (6), 2022, 693.

Sato, S. Ukimoto, S. Kanamoto, T. Sasaki, N. Hashimoto, T. Saito, H. Hida, E. Sat, T. Ta. Mae, & Nakat, K. *Chronic Musculoskeletal Pain, Catastrophizing, and Physical Function in Adult Women were improved after 3-Month Aerobic-resistance Circuit Training*, **Scientific Reports**, 2021, 11, 14939.

Schoenfeld, B. J. Alto, A. Grgic, J. Tinsley, G. Haun, C. T. Campbell, B. I. Escalante, G. Sonmez, G. T. Cote, G. Francis, A. & Trexler, E. T. *Alterations in Body Composition, Resting Metabolic Rate, Muscular Strength, and Eating Behavior in Response to Natural Bodybuilding Competition Preparation: A Case Study*, **The Journal of Strength & Conditioning Research**, 34 (11), 2020, 3124-3138.

Sember, V. Grošelj, J. & Pajek, M. *Balance Tests in Pre-adolescent Children: Retest Reliability, Construct Validity, and Relative Ability*, **International Journal of Environmental Research & Public Health**, 17 (15), 2020, 5474.

Setyawan, R. Setijono, H. & Kusnanik, N. W. *The Effect of Floor and Swiss Ball Exercises Using Circuit Training Methods towards Balance, Strength, Flexibility and Muscle Endurance*, **Britain International of Humanities & Social Sciences (BIoHS) Journal**, 3 (2), 2021, 384-395.

Shejin, K. V. & Vivekanandhan, T. *Effect of Circuit Training on Obesity, Vital Capacity and Flexibility among School Going Obese Children*, **International Journal of Sports Sciences & Fitness**, 10 (2), 2020.

Shekhawat, B. P. & Chauhan, G. S. *Effect of Circuit Training on Speed and Agility of Adolescent Male Basketball Players*, **Int. J. Physiol. Nutr. Phys. Educ**, 6, 2021, 1-5.

Shiddiq, A. N. Kristiyanto, A. & Doewes, M. *Freeletics as Sports Activities Community Recreation (Phenomenological Study of Community Groups that carry out Recreational Sports in the City of Yogyakarta)*, **Journal of Education, Health and Sport**, 9 (4), 2019, 468-474.

Shimada, K. Nishitani-Yokoyma, M. Takahashi, T. & Daida, H. *Physical Activity and Long-term Prognosis in Patients with Stable Coronary Artery Disease: How Often, How Intense, and How Long?,* **European Journal of Preventive Cardiology**, 27 (4), 2020, 422-425.

Singh, S. & Gunjan Kumar, A. *Ultrasound-guided Erector Spinae Plane Block for Postoperative Analgesia in Modified Radical Mastectomy: A Randomised Control Study*, **Indian Journal of Anaesthesia**, 63 (3), 2019, 200.

Smits-Engelsman, B. Smit, E. Doe-Asinyo, R. X. Lawerteh, S. E. Aertssen, W. Ferguson, G. & Jelsma, D. L. *Inter-rater Reliability and Test-retest Reliability of the Performance and Fitness (PERF-FIT) Test Battery for Children: A Test for Motor Skill Related Fitness*, **BMC Pediatrics**, 21 (1), 2021, 1-11.

Sökmen, B. Witchey, R. L. Adams, G. M. & Beam, W. C. *Effects of Sprint Interval Training with Active Recovery vs. Endurance Training on Aerobic and Anaerobic Power, Muscular Strength, and Sprint Ability*, **Journal of Strength & Conditioning Research**, 32 (3), 2018, 624–631.

Song, D. Ge, Q. Chen, M. Bai, S. Lai, X. Huang, G. Liu, M. Lin, M. Xu, J. & Dong, F. *Development and Validation of a Nomogram for Prediction of the Risk of MAFLD in an Overweight and Obese Population*, **Journal of Clinical and Translational Hepatology**, 10 (6), 2022,1027.

Song, Y. Li, L. & Dai, B. *Trunk Neuromuscular Function and Anterior Cruciate Ligament Injuries: A Narrative Review of Trunk Strength, Endurance, and Dynamic Control*, **Strength and Conditioning Journal**, 44 (6), 2022, 82-93.

Sulowska-Daszyk, I. & Skiba, A., *The Influence of Self-myofascial Release on Muscle Flexibility in Long-distance Runners*, **International Journal of Environmental Research and Public Health**, 19 (1), 2022, 457.

Suntharalingam, T. Jawis, M. N. M. Malik, A. A. & Sivanesan, S. *Effects of 8-Week Medicine Ball Training on Physical Performance among Basketball Players*, **Journal of Positive School Psychology**, 2022, 1307-1319.

Tang, K. S. Medeiros, E. D. & Shah, A. D. *Wide Pulse Pressure: A Clinical Review*, **The Journal of Clinical Hypertension**, 22 (11), 2020, 1960-1967.

Tantot, M. Le Moal, V. Mévellec, É. Nouy-Trollé, I. Lemoine-Josse, E. Besnier, F. & Guiraud, T. *Effects of an Intensive 6-Week Rehabilitation Programme with the HUBER Platform in the Treatment of Non-specific Chronic Low Back Pain: A Pilot Study*, **Clinics and Practice**, 12 (4), 2022, 609-618.

Thivel, D. Masurier, J. Baquet, G. Timmons, B.W. Pereira, B. & Berthoin, S. *High-intensity Interval Training in Overweight and Obese Children and Adolescents: Systematic Review and Meta-analysis*, **J Sports Med Phys Fitness**, 59, 2018, 310–324.

Trout, J. *Postural Health in Physical Education*, **Journal of Physical Education, Recreation & Dance**, 93 (7), 2022, 4-11.

Tucker, W. J., Fegers-Wustrow, I., Halle, M., Haykowsky, M. J., Chung, E. H. & Kovacic, J. C., *Exercise for Primary and Secondary Prevention of Cardiovascular Disease: JACC Focus Seminar 1/4*, **Journal of the American College of Cardiology**, 80 (11), 2022, 1091-1106.

Ujuagu, N. A. & Uzor, T. N. *Optimising Female Secondary School Teachers' Body Composition and Muscular Endurance Using Circuit Training Exercise*, **South Eastern Journal of Research and Sustainable Development (SEJRSD)**, 5 (2), 2021, 31-49.

Ullah, I. Gul, R. Muhammad, A. & Usman, K. *Effect of Circuit Training upon Flexibility among Non-athletes of College Students*, **Al-Qantara**, 8 (2), 2022, 227-241.

Van Hecke, L. Loyen, A. Verloigne, M. van der Ploeg, H. P. Lakerveld, J. & Brug, J. *Variation in Population Levels of Physical Activity in European Children and Adolescents according to Cross-European Studies: A Systematic Literature Review within DEDIPAC*, **Int J Behav Nutri Phys Activity**, 13, 2016, 70.

Vandoni, M. Calcaterra, V. Carnevale Pellino, V. De Silvestri, A. Marin, L. Zuccotti, G. V. Tranfaglia, V. Giuriato, M. Codella, R. & Lovecchio, N. *Fitness and Fatness in Children and Adolescents: An Italian Cross-sectional Study*, ***Children****,* 8, 2021, 762.

Venegas-Carro, M. Herring, J. T. Riehle, S. & Kramer, A. *Jumping vs. Running: Effects of Exercise Modality on Aerobic Capacity and Neuromuscular Performance after a Six-week High-intensity Interval Training*, **Plos one**, 18 (2), 2023, e0281737.

Vijayakumar Jain, S. Muthusekhar, M. R. Baig, M. F. Senthilnathan, P. Loganathan, S. Abdul Wahab, P. U. Madhulakshmi, M. & Vohra, Y. *Evaluation of Three-dimensional Changes in Pharyngeal Airway following Isolated Lefort one Osteotomy for the Correction of Vertical Maxillary Excess: A Prospective Study*, **Journal of Maxillofacial & Oral Surgery**, 18, 2019, 139-146.

Wadden, T. A. Tronieri, J. S. & Butryn, M. L. *Lifestyle Modification Approaches for the Treatment of Obesity in Adults*, **American Psychologist**, 75 (2), 2020, 235.

Wahl-Alexander, Z. Jacobs, J. M. Kaeb, B. & Riley Jr, K. *No Gear? No Problem! Fitness Activities for Students with Limited Space and Equipment*, **Journal of Physical Education, Recreation & Dance**, 92 (6), 2021, 34-41.

Wang, Y. Muthu, B. & Sivaparthipan, C. B. *Internet of things Driven Physical Activity Recognition System for Physical Education*, **Microprocessors and Microsystems**, 81, 2021, 103723.

Wewege, M. van den Berg, R. Ward, R. E. & Keech, A. *The Effects of High-intensity Interval Training vs. Moderate-intensity Continuous Training on Body Composition in Overweight and Obese Adults: A Systematic Review and Meta-analysis*, **Obesity Reviews**, 18 (6), 2017, 635-646.

Weyh, C. Krüger, K. & Strasser, B. *Physical Activity and Diet Shape the Immune System during Aging*, **Nutrients**, 12 (3), 2020, 622.

Widodo, A. F., Tien, C. W., Chen, C. W. & Lai, S. C., *Isotonic and Isometric Exercise Interventions Improve the Hamstring Muscles' Strength and Flexibility: A Narrative Review*. **In Healthcare**, 10 (5), 2022, 811).

Wilder, R. P. Greene, J. A. Winters, K. L. Long, W. B. Gubler, K. & Edlich, R. F. *Physical Fitness Assessment: An Update*, **J Long Term Eff Med Implants**, 16 (2), 2006, 193-204.

Winder, B. Keri, P. A. Weberg, D. E. & Beneck, G. J. *Postural Cueing Increases Multifidus Activation During Stabilization Exercise in Participants with Chronic and Recurrent Low Back Pain: An Electromyographic Study*, **Journal of Electromyography and Kinesiology**, 46, 2019, 28-34.

Windisch, P. Schröder, C. Förster, R. Cihoric, N. Zwahlen, D. R. & Windisch, P. Y. *Accuracy of the Apple Watch Oxygen Saturation Measurement in Adults: A Systematic Review*, **Cureus**, 15 (2), 2023.

Witvrouwen, I. Van Craenenbroeck, E. M. Abreu, A. Moholdt, T. & Kränkel, N. *Exercise Training in Women with Cardiovascular Disease: Differential Response and Barriers–Review and Perspective*, **European Journal of Preventive Cardiology**, 28 (7), 2021, 779-790.

Yang, X. Lee, J. Gu, X. Zhang, X. & Zhang, T. *Physical Fitness Promotion among Adolescents: Effects of a Jump Rope-based Physical Activity Afterschool Programme*, **Children**, 7 (8), 2020, 95.

You, H. W. Tan, P. L. & AF, M. L. *The Relationship between Physical Activity, Body Mass Index and Body Composition among Students at a Pre-University Centre in Malaysia*, **IIUM Medical Journal Malaysia**, 19 (2), 2020.

Yunidar, Y. Yaskur, Y. Roslidar, R. & Syaryadhi, M. *Rancang Bangun Alat Pengukur Jarak Tempuh Lari Laun dengan Menggunakan Sensor Inertial Measurement Unit (IMU) Berbasis Mikrokontroler*, **Jurnal Rekayasa Elektrika**, 18 (1), 2022.

Zamparo, P. Cortesi, M. & Gatta, G. *The Energy Cost of Swimming and its Determinants*, **European Journal of Applied Physiology**, 120, 2020, 41-66.

Zavalishina, S. Y. Karpov, V. Y. Rysakova, O. G. Rodionova, I. A. Pryanikova, N. G. & Shulgin, A. M. *Physiological Reaction of the Body of Students to Regular Physical Activity*, **J Biochem Technol**, 12 (2), 2021, 44-47.

Zepp, J. A. & Morrisey, E. E. *Cellular Crosstalk in the Development and Regeneration of the Respiratory System*, **Nature Reviews Molecular Cell Biology**, 20 (9), 2019, 551-566.

Zhao, S. Yang, Y. Gao, Y. Zhang, Z. Zheng, T. & Zhu, Y. *Development of a Soft Knee Exosuit with Twisted String Actuators for Stair Climbing Assistance*, **In *2019 IEEE International Conference on Robotics and Biomimetics (ROBIO)***, 2019, 2541-2546.

Zouhal, H. Abderrahman, A. B. Dupont, G. Truptin, P. Le Bris, R. Le Postec, E. Sghaeir, Z. Brughelli, M. Granacher, U. & Bideau, B. *Effects of Neuromuscular Training on Agility Performance in Elite Soccer Players*, **Frontiers in Physiology**, 10, 2019, 947.

Textbooks

Barrett, K. E. Barman, S. M. Boitano, S. & Brooks, H. *Ganong's Review of Medical Physiology* (24 ed.), 2012, 619, ISBN 978-0071780032.

Hafen, B. B. & Sharma, S. *Oxygen Saturation*, [Updated 2022 Nov 23]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK525974/

Sato, K. & Sato, K. *Blood vessels-on-a-chip. In Principles of Human Organs-on-Chip,s*, Woodhead Publishing, 2023, 167-194.

Sembulingam, K. Sembulingam, P. *Essentials of Medical Physiology*, JP Medical Ltd. 2012, 587-588.

Shimon, J. M. *Introduction to Teaching Physical Education: Principles and Strategies*, Human Kinetics, Incorporated, 2019.

Seminar Paper/ Conference Proceedings

Hardiansyah, S. *The Influence of Circuit Training Method on the Enhancement of Physical Fitness of Sports Education Department Students*, In: Proceedings The 1ST Yogyakarya International Seminar on Health, Physical Education, and Sports Science: Evidence-based Practice of Sports Scinece in Education Performance, and Health, Yogyakarta, 2017.

Hardiansyah, S. Zalindro, A. & Maifitri, F. *Effect of Circuit and Interval Training Method on the Improvement of Physical Fitness*, In 1st Progress in Social Science, Humanities and Education Research Symposium (PSSHERS 2019), Atlantis Press, 2020, 914-918.

Mohammed, V. A. Mohammed, M. A. Mohammed, M. A. Logeshwaran, J.& Jiwani, N, *Machine Learning-based Evaluation of Heart Rate Variability Response in Children with Autism Spectrum Disorder*, *In 2023 Third International Conference on Artificial Intelligence and Smart Energy (ICAIS),* 2023, 1022-1028.

Rashid, N., Rahman, M. M. Ahmed, T. Kuang, J. & Gao, J. A, *Breathie: Estimating Breathing Inhale Exhale Ratio using Motion Sensor Data from Consumer Earbuds*, *In ICASSP 2023-2023 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, 2023, 1-5.

Theses/ Dissertations (Unpublished)

Ajayi, O. A. Effects of Aerobic Dance Circuit Training Programmeme on Body Composition and Cardiorespiratory Variables of Obese Female College Students in Oyo Town, Nigeria (Doctoral Dissertation), 2018.

McNabb, E. *Development of a Physical Movement Programme for Older Adults*, Doctoral Dissertation, California State University, Long Beach, 2022.

Panetta, B. L. *Physical Fitness and Academic Achievement: The Relationship between Fitness and Academic Measures of Third and Fourth Grade Students*, Doctoral Dissertation, Centenary University, 2021.

Woodruff, R. *Effectiveness of Exercise Intervention in Runners with and without Patellofemoral Pain Measured by Functional Movement Screening,* Doctoral Dissertation, University of Pittsburgh, 2022.

Schwartz, B, *Sex Differences in the Impact of A 12-Week High Intensity Interval Training Intervention on Sympathetic Transduction,* (Doctoral Dissertation), 2023.

Websites

Kamble, P. M. Matondkar, A. P. & Paul, A. *An Investigation into Health Related Physical Fitness among Physiotherapists*, Website: www. ijpot. com, 15 (1), 2021, 112.

Patel, S. Y. Jadhav, A. Yadav, T. & Bathia, K. *Assessment of Physical Health among Security Guards Working in Krishna Hospital, Karad-A Cross-sectional Study*, Website: www. ijpot. com, 13 (3), 2019, 128.

Usman, Y. B. Shittu, O. I. Aloysius, M. T. Aliyu, A. O. & Igho, V. G. *Performance Criteria of Modified Multihalver Technique for Detecting Outlying Values of Body Mass Index (BMI): A Higher Risk Factor and Prognosis ff COVID-19 Infections*, 2022.

Wood, R. J. *Complete Guide to Fitness Testing. 2010,* Available at: https://www.topendsports.com/testing/.

Appendix I

Selected Photographs

Appendix II

Ogbara Freedom Festus Circuit Training Exercise Programmeme for Treatment Groups for Eight Weeks

Week 1 and 2 (Monday, Wednesday and Friday)

Warm-up Activities (10 minutes)

Stations	Exercise	Number of Sets	Time/ Station (Sec)	Rest Between Station (Sec)
1	Medicine ball chest pass	4	40 seconds	25 seconds
2	Jumping jack	4	40 seconds	25 seconds
3	Wall sit	4	40 seconds	25 seconds
4	Plank	4	40 seconds	25 seconds
5	Rope skipping	4	40 seconds	25 seconds
6	Frog jumps	4	40 seconds	25 seconds
7	High knees	4	40 seconds	25 seconds
8	Russian twist	4	40 seconds	25 seconds
9	Plank to push ups	4	40 seconds	25 seconds

Cool Down Activities (10 minutes)

Week 3 and 4 (Monday, Wednesday and Friday)

Warm-up Activities (10 minutes)

Stations	Exercise	Number of Sets	Time/ Station (Sec)	Rest Between Station (Sec)
1	Bench stepping	5	40 seconds	25 seconds
2	Modified Push-ups	5	40 seconds	25 seconds
3	Bench squat	5	40 seconds	25 seconds
4	Abdominal crunch	5	40 seconds	25 seconds
5	Jumping jack	5	40 seconds	25 seconds
6	Glute bridges	5	40 seconds	25 seconds
7	Mountain climbing	5	40 seconds	25 seconds
8	Leg raises	5	40 seconds	25 seconds
9	Russian twist	5	40 seconds	25 seconds

Cool Down Activities (10 minutes)

Week 5 and 6(Monday, Wednesday and Friday)

Warm-up activities (10 minutes)

Stations	Exercise	Number of Sets	Time/ Station (Sec)	Rest Between Station (Sec)
1	High knee jogging	5	50 seconds	25 seconds
2	Sit up	5	50 seconds	25 seconds
3	Lunge	5	50 seconds	25 seconds
4	Push up	5	50 seconds	25 seconds
5	Burpee	5	50 seconds	25 seconds
6	Jump lunges	5	50 seconds	25 seconds
7	Side leg raise	5	50 seconds	25 seconds
8	Bicycle crunches	5	50 seconds	25 seconds
9	Glute bridges	5	50 seconds	25 seconds
10	Wall sit	5	50 seconds	25 seconds

Cool Down Activities (10 minutes)

Week 7 and 8 (Monday, Wednesday and Friday)

Warm-up activities (10 minutes)

Stations	Exercise	Number of Sets	Time/ Station (Sec)	Rest Between Station (Sec)
1	Burpee	5	60 seconds	15 seconds
2	Push up	5	60 seconds	15 seconds
3	Rope skipping	5	60 seconds	15 seconds
4	Plank	5	60 seconds	15 seconds
5	Bench squat	5	60 seconds	15 seconds
6	Scissors kick	5	60 seconds	15 seconds
7	Medicine ball chest pass	5	60 seconds	15 seconds
8	Step up	5	60 seconds	15 seconds
9	Side plank	5	60 seconds	15 seconds
10	Jump squat	5	60 seconds	15 seconds

Cool Down Activities (10 minutes)

Proposed Training Programmem for Control Group for Eight Weeks

Week 1

Topic	Objective	Activities	Duration
Concept of nutrition	To examine the meaning of nutrition.	Discuss the meaning of nutrition and its benefits	40 minutes

Week 2

Topic	Objective	Activities	Duration
Classes of food and its nutrients	To list macronutrients: carbohydrates, proteins and fats.	Discuss macronutrients and their functions.	40 minutes

Week 3

Topic	Objective	Activities	Duration
Classes of food and its nutrients	To list micronutrients: vitamins and minerals	Discuss micronutrients and their functions.	40 minutes

Week 4

Topic	Objective	Activities	Duration
Food sources	To list food sources of macro and micronutrients	Mention food sources of macro and micronutrients	40 minutes

Week 5

Topic	Objective	Activities	Duration
Nutrient requirements and recommendations	To list the nutrients required by the body	Mention the recommended nutrients required by the body	40 minutes

Week 6

Topic	Objective	Activities	Duration
Healthy eating patterns	To examine healthy eating patterns.	Discus healthy eating patterns.	40 minutes

Week 7

Topic	Objective	Activities	Duration
Dietary guidelines	To examine the meaning of dietary guidelines.	Discus the meaning of dietary guidelines.	40 minutes

Week 8

Topic	Objective	Activities	Duration
Nutrition-health related conditions	To examine the role of nutrition in preventing chronic diseases	Discus chronic diseases associated with nutrition	40 minutes

Appendix III

Physical Activity Readiness Questionnaire

	Medical Questions	YES	NO
1.	Have you ever had any pain or injuries (ankle, knee, hip, back, shoulder, etc.)?		
2.	Have you ever had any surgery?		
3.	Has your doctor ever diagnosed you with a chronic disease, such as coronary heart disease, coronary artery disease, hypertension (high blood pressure), high cholesterol or diabetes?		
4.	Has your doctor ever said that you have a heart condition and that you should only perform physical activity recommended by a doctor?		
5.	Do you feel pain in your chest when you perform physical activity?		
6.	In the past month, have you had chest pain when you were not performing any physical activity?		
7.	Do you lose your balance because of dizziness or do you ever lose consciousness?		
8	Do you have a bone or joint problem that could be made worse by a change in your physical activity?		
9	Is your doctor currently prescribing any medication for your blood pressure or for a heart condition?		
Physical Activity Questions			
10	Do you partake in any Physical activities like, tennis, playing football etc.?		
11	Do you have any hobby (reading, gardening, exploring the internet, etc.)?		
12	Do you usually engage in intense Physical Activity?		

Appendix IV

Lead City University, Ibadan
Faculty of Education
Department Of Kinesiology, Sports Science and Health Education

Informed Consent Form

In order to assess muscle strength, flexibility, cardiorespiratory fitness and body composition, the undersigned hereby voluntarily consents to engage in a circuit training programmeme.

A. **Explanation of Test**

Circuit training consist of a series of physically demanding, resistance-based, and aerobic activities separated by a set of time for each station to be completed.

B. **Risk and Discomfort**

Participants may experience unpleasant symptoms such as discomfort in the muscles and pains at the start of the training. However, the pains are merely some of the early side effects of the training, which will fade as enough oxygen is produced by consistent involvement in the exercise programmeme.

C. **Expected Benefit**

This study's findings will benefit the field of exercise physiology by expanding the literature and providing empirical data for future research. This study's findings will help participants and related professionals by demonstrating the effect of circuit training on muscle strength, flexibility, cardiorespiratory fitness, and body composition.

D. **Inquiries**

Questions regarding the procedure of this research work will be accommodated.

E. **Freedom of Consent**

Your permission to perform this exercise Programmeme is strictly voluntary. You are free to deny consent if you wish.

I ……………………………………………………………………………………………….., have read this form carefully and I fully understand the programmeme procedure. I consent to participate in this programmeme.

Signature of the participant………………………. Date………………………

I certify that I have explained to the above individual the nature and purpose, the potential benefit, risk and discomfort associated with the programmeme.

Signature of the Investigator ………………………. Date………………………

Appendix V

Pre-field Physical Fitness Parameters

	Muscle Strength (30sec)	Flexibility (cm)	Heart Rate (bpm)	Respiratory Rate (bpm)	Oxygen Saturation (%)	Body Composition
1	22.00	2.30	68.00	15.00	98.00	.86
2	23.00	2.40	70.00	17.00	98.00	.92
3	15.00	1.00	74.00	17.00	99.00	.81
4	24.00	2.40	80.00	20.00	97.00	.95
5	20.00	2.30	79.00	14.00	97.00	.92
6	20.00	2.20	74.00	16.00	98.00	.91
7	20.00	2.40	74.00	18.00	97.00	.85
8	20.00	3.00	75.00	19.00	97.00	.88
9	21.00	3.60	73.00	19.00	97.00	.85
10	22.00	3.80	75.00	20.00	97.00	.84
11	13.00	1.00	80.00	19.00	98.00	.82
12	22.00	.10	76.00	18.00	97.00	.92
13	19.00	.10	78.00	20.00	96.00	.87
14	17.00	1.10	78.00	19.00	97.00	.87
15	18.00	1.60	82.00	19.00	96.00	.86
16	6.00	.20	80.00	19.00	97.00	.82
17	8.00	.10	81.00	20.00	98.00	.84
18	10.00	.20	78.00	20.00	97.00	.89
19	10.00	.40	78.00	20.00	95.00	.90
20	5.00	.10	82.00	20.00	96.00	.83
21	22.00	2.20	69.00	14.00	98.00	.84
22	14.00	1.80	78.00	17.00	98.00	.84
23	13.00	2.60	82.00	13.00	98.00	.84
24	20.00	5.50	79.00	15.00	97.00	.84
25	20.00	2.40	73.00	15.00	97.00	.92
26	20.00	2.30	76.00	17.00	97.00	.90
27	20.00	2.20	79.00	17.00	97.00	.90
28	21.00	3.40	78.00	19.00	97.00	.88
29	21.00	4.00	78.00	16.00	97.00	.92

30	16.00	1.10	83.00	20.00	98.00	.82
31	12.00	1.20	78.00	18.00	99.00	.83
32	19.00	.20	82.00	18.00	96.00	.90
33	17.00	1.20	79.00	18.00	97.00	.88
34	18.00	1.20	78.00	19.00	97.00	.86
35	7.00	.10	82.00	20.00	98.00	.89
36	5.00	.10	78.00	19.00	96.00	.89
37	9.00	.10	77.00	21.00	96.00	.91
38	11.00	.30	78.00	20.00	97.00	.89
39	12.00	.20	81.00	20.00	95.00	.87
40	5.00	.10	83.00	22.00	97.00	.82
mean±SEM	**15.93±0.91**	**1.56±0.22**	**77.65±0.58**	**18.18±0.33**	**97.10±0.14**	**0.87±0.01**

Appendix VI

Post-field Physical Fitness Parameters

	Muscle Strength (30sec)	Flexibility (cm)	Heart Rate (bpm)	Respiratory Rate (bpm)	Oxygen Saturation (%)	Body Composition
1	22	2.4	70	15	98	0.86
2	20	2.3	72	17	98	0.92
3	12	1.1	73	17	99	0.82
4	24	2.4	80	19	97	0.95
5	21	2.3	81	14	97	0.91
6	21	2.3	77	17	98	0.91
7	20	2.4	74	18	97	0.85
8	20	2.9	75	19	97	0.88
9	22	3.6	74	20	97	0.85
10	21	4.1	75	20	97	0.84
11	10	1	84	19	98	0.82
12	22	0.2	76	18	97	0.92
13	20	0.2	78	21	96	0.87
14	17	1.1	78	19	97	0.86
15	17	1.7	82	19	96	0.86
16	7	0.3	84	19	97	0.82
17	5	0.1	80	20	98	0.83
18	10	0.2	78	20	97	0.89
19	11	0.4	82	21	95	0.9
20	4	0.2	84	20	96	0.84
21	26	6	65	13	98	0.83
22	19	4.1	70	13	98	0.83
23	25	4	60	12	98	0.82
24	22	7	77	13	97	0.83
25	28	3.8	70	14	98	0.91
26	24	4.4	70	15	98	0.88
27	26	6.3	76	14	97	0.9
28	26	6.8	71	13	97	0.87

29	26	5.6	68	12	98	0.91
30	20	3.2	70	15	98	0.81
31	16	3.8	69	14	99	82
32	20	5.1	60	14	96	0.88
33	19	5.2	70	15	97	0.87
34	19	2.9	68	14	98	0.78
35	10	1.5	78	15	98	0.88
36	12	1	74	16	96	0.88
37	11	0.8	77	17	97	0.89
38	17	0.6	68	15	98	0.88
39	14	0.9	73	18	95	0.86
40	10	0.7	80	18	97	0.81
mean±SEM	**17.90±0.99**	**2.62±0.32**	**74.28±0.95**	**16.55±0.43**	**97.25±0.15**	**0.86±0.01**

Appendix VII

Ethical Approval

Lead City University (LCU)

Motto: Knowledge for Self-reliance

Lagos - Ibadan Expressway, Toll Gate Area, Ibadan, Oyo State, Nigeria
Email: lcu.hrec@lcu.edu.ng

NHREC

University Research Ethics Committee

PROJECT TITTLE:	**EFFECT OF AN 8-WEEK CIRCUIT TRAINING PROGRAMME ON STRENGTH, FLEXIBILITY, CARDIORESPIRATORY FITNESS, AND BODY COMPOSITION OF ACADEMIC STAFF OF BAYELSA MEDICAL UNIVERSITY, YENAGOA, BAYELSA STATE NIGERIA**
PROJECT NUMBER:	**LCU-REC/23/226.**

APPROVAL LETTER

The above-named proposal has been adequately reviewed; the protocol and safety guidelines satisfy the conditions of *LCU-REC* policies regarding experiments that use human subjects. Therefore, the study under its reviewed state is hereby approved by the LCU-Research Ethics Committee.

Prof. Olusola Ladokun

Name of LCU-REC Chairman ....

Dr. Folahanmi Akinsolu

Name of LCU-REC Secretary ....

This approval is given with the investigator's Declaration as stated below;

By signing below I agree/certify that:

1. I have reviewed this protocol submission in its entirety and that I am fully cognizant of, and in agreement with all submitted statements.
2. I will conduct this research study in strict accordance with all submitted statements except where a change may be necessary to eliminate apparent immediate hazard to a given research subject.
   - I will notify the LCU-REC promptly of any change in research procedures necessitated in the interest of the safety of a given research subject.
   - I will request and obtain LCU-REC approval of any proposed modification to the research protocol or informed consent document(s) prior to implementing such modifications.

Appendix VIII

Letter of Introduction

Lead City University (LCU)

Motto: Knowledge for Self-reliance

Lagos – Ibadan Express Way, Toll Gate Area P.O. Box 30678, Secretariat, Ibadan, Oyo State, Nigeria.

Department of Kinesiology, Sports Science & Health Education

Head of Department
Dr. Faderera A. ADEPOJU
B.Sc. (Ib.), M.Sc(Ib), Ph.D(Ib) Neurophysiotherapy, AMNIM
Department of Physiotherapy and Sports Science
Tel: 08030474886; Email: mofiaderera@yahoo.com & faderera.adepoju@*lcu.edu.ng*

21st July, 2023

Dean, Students Affairs
Pls, allow the Research student to use the University sports field for his research.
25/07/2023

The Vice Chancellor,
Bayelsa Medical University
Yenagoa, Bayelsa State,
Nigeria.

Dear Ma/Sir

Introduction Letter

This is to introduce to you **Festus Freedom OGBARA** a Masters student in the above stated department. He is required to undertake a field work to collect data for his research thesis. The department requests that you kindly accord the student or assistance that may be needed to ensure the success of the exercise.

Thank you for your anticipated cooperation.

21-07-23
Dr. Faderera Adepoju
Head of Department

Cc: The Registrar
The Chairman ASUU

Bio-data

A. Personal Data

1. **Full Name:** Freedom Festus OGBARA

   Address: Department of Kinesiology, Sports Science and Health Education, Lead City University, Ibadan, Oyo State

   E-mail Address: ogbaraf@gmail.com

   Phone Number: 08038616077

2. **Date and Place of Birth:** 10th June, 1986/ Biogbolo-Epie
3. **Nationality:** Nigeria
4. **Marital Status:** Single
5. **No. of Children & their Ages:** Nil
6. **Name and Address of Spouse:** Nil
7. **Name and Address of Next of Kin:** Praise-God OGBARA; Samphino Street, Kpansia, Yenagoa, Bayelsa State

B. Educational Background

- Lead City University, Ibadan, Oyo State, Master of Science Education (In-view), Exercise Physiology, 2022-2023.
- University of Ibadan, Ibadan, Oyo State, Master of Science, Physiology (Applied and Environmental Physiology), 2016-2018.
- University of Benin, Benin City, Edo State, Bachelor of Science, Physiology, 2009 – 2013.
- Community Comprehensive Secondary School Biogbolo/ Yenizue-gene, Yenagoa, Bayelsa State, West African School Certificate (WAEC), 1999-2005.
- Community Primary School, Biogbolo/ Yenizue-gene, Yenagoa, Bayelsa State, First School Leaving Certificate (FSLC), 1993-1999.

C. Awards and Fellowships: Nil

D. **Work Experience: With Dates(including courses taught where relevant)**

- Assistant Gym Instructor (Internship). Doncont Homes and Apartments, Yenagoa, Bayelsa State. May to August, 2023.
- Research Assistant (Volunteer).Applied and Environmental Physiology Unit, Department of Physiology, University Of Ibadan.2016-2018.

- Class Room Teacher**.** Nadam International Academy, Samphino Road, Kpansia, Yenagoa, Bayelsa State. 2016-2022. I taught Biology and Health Education.
- Lecturer (National Youth Service Corps).School Of Nursing Ogoja, Ogoja, Cross River State. 2014-2015. I taught Anatomy and Physiology.

E. **Membership of Academic Professional Bodies:** Physiological Society of Nigeria (PSN)

F. Publications:

- **F. F. Ogbara,** A. O. Ige, B. O. Adele, E. O. Adewoye, *Erythrocyte Membrane Intergrity and Protein Activity in High Fat Diet Fed Male Wistar Rats*, **Nutrire** ,47, 2022, 30, https://doi.org/10.1186/s41110-022-00181-9.
- **F. F. Ogbara,** K. O. Omosigho, I. Aikpitanyi, *Neuroscience as a Tool in African Translational Research*, **Nig J Neurosci**, Manuscript_NJN_2022_017, 2022.

G. Notable Scholarly or Professional Accomplishments: Nil

H. Major Conferences/Workshops Attended:

- 4th NAPHER-SD SouthWest Conference, 25th - 28th July, 2023, at the Lead City University. Titled Current Issues in Health, Recreation and Sports for Fitness and Healthy Lifestyle.
- Biomolecular Workshop, 1ST June, 2022, at the University of Medical Sciences, Ondo, Ondo State. Titled Basic Training on Molecular Biology Techniques: Agarose Gel Electrophoresis.

I. Services in Lead City University: Nil

J. Extra Curricular Activities: Volunteering for Community Development Work, Travelling, and Sports.

K. Names and Addresses of Referees

- Prof. S. A. Adeyanju. Department of Kinesiology, Sports Science and Health Education, Lead City University, Ibadan.08034028072.
- Dr. B. O. Adele. Applied and Environmental Physiology Unit, Department of Physiology, University of Ibadan, Ibadan, Oyo State. 08062895538.

…………………….. **……………………..**

Signature **Date**

The University Compliance Certification

This is to certify that this thesis written by **Freedom Festus OGBARA** with Matric No: **LCU/PG/002896** in the Department of Kinesiology, Sports Science & Health Education, Faculty of Education, Lead City University, Ibadan is in full compliance with the approved University format and style.

……………………………………… ……………………………………

Signature **Date**

Turn-it-in Certificate

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