COMPARISON OF BONE HEALTH STATUS AND PHYSICAL FITNESS COMPONENT AMONG YOUNG MALE SEDENTARY INDIVIDUALS, FRISBEE AND FOOTBALL PLAYERS

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By

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Dissertation submitted in partial fulfilment of the requirements for the degree of Bachelor of Health Sciences

(Exercise and Sports Science)

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CERTIFICATE

This is to certify that the dissertation entitled "COMPARISON OF BONE HEALTH STATUS AND PHYSICAL FITNESS COMPONENT AMONG YOUNG MALE SEDENTARY INDIVIDUALS, FRISBEE AND FOOTBALL PLAYERS" is the bona fide record of research work done by Mr MUHAMMAD HIDAYATULLAH BIN RAZALI during the period from September 2020 to June 2021 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfillment for the degree of Bachelor of Health Science (Honours) (Exercise and Sports Science).

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly knowledge. I also declare that it has not been previously or currently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use this dissertation for teaching, research and promotional purposes.

……………………………………..
Muhammad Hidayatullah Bin Razali

Date: 22/6/2021

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LIST OF ABBREVIATIONS

BMD	Bone mineral density
BMI	Body mass index
%BF	Percent body fat
FFM	Fat free mass
SOS	Speed of sound
PT	Peak torque
PT/BW	Peak torque per body weight
AVG.P	Average power
SD	Standard deviation
±	Plus/minus
^{0}	Degree
$^{0}.s^{-1}$	Degree per second
$m.s^{-1}$	Meter per second
Nm	Newton meter
W	Watt
cm	Centimeter
kg	Kilogram
%	Percent

PERBANDINGAN STATUS KESIHATAN TULANG DAN KOMPONEN KECERGASAN FIZIKAL DALAM KALANGAN LELAKI MUDA YANG SEDENTARI, PEMAIN FRISBEE DAN PEMAIN BOLA SEPAK

ABSTRAK

Kajian ini mengkaji perbezaan antara status kesihatan tulang dan komponen kecergasan fizikal dalam kalangan lelaki muda yang sedentari, pemain frisbee danpemain bola sepak. Seramai 21 orang peserta (umur purata= 23.0 ± 0.8 tahun) telah direkrut. Terdapat tiga kumpulan, iaitu kumpulan kawalan sedentari (n=7), kumpulan frisbee (n=7) dan kumpulan bola sepak (n=7). Komposisi badan peserta-peserta diukur dengan menggunakan alat analisis komposisi badan. Ujian Wingate anaerobik dan ujian genggaman kekuatan tangan telah dilakukan. 'Peak torque' (kekuatan) dan kuasa purata otot isokinetik ekstensi dan fleksi lutut dan bahu diukur dengan menggunakan 'isokinetic dynamometer' (BIODEX) pada 3 halaju yang berbeza, iaitu $60^{0}.s^{-1}$, $180^{0}.s^{-1}$ dan $300^{0}.s^{-1}$. Sonometer tulang telah digunakan untuk mengukur kelajuan bunyi tulang (SOS) yang boleh mencerminkan ketumpatan mineral tulang pada tulang radius dan tibia. ANOVA sehala dilakukan untuk menentukan perbezaan antara kumpulan bagi parameter-parameter yang diukur. Kajian ini mendapati bahawa tidak ada perbezaan yang signifikan secara statistik bagi pengukuran tinggi badan, berat badan, indeks jisim badan, peratusan lemak badan dan jisim bebas lemak antara kumpulan kawalan sedentari, frisbee dan bola sepak. Tidak ada juga perbezaan yang signifikan secara statistik bagi pengukuran Wingate 'mean power', 'peak power', 'anaerobic capacity', 'anaerobic power' dan

‘fatigue index’, serta genggaman kekuatan tangan antara semua kumpulan. Walau bagaimanapun, nilai Wingate ‘mean power’ dan ‘peak power’ tidak signifikan secara statistik dapat diperhatikan pada kumpulan frisbee dan bola sepak dibandingkan dengan kumpulan kawalan sedentari. Tambahan pula, nilai-nilai kekuatangenggaman tangan lebih tinggi yang tidak signifikan secara statistik dapat diperhatikan pada kumpulan frisbee dibandingkan dengan kumpulan bola sepak dan kawalan sedentari. Berkenaan dengan prestasi otot isokinetik, tidak ada perbezaan yang signifikan secara statistik bagi parameter yang diukur dalam ‘peak torque’ dan kuasa purata extensi lutut, fleksi lutut dan ekstensi bahu di antara semua kumpulan. Walau bagaimanapun, terdapat nilai ‘peak torque’ dan kuasa purata bagi fleksi bahu yang lebih tinggi bagi kumpulan frisbee dibandingkan dengan kumpulan- kumpulan kawalan sedentari dan bola sepak. Tidak ada perbezaan yang signifikan secara statistik dalam semua parameter SOS tulang yang diukur pada lengan dan kaki dominan dan bukan dominan peserta-peserta antara kawalan sedentari, pemain frisbee dan pemain bola sepak. Hasil keputusan kajian ini menunjukkan bahawa penglibatan diri dalam sukan frisbee dan bola sepak dapat meningkatkan komponen kecergasan fizikal berbanding dengan gaya hidup sedentari di kalangan lelaki muda.

COMPARISON OF BONE HEALTH STATUS AND PHYSICAL FITNESS COMPONENT AMONG YOUNG MALE SEDENTARY INDIVIDUALS,FRISBEE AND FOOTBALL PLAYERS

ABSTRACT

This study investigated the differences in bone health status and physical fitness components among young male sedentary individuals, frisbee and football players. A total of 21 partcipants (mean age= 23.0 ± 0.8 years) were recruited. There were three groups including sedentary control group (n=7), frisbee group (n=7) and football group (n=7). Participants' body composition was measured by using a body composition analyzer. Wingate anaerobic test and handgrip strength test were performed. Isokinetic knee and shoulder extension and flexion muscular peak torque (strength) and power were measured using an isokinetic dynamometer (BIODEX) at 3 different angular velocities, i.e. $60^0.s^{-1}$, $180^0.s^{-1}$ and $300^0.s^{-1}$. A bone sonometer was used to measure bone speed of sound (SOS) which reflect bone mineral density of radius and tibia bone. One-Way ANOVA was performed to determine the differences of the measured parameters among groups. The present study found that there were no statistically significant differences in body height, body weight, body mass index, percentage of body fat and fat-free mass among sedentary control, frisbee and football groups. There were also no statistically significant differences in Wingate mean power, peak power, anaerobic capacity, anaerobic power and fatigue index, as well as handgrip strength between the groups. However, non-statistically significant Wingate mean power and peak power were observed in frisbee and football groups when compared to sedentary control

group. In addition, non-statistically significant higher handgrip strength values were observed in frisbee group than football and sedentary control groups. Regarding isokinetic muscular performance, no statistically significant differences were observed in measured parameters of isokinetic knee extension, knee flexion and shoulder extension peak torque and average power among all the groups. Nevertheless, there were statistically significantly greater values of isokinetic shoulder flexion peak torque and average power ($p<0.05$), in frisbee group than sedentary control and football groups. There were no statistically significant differences in all the bone SOS measured parameters in dominant and non-dominant arms and legs of the participants among sedentary controls, frisbee and football players. This study results implying that participation in frisbee and football can improve physical fitness component compared to sedentary lifestyle in young males.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Frisbee sports are a diverse collection of games that focus on using a flying disc to hit the target of the game. The history of the flying disk as a sports tool can be traced back to Yale University in the pre-World War II era (Talip *et al.,* 2019). Frisbee competition does not require a referee or judge, the players follow rules of the game themselves. The general purpose of a frisbee team is to advance the disc across the opponent's target line into an end zone on a field 110 yd (100 m) long and 45 yd (37 m) wide bypasses that can be made in any direction. No players can keep the disk for more than 10 seconds, and there is a change of control between teams where the disk is intercepted, when the disk hits the ground on a throw, or if the disk is caught out of bounds. Aerobic and anaerobic endurance, running speed, long-throwing accuracy and jumping strength are vital fitness components of frisbee players (Talip *et al.*, 2019).

Football which is also known as soccer, particularly in North America is widely recognized as the most popular single sport in the world. The game is played at each end of a rectangular field called a pitch with a goal. The objective of the game is to score the goal by moving the ball to the opposing goal beyond the goal line. There are four positions in football,including. goalkeepers, defenders, midfielders, and attackers which require different physiological demands and physical fitness components (Nikolaidis, 2014).

Anaerobic capacity is the ability of the muscles to respond in the form of very short maximum and supramaximal physical activities to the workouts. Anaerobic workouts refers to the activity that use of explosive power and a load that exceeds anaerobic threshold and can cause fatigue. Anaerobic activity cannot be maintained for extended periods because the skeletal muscles function above the metabolism of steady-rate oxygen and through anaerobic metabolism (Sözen & Akyıldız, 2018).

Muscular strength is defined as the maximum force a muscle can exert in one single effort against some form of resistance. Building muscle strength could improve balancing of the body, makes it easier to perform everyday actions (Manoharan *et al.*, 2018). Muscular strength depends on gender, age and physical attributes. High level of muscle strength can improve work capacity and enhance athletic performance. Muscular power is defined as the capability to exert full force in the shortest possible time, such as in the acceleration, jumping and throwing of instruments. Training such as lifting weights and throwing implements can be performed to improve muscular power.

Dual energy X-ray absorptiometry (DEXA) is globally accepted as a standard technique for measuring bone mineral density, performed typically at the lumbar spine and femoral neck. Nevertheless, bone sonometer can also be used to measure bone speed of sound which can reflect bone mineral density. It is known that weight-bearing exercises are effective in enhancing bone health (Ooi *et al*, 2009). Frisbee and football are considered as field team sports involving weight-bearing activities (Krustrup and Mohr, 2015; Alfredson *et al.*, 1996). Therefore, it is expected that involvement in frisbee and football may elicit beneficial effects on individuals bone health status reflected by bone speed of sound measured in this present study.

Recently, Abidin *et al.* (2018) investigated physiological profiles and bone health status of Malay adolescent male boxing, Muay Thai and Silat athletes. Meanwhile, Samsudin and Ooi (2018) investigated bone health status, isokinetic muscular strength and power, and body composition of Malay adolescent female Silat and taekwondo practitioners. To our knowledge, to date, the study on the comparison of bone health status and physical fitness component among Malaysian young male sedentary individuals, frisbee and football players in one single study has not been carried out. Therefore, the present study was proposed.

1.2 OBJECTIVES OF THE STUDY

1.2.1 General objective

To compare bone health status and physical fitness components among young male sedentary individuals, frisbee and football players.

1.2.2 Specific objectives

1. To determine the differences of bone health status among young male sedentary controls, frisbee and football players.

2. To determine the differences in Wingate anaerobic capacities among young male sedentary controls, frisbee and football players.

3. To determine the differences in muscular strength and power among young male sedentary controls, frisbee and football players.

1.3 HYPOTHESES OF THE STUDY

Ho_1: There are no differences in bone health status among young male sedentary controls, frisbee and football players.

HA_1: There are differences in bone health status among young male sedentary controls, frisbee and football players.

Ho_2: There are no differences in Wingate anaerobic capacities among young male sedentary controls, frisbee and football players.

HA_2: There are differences in Wingate anaerobic capacities among young male sedentary controls, frisbee and football players.

Ho_3: There are no differences in muscular strength and power among young male sedentary controls, frisbee and football players.

HA_3: There are differences in muscular strength and power among young male sedentary controls, frisbee and football players.

1.4 SIGNIFICANCE OF THE STUDY

To our knowledge, to date, information on the comparison of bone health status and physical fitness components among young male sedentary controls, frisbee and football players in one single study are limited. Therefore, the present study was proposed for adding new scientific information on bone health status and physical fitness components among young male sedentary controls, frisbee and football players in the field of sports science.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF FRISBEE AND FOOTBALL

Frisbee is a game that originated in the 1960s, known as worldwide sport that is now played in more than 50 countries, where popularity has grown (Weatherwax *et al.*, 2015). Frisbee includes two teams with players throw a disc to each other until they have crossed the goal of the opponent. Possession changes hands when intercepting the disc, touching the ground or leaving the boundaries. Frisbee is playedin 10-minute quarters under professional rules. Frisbee can be played in both pickup games and organized competitive leagues. In 2000, a group of expatriate teachers from Kuala Lumpur International School played the first game of Ultimate on Malaysian soil (Talip *et al.*, 2019). According to Rodrigo (2017), Malaysia has become a famous venue for international competitions, with its Malaysian stage Frisbee Open in 2016 with 800 competitors across 32 teams participated in the annual competition.

Football is a team sport and also known as the world's most popular sport, played by two teams of 11 players using a spherical ball. Two teams compete to get the ball into the goal of the other team (between the posts and under the bar) and thus score a goal. The winner is the team that scores more goals than another team at the end of the game. if both teams score an equal number of goals then the game is a draw. The Football Association of Malaysia (FAM) is the governing body responsible for the organisation within the country of the Malaysian national football team.

2.2 ANTHROPOMETRY AND BODY COMPOSITION OF FRISBEE AND FOOTBALL PLAYERS

Despite being a limited-contact sport, ultimate frisbee is a physically demanding sport. In frisbee, there are some differences in the anthropometric characteristics and the body structure, which are depending on the position of play (Weatherwax *et al.*, 2015). Running, cutting, defending, jumping, catching, and diving/laying out for a disc are all common skills or biomechanics in ultimate frisbee. Ultimate frisbee adheres to the American College of Sports Medicine's intensity guidelines, which are designed to encourage daily bursts of physical activity (Weatherwax *et al.*, 2015). Frisbee combines intense running with high aerobic loading which can affect body composition (Krustrup & Mohr, 2015; Weatherwax et al., 2015).

Football is a sport involves various complex kinesiological movements which are characterized by cyclical or acyclical movements (Sermaxhaj *et al.*, 2017). Understanding the nature of certain anthropological capabilities and characteristics of the player is important for coaches in planning training program for development of football players to improve performance (Gardasevic and Bjelica, 2020). Hoare (2000) recognized that there are some differences in the morphological profile of players holding different team positions in sports of ball games such as football, basketball, handball, volleyball, and rugby. According to Gardasevic and Bjelica (2020), findings of morphological characteristics and body composition are important for complex sports games like football.

2.3 PHYSICAL FITNESS COMPONENT

2.3.1 Anaerobic Capacities in Frisbee and Football Players

Anaerobic capacities are needed in frisbee sports so that players can perform high-intensity activities in the absence of oxygen. During the Ultimate Frisbee (UF) game, players regularly perform sprints, accelerations, decelerations, changes of direction, jumps, and lateral displacements. In reality, during a match play, collegiate male UF players cover 4.7 ± 0.5 km, including ~600 m of high-intensity running (14–22 km/h) and ~200 m moving above 22 km/h during match-play (Krustrup & Mohr, 2015). Furthermore, a during match-play, recreational, male and female players experience high physical loading across all movement planes covering 3 km, as measured by accelerometer (Madueno et al., 2017).

With regards to football, this sport involves the use of anaerobic energy system in sprinting and acceleration (Little and Williams, 2003). According to Kalinski *et al.* (2002), team sports events such as football, handball and basketball consist of different rapid movement patterns, such as forward, side-to-side and backward shuffles), running at various intensities (such as from jog to sprints), kicks, tackles, turns jumps, and continuous strong muscle contractions to control the ball under defensive pressure. According to Stolen *et al.* (2005), soccer elite-level players ran about 10 km at an average speed close to the anaerobic threshold during a 90-minute game (80-90 % of maximum heart rate). Therefore, anaerobic endurance training can be important helping to delay the onset of fatigue as well as reducing the fatigue effect (Sporis *et al.*, 2014).

2.3.2 Muscular Strength and Power in Frisbee and Football Players

Koeble and Seiberl (2020) mentioned that functional adaptations in the glenohumeral joint, especially changes in the range of motion (ROM) or strength parameters of internal and external rotation, are well documented for athletes in throwing, pitching or striking sports like frisbee, tennis, baseball and volleyball. Muscular strength and power are important in producing efficient movements in frisbee.

Muscular strength and power are also important in football games. According to Maly *et al.* (2016), lower limb strength is extremely important as muscle groups (e.g., quadriceps, hamstrings and calves) must produce and withstand high forces throughout a football match including acceleration, deceleration, running, kicking turning tackling, direction changes and other movement activities. Morgan and Oberlander (2001) identified that about 75 % of football injuries occur in the lower limbs. Lower limb strength is a determinant of injury risk (Fousekis *et al.*, 2010). The time available for generating force is limited in most sports activities, such as sprinting, running, or throwing a ball. For example, when kicking, the foot contacts the ball as ~50ms^{-1} for a short time. Muscular strength is determined by force and speed, thus it can be improved with maximum force, maximum speed or both.

2.4 BONE HEALTH STATUS AMONG FRISBEE AND FOOTBALL PLAYERS

Frisbee incorporates physical skills found in other sports such as football, basketball and rugby. The sport requires players to run, cut, jump throw, defend, catch and sometimes layout (dive horizontally with an outstretched arm) for the disc (Reynolds and Halsmer, 2006), it is considered as high-impact exercise. Research has shown that bone mineral density (BMD) is significantly greater in athletes compared to sedentary individuals. Also, BMD is high in athletes who involve in high-impact exercise, described as running, jumping, and weightlifting activities (Bennell *et al.*, 1997). Although previous studies have shown that some form of exercise benefit the maintenance of bone mass and structure at one age (Van Langendonck *et al.*, 2003), the specific effects of high-impact exercise of frisbee on bone health have still not been fully explored.

It was documented that athletes who are participating in sports of impact loading such as tennis, volleyball, football and gymnastics have higher bone mineral density (BMD) (Alfredson *et al.*, 1998). According to Alfredson *et al.* (1996), football is characterized by specific types of running with rapid changes in direction, stop and go action, jumping and kicking that resulting in large ground reaction forces on the skeleton, therefore it can be categorized as an impact loading sport. Some studies showed the site-specific, bone mass-increasing impact of football carries significant weight in specific skeletal regions (Soderman *et al.*, 2000). Magnusson **(**2001) reported that BMD increased in the years following the end of an active football career. Uzunca et al. (2005) reported high bone mineral density in a group of professional football players who had retired at least 10 years earlier.

To our knowledge, to date, comparisons between bone health status among Malaysian young male sedentary individuals, frisbee and football players in one single study have not been carried out. Therefore, the present study was proposed .

CHAPTER 3

METHODOLOGY

3.1 STUDY DESIGN

This study is a cross-sectional study design. Twenty-one young male participants with age ranging from 18-23 years old were recruited. There were three groups with 7 participants per group. The groups were sedentary control group (n=7), frisbee group (n=7) and football group (n=7).

This study was carried out in School of Health Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan. All the tests were conducted in the Exercise and Sport Science Laboratory, Universiti Sains Malaysia under the supervision of qualified and experienced lab technologists. All the participants were required to undergo anthropometric and body composition measurements, anaerobic capacity measurement via Wingate test, isokinetic muscular peak torque (strength) and power test, hand grip strength test and bone health status measurement of bone speed of sound using bone sonometer.

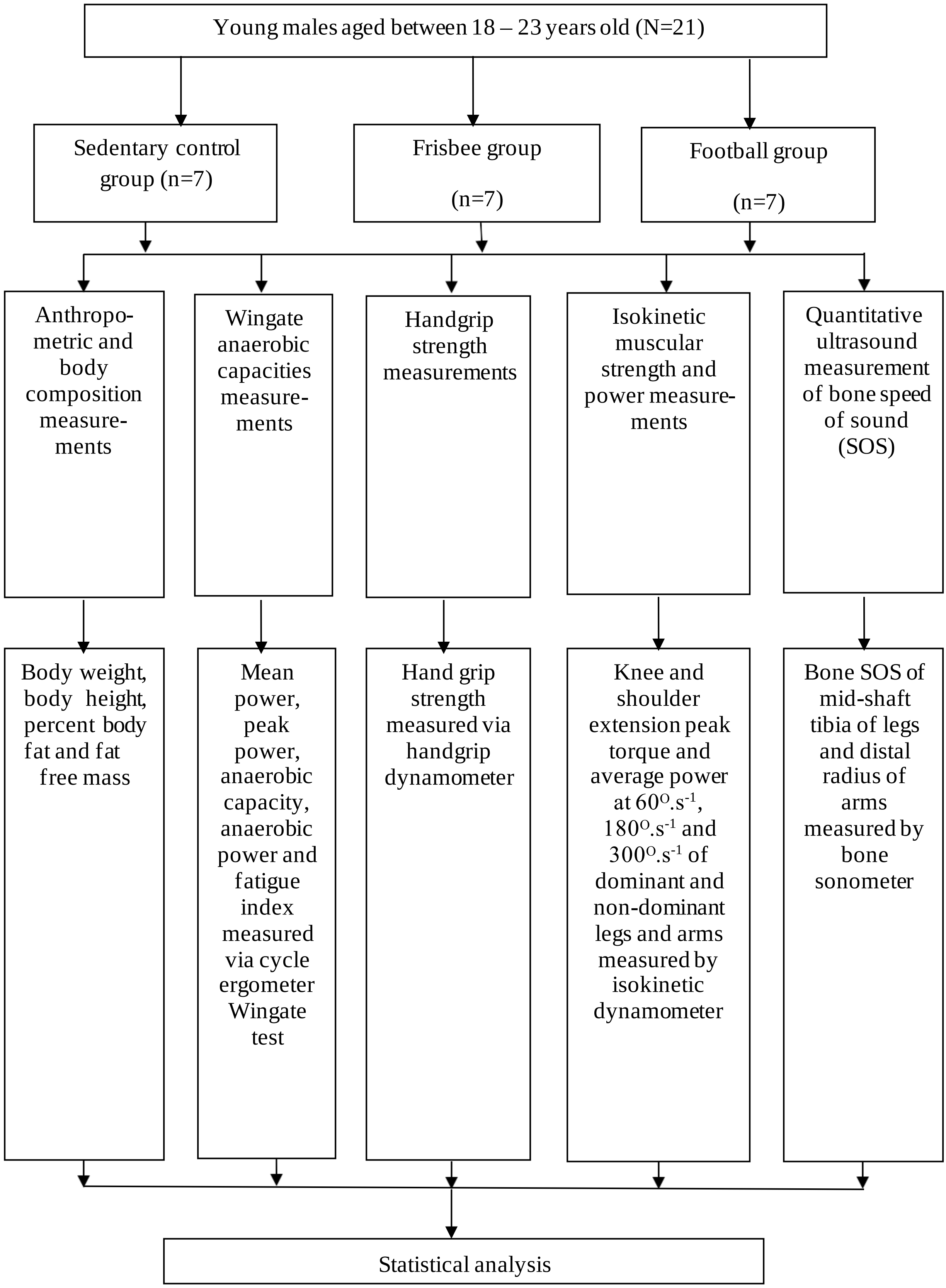

Figure 3.1 Flow chart of the experimental design

3.2 RECRUITMENT OF PARTICIPANTS

All participants of young male sedentary controls, frisbee and football players with age ranged between 18-23 years old were recruited from Universiti Sains Malaysia, Kubang Kerian, Kelantan. The participants who met the inclusion criteria and agreed to participate in this study had given their written consent.

3.3 INCLUSION AND EXCLUSION CRITERIA OF THE PARTICIPANTS

3.3.1 Inclusion criteria

3.3.1.1 Frisbee and football players participants

The inclusion criteria of the frisbee and football players were young male with age ranged between 18 and 23 years old and representing health campus of Universiti Sains Malaysia in either frisbee or football competitions, had been involved in either frisbee and football sports for at least two years.

3.3.1.2 Sedentary individual participants

The inclusion criteria of the sedentary individual participants were young males with age ranged between 18 and 23 years old and were not involved in any competitive sports and exercised less than two times per week.

3.3.2 Exclusion criterion

The exclusion criterion of the participants was having any acute or chronic diseases.

3.4 SAMPLE SIZE CALCULATION

The sample size used in this study was calculated by using PS Power and Sample Size Calculation version 3.0.43. Based on a study which was carried out by Rahim *et al.* (2016), the power of the study was set at 80% with 95% confident interval, the standard deviation observed was 11.27 of power and the mean difference was 15. The calculated sample size was 10 per group. The actual number of participants recruited in the present study was 7 per group, with a total of 21 participants. This is the maximum number of the participants we managed to achieve despite maximum effort has been put in for recruiting participants during the covid-19 pandemic period.

3.5 STUDY PROCEDURES

3.5.1 Anthropometric and Body Composition Measurements

Body height and weight of the participants were measured barefooted and in light clothing condition via stadiometer scale (Seca 220, Hamburg, Germany). The height and weight of the participants were recorded nearest to the 0.5cm and 0.1 kg respectively. Body composition of the participants such as percent body fat (% BF) and fat-free mass (FFM, kg) were measured using a body composition analyser (Tanita, TBF-140 Japan).

3.5.2 Physical Fitness Component Measurements

3.5.2.1 Anaerobic Capacity Measurement via Wingate Test

In Wingate anaerobic capacity test, the participants were required to perform 30-second maximal cycling on a cycle ergometer (H-300-RLode, Groningen, Holland). Before testing, necessary information such as body weight, gender, date of birth and type of sports was keyed into the system. The participants selected their optimal seat height on a cycle ergometer. The seat height was adjusted so that no more than 5 degrees of knee flexion was present when the leg was fully extended. Then, each participant warmed up by pedalling for about 3 minutes on the cycle ergometer. The actual testing procedure consisted of the participants performing a 10-second countdown phase, a 30-second all-out pedalling phase and an active recovery phase. All participants were verbally encouraged to continue to pedal as fast as they can for the entire 30 seconds. Mean power (MP), peak power (PP), anaerobic capacity (AC), anaerobic power (AP) and fatigue index (FI) were measured and recorded respectively throughout the 30-second cycling test.

3.5.2.2 Hand Grip Strength Test

For hand grip strength test, a handgrip dynamometer (JAMAR J00105, USA) was used. Firstly, participants held a handgrip dynamometer by dominant hand with the arm at the right angles and the elbow at the side of the body. Then the dynamometer was gripped as hard as possible for 5 seconds with no other body movement involved. Next, all the steps were repeated for non-dominant hand. Three trials were repeated and the best score was recorded.

3.5.2.3 Isokinetic Muscular Strength and Power Test

An isokinetic dynamometer (Biodex Multi-Joint system 3 Pro, New York) was used in the measurement of the isokinetic knee and shoulder extension muscular peak torque (strength) and power. The guidelines of the Biodex isokinetic dynamometer operations manual were followed. A warm-up session was carried out before the isokinetic test. Participant's descriptive data such as body height, weight, gender, date of birth, dominant and non-dominant limbs were keyed into the computer program prior to the warm-up session.

i. Knee Extension and Flexion Protocol

Before the test, the participants were seated while leaning against a backrest tilted at 85^{O} from the horizontal plane. Straps were applied to the chest, hip and thigh on the tested sites to minimize body movements during the test. Shoulder straps were applied diagonally across the chest to prevent excessive upper body movement, hip strap was applied across the pelvic and thigh strap was applied across the dominant side. Knee attachments were attached to the dynamometer. Then, the chair was moved approximately near the output shaft of the dynamometer. Subsequently, the dynamometer shaft red dot was aligned with the red dot on the attachment. The lateral femoral epicondyle was palpated and used as a bony landmark for matching the axis rotation of the knee joint and the axis rotation of the dynamometer shaft. The calf pad was placed 2 inches proximal to the lateral malleolus and secured with the padded shin strap. Next, participants were asked to extend their knees to set the limit away and flexed the knee at 90^{O} to set the limit toward. Throughout the test, the participants were instructed to grasp the sides of the chair. The whole procedure was fully informed to all the participants before performing this test. The participants perform five repetitions forthe 60^{O}.s^{-1} angular velocity, 10 repetitions for the 180^{O}.s^{-1} angular velocity and 10 repetitions for the 300^{O}.s^{-1} angular velocity, both during extension and flexion. At each speed setting, the participants were given 20 seconds to rest between each angular velocity. Verbal encouragement was given to the participants in an attempt to achieve maximal effort level. On completion of the test on one leg, the thigh strap wasunstrapped. Then, the same protocol was followed with the opposite leg.

ii. Shoulder Extension and Flexion Protocol

Prior to the test, each participant was seated on the chair. To minimize body movement during the test, straps were applied to the chest, hip and thigh on the tested site. Chest straps were applied diagonally across the chest to prevent excessive upper body movement. Then, the chair was rotated to 15 degrees and moved approximately near to input shaft of the dynamometer. The humerus was aligned with a rotational axis of the dynamometer. The length of the lever arm was adjusted so that the participant's dominant hand was straight and comfortable. The angle of flexion was set near the participant's knee. The participants were asked to lift the lever to set the limit away at 90^{O}. Throughout the test, the participants were instructed to grasp the sides of the chair using a non-tested hand. Five maximal repetitions were performed at a $60^{O}.s^{-1}$ angular velocity, 10 maximal repetitions were performed at $180^{O}.s^{-1}$ angular velocity and another 10 maximal repetitions were performed at $300^{O}.s^{-1}$ angular velocity, both during extension and flexion. At each speed setting, the participants were given 20 seconds to rest between each angular velocity. The participants were encouraged verbally to achieve their maximal results during the test. Then, the same protocol was followed with the opposite upper limb.

3.5.3 Quantitative Ultrasound Measurements of Bone Speed of Sound (SOS) by using Bone Sonometer

Quantitative ultrasound measurements of bone speed of sound (SOS, $m.s^{-1}$) which reflects bone mineral density was carried out by using a bone sonometer (Sunlight Mini Omni™, Petah Tikva, Israel). The participant's middle shaft tibia of the legs and distal radius of their arms for both dominant and non-dominant legs and arms were measured. Prior to the measurements, a system quality verification of the bone sonometer was carried out. Each participant was seated with the tested forearm supported on a table and ultrasound gel was applied to the skin surface at the measurement site. The placement of the handheld probe was on the radius at the midpoint between the olecranon process of the ulna and the tip of the distal phalanx of the third digit. The transducers within the probe were rotated around the distal radius slowly by the tester without lifting the probe from the skin surface. The same procedure was applied at the middle shaft of the tibia which was the midpoint between the plantar surface of the heel and the proximal edge of the knee. The measurements of both sites were repeated at least three times for each measurement site until the speed of ultrasound (SOS) (in $m.s^{-1}$) was determined by the inbuilt computer program. The result of the bone speed of sound was recorded.

3.6 STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 25.0. One way analysis of variance (ANOVA) was performed to determine differences of the measured parameters among three study groups. The results are presented as means and standard deviation; mean ± SD. The acceptance level of significance was set at $p<0.05$.

CHAPTER 4

RESULTS

4.1 PHYSICAL CHARACTERISTICS AND BODY COMPOSITION

A total of 21 participants, i.e. 7 participants represented sedentary control group, 7 participants represented frisbee group and 7 participants represented football group. The mean age of all the participants was 23 ± 0.8 years old. **Table 4.1** illustrates the mean age, body height, body weight, body mass index (BMI), percentage of body fat (% BF) and fat-free mass (FFM) of the participants in sedentary control, frisbee and football groups.

There were no statistically significant differences in body height, body weight, body mass index, percentage of body fat and fat-free mass among sedentary control, frisbee and football groups.

Table 4.1: Mean age, body height, body weight, body mass index (BMI), percent body fat (% BF) and fat free mass (FFM) of the participants in sedentary control, frisbee and football groups

	Sedentary control group (n=7)	Frisbee players (n=7)	Football players (n=7)	*p* values		
				Frisbee versus sedentary	Football versus sedentary	Frisbee versus football
Age (years)	22.9 ± 0.7	23.0 ± 0.8	23.0 ± 1.0	1.000	1.000	1.000
Body height (cm)	165.9 ± 4.0	168.9 ± 5.0	168.0 ± 3.7	0.599	1.000	1.000
Body weight (kg)	65.1 ± 15.5	71.2 ± 8.0	68.0 ± 13.8	1.000	1.000	1.000
BMI ($kg.m^{-2}$)	23.5 ± 5.0	25.0 ± 3.0	24.1 ± 4.5	1.000	1.000	1.000
% BF (%)	22.4 ± 7.0	24.2 ± 5.1	21.9 ± 6.1	1.000	1.000	1.000
FFM (kg)	49.8 ± 8.8	53.6 ± 3.0	52.4 ± 6.4	0.873	1.000	1.000

Values are expressed as means ± SD.

Abbreviations: BMI = Body mass index; % BF = Percent body fat; FFM = Fat-free mass

4.2 WINGATE ANAEROBIC CAPACITIES

Table 4.2 shows the results of the Wingate anaerobic capacity test in sedentary control, frisbee and football groups. There were no statistically significant differences in Wingate mean power, peak power, anaerobic capacity, anaerobic power and fatigue index among all the groups. Wingate mean power and peak power were higher in frisbee and football groups when compared to the sedentary control group.

Table 4.2: Wingate anaerobic capacities in sedentary control, frisbee and football groups

Variables	Sedentary control group (n=7)	Frisbee group (n=7)	Football group (n=7)	*p* values		
				Frisbee versus sedentary	Football versus sedentary	Frisbee versus football
Mean power (Watt)	448.3 ± 32.0	463.4 ± 68.8	471.5 ± 51.6	1.000	1.000	1.000
Peak power (Watt)	537.3 ± 38.3	581.6 ± 98.8	580.6 ± 88.1	0.934	0.967	1.000
Anaerobic capacity ($Watt.kg^{-1}$)	7.2 ± 1.6	6.7 ± 1.5	7.1 ± 1.2	1.000	1.000	1.000
Anaerobic power ($Watt.kg^{-1}$)	8.6 ± 1.8	8.4 ± 2.1	8.8 ± 1.8	1.000	1.000	1.000
Fatigue index ($Watt.sec^{-1}$)	12.6 ± 8.0	14.4 ± 3.8	12.0 ± 2.2	1.000	1.000	1.000

Values are expressed as means ± SD.

4.3 HANDGRIP STRENGTH

Table 4.3 shows the results of handgrip strength test of all the participants. There were no statistically significant differences in handgrip strength of dominant and non-dominant hands among sedentary control, frisbee and football groups. However, non-statistically significant higher handgrip strength values of dominant and non-dominant hands were observed in frisbee group than football and sedentary control group.

Table 4.3: Dominant and non-dominant hand grip strength in sedentary control, frisbee and football groups

Variables	Sedentary control group (n=7)	Frisbee group (n=7)	Football group (n=7)	*p* values		
				Frisbee versus sedentary	Football versus sedentary	Frisbee versus football
Dominant hand	34.9 ± 2.5	40.0 ± 7.2	36.4 ± 6.4	0.334	1.000	0.781
Non-dominant hand	33.7 ± 4.3	40.4 ± 6.5	34.6 ± 5.6	0.107	1.000	0.189

Values are expressed as means ± SD.

4.4 ISOKINETIC MUSCULAR PEAK TORQUE (STRENGTH) AND POWER

4.4.1 Isokinetic shoulder extension and flexion peak torque, peak torque per body weight and average power

Table 4.4.1(a) shows the means of isokinetic shoulder extension peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) at $60^0.s^{-1}$, $180^0.s^{-1}$ and $300^0.s^{-1}$ in sedentary control, frisbee and football groups.

There were no statistically significant differences in isokinetic shoulder extension peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) at $60^0.s^{-1}$, $180^0.s^{-1}$ and $300^0.s^{-1}$ in sedentary controls, frisbee and football players. However, non-statistically significant higher isokinetic shoulder extension peak torque per body weight (PT/BW) values at all velocities of dominant and non- dominant arms were observed in frisbee group than football and sedentary control groups.

Table 4.4.1(a): Isokinetic shoulder extension peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) in sedentary controls, frisbee and football groups

	Sedentary control group (n=7)	Frisbee group (n=7)	Football group (n=7)	*p* values		
				Frisbee versus sedentary	Football versus sedentary	Frisbee versus football
Dominant arm						
PT $60^0.s^{-1}$ (Nm)	34.1 ± 9.0	39.6 ± 13.0	29.5 ±12.3	1.000	1.000	0.363
PT/BW $60^0.s^{-1}$ (%)	55.4 ± 21.0	74.4 ± 59.4	44.6 ±20.3	0.483	1.000	0.483
AVG.P $60^0.s^{-1}$ (W)	13.1 ± 5.2	17.9 ± 11.0	10.5 ± 8.8	0.965	1.000	0.397
Non-dominant arm						
PT $60^0.s^{-1}$ (Nm)	34.4 ± 10.0	37.8 ± 12.4	30.5 ±13.5	1.000	1.000	0.816
PT/BW $60^0.s^{-1}$ (%)	55.9 ± 22.3	70.7 ± 54.9	44.0 ±10.6	1.000	1.000	0.501
AVG.P $60^0.s^{-1}$ (W)	11.4 ± 5.7	15.1 ± 9.8	11.6 ±11.6	1.000	1.000	1.000
Dominant arm						
PT $180^0.s^{-1}$ (Nm)	39.0 ± 6.7	53.2 ± 21.5	40.5 ±14.7	0.313	1.000	0.436
PT/BW $180^0.s^{-1}$ (%)	61.7 ± 12.6	100.0 ± 84	61.0 ±24.5	0.533	1.000	0.511
AVG.P $180^0.s^{-1}$ (W)	11.2 ± 4.8	15.2 ± 16.1	17.1 ±20.6	1.000	1.000	1.000
Non-dominant arm						
PT $180^0.s^{-1}$ (Nm)	53.0 ± 20.3	57.3 ± 16.9	38.3 ±12.1	1.000	0.354	0.147
PT/BW $180^0.s^{-1}$ (%)	83.6 ± 33.2	105.8 ± 78.6	58.1 ±22.4	1.000	1.000	0.290
AVG.P $180^0.s^{-1}$ (W)	8.5 ± 8.8	18.6 ± 13.4	11.6 ±13.1	0.398	1.000	0.863
Dominant arm						
PT $300^0.s^{-1}$ (Nm)	74.8 ± 20.4	83.4 ± 17.8	61.6 ±14.5	1.000	0.543	0.101
PT/BW $300^0.s^{-1}$ (%)	122.4 ± 51.7	143.2 ± 58.7	92.5 ±23.5	1.000	0.750	0.179
AVG.P $300^0.s^{-1}$ (W)	9.3 ± 3.7	11.5 ± 9.0	12.1 ±14.0	1.000	1.000	1.000
Non-dominant arm						
PT $300^0.s^{-1}$ (Nm)	73.2 ± 18.0	89.8 ± 24.0	66.3 ±20.5	0.465	1.000	0.152
PT/BW $300^0.s^{-1}$ (%)	116.3 ± 33.7	164.8 ±116.2	99.0 ±31.5	0.674	1.000	0.315
AVG.P $300^0.s^{-1}$ (W)	10.1 ± 6.6	13.8 ± 5.9	8.8 ± 7.0	0.903	1.000	0.504

Values are expressed as means ± SD.

Table 4.4.1(b) shows the means of isokinetic shoulder flexion peak torque (PT), peak torque per body weight (PT/BW) and average power (AVG.P) at $60^0.s^{-1}$, $180^0.s^{-1}$ and $300^0.s^{-1}$ in sedentary controls, frisbee and football players.

At the angular velocity of $60^0.s^{-1}$ of isokinetic shoulder flexion, frisbee group showed statistically significant higher mean values of PT ($p < 0.05$) compared to football group, and AVG.P ($p < 0.05$) compared to sedentary and football groups at the dominant arm.

At the angular velocity of $180^0.s^{-1}$ of isokinetic shoulder flexion, frisbee group showed statistically significant higher mean values of PT ($p < 0.05$) compared to football group at the dominant arm.

At angular velocity of $300^0.s^{-1}$ of isokinetic shoulder flexion, frisbee group showed statistically significant greater mean values in peak torque ($p < 0.05$) compared to sedentary control group at the non-dominant arm.

In addition, frisbee group showed non-statistically significant higher isokinetic shoulder flexion peak torque per body weight (PT/BW) values at all velocities of dominant and non-dominant arms were observed in frisbee group than football and sedentary control groups.