COMPARISON OF BONE HEALTH STATUS AND PHYSICAL FITNESS COMPONENT BETWEEN INACTIVE NON-BOWLERS AND RECREATIONAL BOWLERS

AHMAD ARIFF ZAKI BIN ABDILLAH

SCHOOL OF HEALTH SCIENCES

UNIVERSITI SAINS MALAYSIA

2021

COMPARISON OF BONE HEALTH STATUS AND PHYSICAL FITNESS COMPONENT BETWEEN INACTIVE NON-BOWLERS AND RECREATIONAL BOWLERS

By

AHMAD ARIFF ZAKI BIN ABDILLAH

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

(Exercise and Sports Science)

JULY 2021

CERTIFICATE

This study is to certify that the thesis entitled "Comparison of Bone Health Status and Physical Fitness Component Between Inactive Non-Bowlers and Recreational Bowlers" is the bona fide record of research work done by Mr Ahmad Ariff Zaki Bin Abdillah during the period from March 2021 to July 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 thesis to be submitted in partial fulfilment for the degree of Bachelor of Health Science (Honours) (Exercise and Sports Science).

Main supervisor,

Assoc. Prof. Dr. Ooi Foong Kiew

Exercise and Sports Science Programme,

School of Health Sciences,

Universiti Sains Malaysia,

Health Campus,

16150 Kubang Kerian, Kelantan.

Date: 10 JULY 2021

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted 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.

Ahmad Ariff Zaki Bin Abdillah

Date: 10 JULY 2021

ACKNOWLEDGEMENTS

First and foremost, the greatest thank is to God the Almighty for granting me with the chance, patience, strength, attention, abilities, and ideas to successfully accomplish my research project.

I would like to express my special thanks of gratitude to my supervisor, Associate Professor Dr. Ooi Foong Kiew, as well as my co-supervisor, Mr. Nurul Azuar Hamzah for helping me along my research project. They deserve a huge thank you for their kindness, guidance, and continuous advice during the planning and execution of the present research project. In addition, I would like to express my gratitude to all the staff of Exercise and Sports Science Programme, Universiti Sains Malaysia for their assistance throughout my study.

Special thanks to my parents and family members, who have always been supportive of me during my research project. I would also want to thank the Exercise and Sports Science Program lecturers at USM for their thoughts and recommendations for my research project. My thanks extend to all my classmates and friends for their support and encouragement. Finally, I want to express my appreciation to all the participants for their cooperation and commitment in this research, I truly appreciate it. I will not be able to complete my research project with their kindness and encouragement.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

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 ANTARA BUKAN PEMAIN BOLING YANG TIDAK AKTIF DAN PEMAIN BOLING REKREASI

ABSTRAK

Kajian ini mengkaji perbezaan status kesihatan tulang dan komponen kecergasan fizikal antara lelaki Malaysia yang tidak aktif bermain boling dan pemain boling tenpin. Seramai 16 orang peserta (purata umur = 27.81 ± 8.04 tahun) telah direkrut. Terdapat dua kumpulan, iaitu kumpulan bukan pemain boling yang tidak aktif (n=8) dan kumpulan pemain boling tenpin (n=8). Komposisi tubuh badan peserta diukur dengan menggunakan alat analisis komposisi badan (Tanita, TBF-140 Japan). *Peak Torque* (PT), *Peak Torque per body weight* (PT/BW) dan purata *peak torque* (AVG.P) otot ekstensi dan fleksi lutut dan bahu diukur dengan menggunakan alatan 'isokinetic dynamometer' (BIODEX) meliputi 3 halaju yang berbeza, iaitu $60°.s^{-1}$, $180°.s^{-1}$ and $300°.s^{-1}$. Alat Sonometer tulang digunakan untuk mengukur kepadatan mineral tulang radius dan tulang tibia. Ujian kekuatan cengkaman tangan, ujian kekuatan belakang dan kaki dan ujian fleksibiliti turut dilakukan. Ujian-t tidak bersandar dilakukan untuk menentukan perbezaan antara dua kumpulan bagi parameter yang diukur. Kajian ini mendapati bahawa tiada perbezaan yang signifikan secara statistik bagi berat badan, indeks jisim badan, peratusan lemak badan dan jisim bebas lemak antara kumpulan bukan pemain boling yang tidak aktif dan kumpulan pemain boling tenpin. Ketinggian badan bagi peserta dalam kumpulan pemain boling tenpin adalah lebih tinggi secara statistik berbanding kumpulan bukan pemain boling yang tidak aktif. Kumpulan pemain boling rekreasi menunjukkan nilai purata fleksi lutut (kaki yang bukan dominan) PT pada halaju $60^{o}.s^{-1}$ yang lebih tinggi secara signifikan ($p < 0.05$) berbanding dengan kumpulan bukan pemain boling yang tidak aktif.

Kumpulan pemain boling tenpin juga menunjukkan nilai purata fleksi lutut isokinetik PT (kaki yang tidak dominan) ($p = 0.057$) dan PT / BW ($p = 0.059$) pada $300^{o}.s^{-1}$ yang hampir signifikan secara statistik lebih tinggi berbanding kumpulan bukan pemain boling yang tidak aktif. Walaubagaimanapun, bagi ekstensi bahu isokinetik PT, PT / BW AVG.P pada $60^{o}.s^{-1}$ dan $300^{o}.s^{-1}$ pada lengan dominan menunjukkan nilai yang lebih tinggi yang tidak signifikan secara statistik antara kumpulan pemain boling tenpin dengan kumpulan bukan pemain boling yang tidak aktif. Begitu juga, bagi nilai ekstensi isokinetik lutut dan fleksi isokinetik PT, PT / BW dan AVG.P pada $300^{o}.s^{-1}$ untuk kaki dominan dan tidak dominan antara kumpulan pemain boling tenpin menunjukkan tidak signifikan secara statistik lebih tinggi dengan kumpulan bukan pemain boling yang tidak aktif. Disamping itu, bacaan kekuatan cengkaman tangan menunjukkan nilai yang lebih tinggi tetapi tidak berbeza secara signifikan pada tangan dominan, kekuatan belakang dan kaki dan kelenturan antara kumpulan pemain boling tenpin dengen kumpulan bukan pemain boling yang tidak aktif. Tidak ada perbezaan yang signifikan bagi semua parameter kelajuan bunyi tulang (SOS) yang diukur pada lengan dan kaki dominan dan tidak dominan antara kumpulan pemain boling tenpin dan kumpulan bukan pemain boling yang tidak aktif. Hasil kajian ini menunjukkan bahawa penyertaan dalam boling tenpin dapat meningkatkan komponen kecergasan fizikal berbanding gaya hidup tidak aktif pada lelaki Malaysia.

COMPARISON OF BONE HEALTH STATUS AND PHYSICAL FITNESS COMPONENT BETWEEN MALAYSIAN MALE INACTIVE NON-BOWLERS AND RECREATIONAL BOWLERS

ABSTRACT

This study investigated the differences in bone health status and physical fitness component among Malaysian male inactive non-bowlers and recreational tenpin bowlers. A total of 16 participants (mean age= 27.81 ± 8.04 years) were recruited. There were two groups, i.e., inactive non-bowler group (n=8) and tenpin bowlers group (n=8). Participants' body composition was measured by using a body composition analyser. Isokinetic knee and shoulder extension and flexion muscular peak torque (PT) (strength), peak torque per body weight (PT/BW), and average power (AVG.P) were measured using an isokinetic dynamometer (BIODEX) at 3 different angular velocities, i.e., $60^o.s^{-1}$, $180^o.s^{-1}$ and $300^o.s^{-1}$. A bone sonometer was used to measure bone speed of sound (SOS) which can reflect bone mineral density of radius and tibia bones. Hand grip strength test, back and leg strength test and flexibility test were performed. Independent t-test was performed to determine the differences of the measured parameters between groups. The present study found that there were no statistically significant differences in body weight, body mass index, percentage of body fat and fat-free mass between inactive non-bowler and tenpin bowler groups. Body height was statistically significant higher in tenpin bowlers than inactive non-bowlers. Tenpin bowler group showed statistically significant higher mean value of isokinetic knee flexion PT ($p < 0.05$) at the angular velocity of $60^o.s^{-1}$ at the non-dominant leg compared to inactive non-bowlers control group. Tenpin bowler group also showed statistically borderline significant higher mean values of isokinetic knee flexion PT ($p = 0.057$) and PT/BW ($p = 0.059$) at $300^o.s^{-1}$ at the non-dominant leg compared to inactive non-bowlers control group. Nevertheless, non-statistically

significant higher values of isokinetic shoulder extension PT, PT/BW AVG.P at $60^{o}.s^{-1}$ and $300^{o}.s^{-1}$ at dominant arms were observed in tenpin bowlers compared to inactive non-bowler controls. Similarly, non-statistically significant higher values of isokinetic knee extension and flexion PT, PT/BW and AVG.P at $300^{o}.s^{-1}$ of dominant and non-dominant legs were observed in tenpin bowlers compared to inactive non-bowler controls. In addition, non-statistically significant higher hand grip strength of dominant arm, back and leg strength and flexibility were observed in tenpin bowlers than inactive non-bowler controls. There were no statistically significant differences in all the bone SOS measured parameters in dominant and non-dominant arms and legs of tenpin bowler and inactive non-bowler controls. This study results implying that participation in tenpin bowling can improve physical fitness component compared to sedentary lifestyle in Malaysian males.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Tenpin bowling sports is a game where players aim to knock down 10 pins by rolling a ball towards the pins at 18-m distance. In tenpin bowling, for each pin that is knocked down, one point is scored in standard scoring, and if less than all ten pins are knocked down in two rolls in a frame, the frame is scored with the total amount of pins knocked down. When all ten pins are knocked down on the first roll, it is called strike. When all ten pins are knocked down on the first roll, the second roll is called spare.

In the environment of the bowling arena, bowling includes consideration of the player's own physical characteristics and techniques, as well as separate space (lane, approach) and ball choice to work effectively in accordance with the condition of the lane (Kim, 2019). In addition, physical fitness components such as muscular strength and power, flexibility and balance are important elements in tenpin bowling players. It is generally known that there is a close relationship between muscular fitness and bone health.

Bone mineral density (BMD) is an indicator of the bone's strength as shown by the minerals (Chisati et al., 2020). Dual energy X-ray absorptiometry (DEXA) is recognised globally as a standard BMD measurement technique usually performed on the lumbar spine and femoral neck. Nevertheless, bone sonometer can also be used to measure bone sound bone speed, which can reflect bone mineral density and represent bone health status of an individual. Weight-bearing exercises are widely known to be effective in improving bone health (Ooi *et al*, 2009). Tenpin bowling is considered a type of weight-bearing exercise. In a previous study by Young *et al.* (2011), it was found that there were differences between the loaded and non-loaded limbs of competitive tenpin bowlers in bone and muscle measurements measured by DXA and pQCT tests. Their study finding implying that participation in tenpin bowling may elicit beneficial effects on bone health.

Muscular strength and power are important in producing efficient movements in tenpin bowling especially for upper limb. To retain full control of the heavy bowling ball and remain consistent in a tenpin bowling tournament, appropriate muscle strength is required (Razman & Cheong, 2010). In the previous study by Razman & Cheong, 2010. isometric strength tests were performed on the dominant hand, and scores were normalised to body mass. Finger pinch force between the index and thumb, middle finger to thumb, third finger to thumb, flexion of the arm, flexion of the wrist, internal rotation and external rotation were evaluated.

Flexibility is one of the physical components needed for precise movement, especially in the trunk and hamstring. (Yoon, 2002). The longer distances achieved by the bowlers can be attributed to their ability to lower the centre of mass of their body more by bending the joints and stretching the muscles of the supporting lower limb more effectively during reaching.

Recently, there are some studies on study related to bone health status and physiological profile were performed such as Samsudin and Ooi (2018) was studied on bone health status, isokinetic muscular strength and power, and body composition of Malay adolescent female Silat and taekwondo practitioners. To date, information on bone speed of sound, an indicator of bone mineral density, and physical fitness component in Malaysian recreational male tenpin bowlers is limited, therefore the present study was proposed.

1.2 PROBLEM STATEMENT

The skills and movement of tenpin bowling may benefit players' health related fitness although they do not perform at a highly competitive level. Studies on physical fitness and bone health status in players participating in bowling game is important, however, limited data has been reported involving recreational players. Some existing studies in Malaysia focuses on the training aspect of bowling, for example a study by Razman and Cheong (2010), which investigated the effects of ball height during backswing on tenpin bowling performance and upper limb strength. Therefore, the present study was proposed to examine on the bone density, and selected physical fitness component in recreational male tenpin bowlers.

1.3 OBJECTIVES OF THE STUDY

1.3.1 General objective

To compare bone health status and physical fitness component between Malaysian male inactive non-bowlers and recreational tenpin bowlers.

1.2.2 Specific objectives

1. To determine the differences in anthropometry and body composition between Malaysian male inactive non-bowler controls and tenpin bowlers.
2. To determine the differences of bone health status reflected by bone speed of sound between Malaysian male inactive non-bowler controls and tenpin bowlers.
3. To determine the differences in muscular strength and power, and flexibility between Malaysian male inactive non-bowler controls and tenpin bowlers.

1.2.3 HYPOTHESES OF THE STUDY

H_{O1}: There are no differences in anthropometry and body composition between Malaysian male inactive non-bowler controls and tenpin bowlers.

H_{A1}: There are differences in anthropometry and body composition between Malaysian male inactive non-bowler controls and tenpin bowlers.

H_{O2}: There are no differences in bone health status between Malaysian male inactive non-bowler controls and tenpin bowlers.

H_{A2}: There are differences in bone health status between Malaysian male inactive non-bowler controls and tenpin bowlers.

H_{O3}: There are no differences in muscular strength and power, and flexibility between Malaysian male inactive non-bowler controls and tenpin bowlers.

H_{A3}: There are differences in muscular strength and power, and flexibility between Malaysian male inactive non-bowler controls and tenpin bowlers.

1.4 SIGNIFICANCE OF THE STUDY

To our knowledge, to date, there is limited information on the comparison of bone health status and physical fitness component between Malaysian male inactive non-bowler controls and recreational tenpin bowlers. Therefore, the present study was proposed to add new scientific information in sports science, particularly the field of tenpin bowling. The results obtained from this study can be used as reference and being applied in selection of potential bowling athletes and help to facilitate the development of specific training programmes for optimal performance of bowlers. It is hoped that sport organisations, coaches and athletes can apply the results obtained from this study for maximising an individual potential in the field of bowling.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF TENPIN BOWLING

Tenpin bowling is a game played by delivering (rolling) a ball down an alley or lane. The ball rolled toward a rack of 10 pins arranged in an equilateral triangular shape. The purpose of the game was to knock down all the pins (Strickland, 1996). Tenpin bowling has been a sport since ancient times and is generally known at a recreational level as a sport. With its inclusion into the Commonwealth (since 1998) and Asian Games (since 1978) as a medal event, it was only regularly known as a competitive sport (Razman *et al.*, 2012). It is widely considered that tenpin bowling is not a sport that is physically demanding. However, the modern ten-pin bowling game allows an athlete to have enhanced levels of physical preparation to perform. It was mentioned in Thomas *et al*. (1996) that an athlete can be able to enhance performance in the sport of tenpin bowling by engaging in physical training programme.

2.2 ANTHROPOMETRY AND BODY COMPOSITION OF TENPIN BOWLERS

Anthropometry is a simple, valid method to determine body size and proportions by measuring body length, width, circumference, and thickness of the skin fold. Over the past decade, researchers have emphasised the precision of newer techniques for measuring body composition, such as dual-energy X-ray absorptiometry (DXA), magnetic resonance imaging (MRI), and computerised tomography (CT), but anthropometry is still the most commonly used tool and has recently been used to estimate the distribution of fat (Wang *et al.*, 2006).

Body composition is one of the tissue component elements of physical fitness that make up the body and is typically used to mark the relative proportion of fat and lean body tissue. The most common factor in the measurement of body composition is fat-free mass (FFM) and the percentage of body fat. The weight of muscles, bones, ligaments, tendons, and internal organs is the amount of body fat measured by the percentage of total body mass composed of fat and lean body mass.

According to Gardasevic and Bjelica (2020), management of high-quality training processes depends on understanding the nature of certain anthropological skills and the player's characteristics and their development to improve performance. According to Hoare (2000), it is also recognised that for a variety of sports ball games, there are several variations in the morphological profile of players occupying various team positions.

Regarding research studies attempted to discriminate against bowlers in tenpin bowling by utilising strength and anthropometric attributes, one research was performed to distinguish between bowlers at different levels in which anthropometry and physiological parameters were measured. It was expected that differences would be detected between the two levels of bowlers as well as between the bowlers and non-bowlers (Razman *et al.*, 2012).

2.3 BONE HEALTH STATUS AND TENPIN BOWLERS

Bone health status is important and it has some functions that provide maximum mechanical competence with minimum weight for movement, organ protection, as well as mineral and blood homeostasis engagement (Nikander *et al.*, 2010). Bone health status can be measured by bone mineral density (BMD) and bone mineral content measurements (BMC). The bones in the foot are an important area for assessment when evaluating the effects of physical activity on bone mineral density (BMD), as they have the greatest effects of gravity during exercise (Nohara *et al.*, 2009). Significant differences in BMD and BMC between the loaded limb and the non-loaded limb have been recorded by several studies. For example, a greater bone mass has been recorded for the playing arm of squash and tennis athletes as well as the take-off lower limb of gymnasts. Bones that adapt by increasing in size and increasing accrual of bone mineral can lead to a stronger, more competent bone and can reduce bone loss later in life.

Bowling produces a unique unilateral model for the study of bone adaptation in both the upper and lower limb, as contrast to the non-throwing arm and non-slide leg, the throwing arm and slide leg are under significant mechanical load. DXA and pQCT analysis revealed significant differences between the loaded and non-loaded limbs of competitive tenpin bowlers in many bone and muscle measurements (Young *et al.*, 2011). Compared with the non-loaded distal radius, total BMC and trabecular vBMD were significantly higher in the loaded distal radius. Similar results have been reported for tennis players (Ashizawa et al. 1999).

2.4 PHYSICAL FITNESS COMPONENT OF TENPIN BOWLERS

2.4.1 Muscular Strength and Power

Koeble and Seiberl (2020) stated that for athletes in throwing, pitching or striking sports, functional adaptations in the glenohumeral joint, particularly changes in range of motion (ROM) or strength parameters of internal and external rotation, are well documented. Muscular strength and power are important in producing efficient movements in tenpin bowling especially for upper limb. To retain full control of the heavy bowling ball and remain consistent in a tenpin bowling tournament, appropriate muscle strength is required (Razman & Cheong, 2010).

In the study carried out by Razman & Cheong (2010), isometric strength tests were performed on the dominant hand, and scores were normalised to body mass. Finger pinch force between the index and thumb, middle finger to thumb, third finger to thumb, flexion of the arm, flexion of the wrist, internal rotation and external rotation were evaluated. In addition, there was no significant relationship between the velocity of ball release and average bowling results. The authors concluded that upper limb strength seems to be important to the velocity of ball release, and the upper limb strength varies between bowlers and the normal population.

2.4.2 Flexibility

The range of motion in a joint to move efficiently through a complete range of motion is flexibility. It is one of the main components of physical fitness, which is necessary for success in many sports including tenpin bowling. Flexibility is one of the physical components needed for precise movement, especially in the trunk and hamstring. (Yoon, 2002). The longer distances achieved by the bowlers can be attributed to their ability to lower the centre of mass of their body more by bending the joints and stretching the muscles of the supporting lower limb more effectively during reaching. Sit and reach, a measure that involves flexible hip extensors (hamstrings) and paravertebral muscles, which are muscle groups that are hardly extended in the bowling approach, was tested for flexibility in a study carried out by Stefopoulos *et al.* (2020).

CHAPTER 3

METHODOLOGY

3.1 STUDY DESIGN

This was a cross-sectional study. Sixteen males aged between 20-45 years old were recruited. There were two groups with 8 participants per group. The groups were male inactive non-bowler control group (n=8) and male tenpin bowler group (n=8). All the participants were age-matched before being assigned into two study groups. All the participants were required to perform anthropometric and body composition measurements, bone health status measurement of bone speed of sound using bone sonometer, hand grip strength test, back and leg strength test, and isokinetic muscular peak torque (indicator of strength) and power test, as well as flexibility measurement by sit and reach test.

This study was carried out in the School of Health Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan. All the tests were carried out under the supervision of qualified and experienced laboratory technologists at the Exercise and Sport Science Laboratory, Universiti Sains Malaysia.

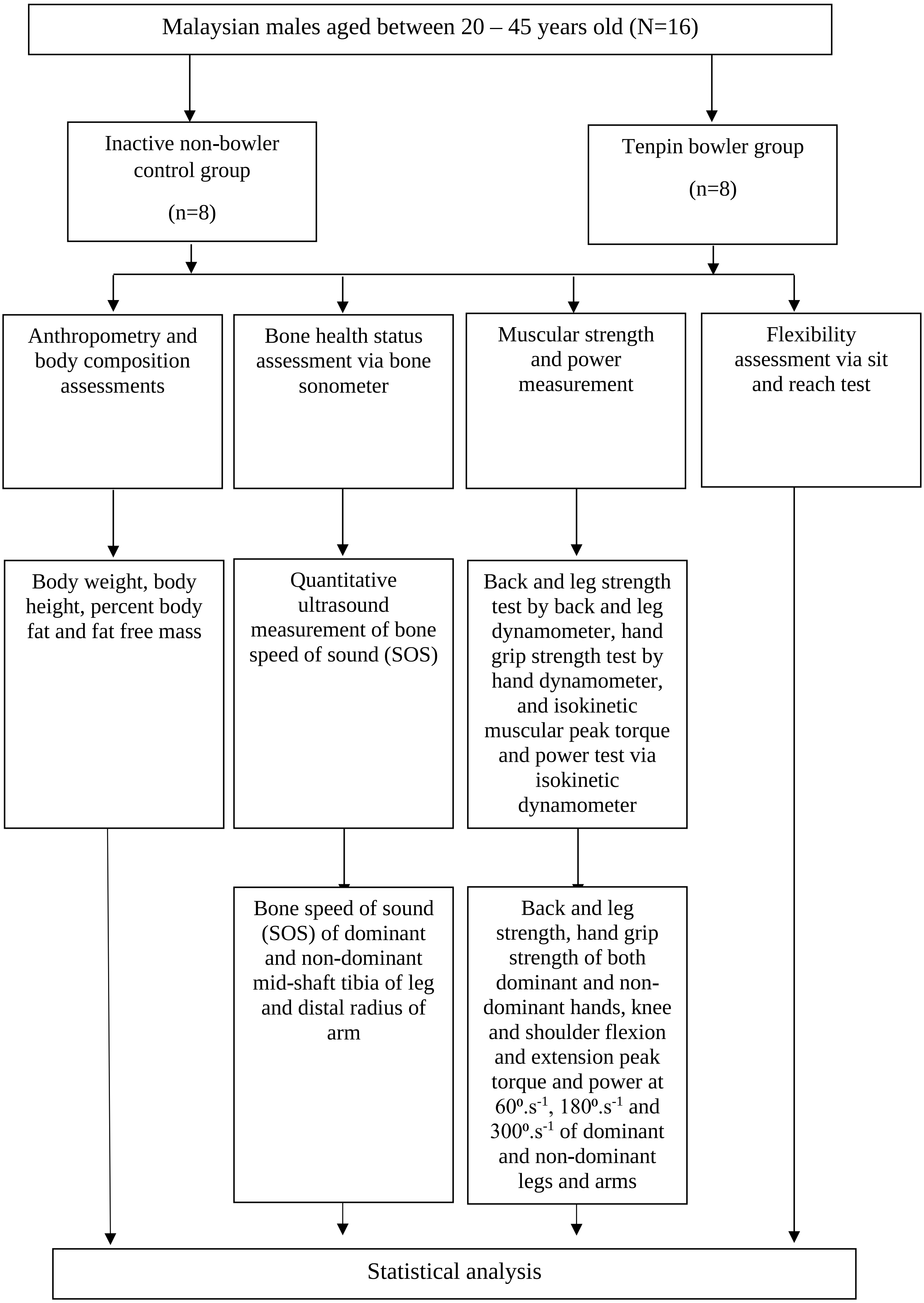

Figure 1 Flow chart of the experimental design

3.2 RECRUITEMENT OF PARTICIPANTS

A group of male inactive non-bowlers and recreational tenpin bowlers with age ranged between 20-45 years old were recruited among staff and students of Health Campus, Universiti Sains Malaysia (USM). This study used purposive sampling method. The recruitment of participant was advertised through poster. In this study, we only recruited male participants but not both males and females for maintaining homogeneity of the study.

During the first meeting with the participants, they were briefed on the details of the study design, including inclusion and exclusion criteria, termination or withdrawal, potential risks, benefits, and incentive. Then, they were asked to fill in the Participant's Information and Consent form and Participant's Material Publication Consent Form.

Involvement as participants in this study was on voluntary basis. Their participation could also be terminated if they did not complete any or all the laboratory tests. Regarding the benefits obtained from this study, participants would get to know their bone health status and physical fitness level, and they also had an opportunity to participate in sports science project.

3.3 INCLUSION AND EXCLUSION CRITERIA OF THE PARTICIPANTS

3.3.1 Inactive non-bowler control group

The inclusion criteria of participants in inactive non-bowler control group were Malaysian males aged between 20 to 45 years old, who were not involved in any competitive and recreational sports events, exercised less than two times per week, and were not engaged with tenpin bowling sport.

The exclusion criteria of the participants of this group were Malaysian males who were having any acute and chronic diseases.

3.3.2 Bowler group

The inclusion criteria of participants in tenpin bowler group were Malaysian males aged between 20 to 45 years old who were physically healthy, free from any health problems or injuries, engaged with tenpin bowling as recreational sport, had been involved in tenpin bowling sport for at least two years.

The exclusion criteria of the participants of this group were Malaysian males who were having any acute and chronic diseases.

3.4 STUDY PROCEDURES

3.4.1 Anthropometric and body composition measurements

Anthropometric parameters such as body height and body weight were measured in this study. Participants' body height was measured with barefooted and light clothing conditions via stadiometer and body weight scale (Seca 220, Hamburg, Germany). The participants' height and weight were recorded closest to 0.5cm and 0.1kg, respectively.

A body composition analyser (Tanita, TBF-140 Japan) was used to measure the participants' body weight and body composition such as percent body fat (percent BF, %) and fat-free mass (FFM, kg). Participants were required to be shoeless when using this device and wore minimal clothing for obtaining accurate results.

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

In this study, a bone sonometer (Sunlight Mini OmniTM, Petah Tikva, Israel) was used to conduct quantitative ultrasound measurements of bone speed of sound (SOS, $m.s^{-1}$) that can reflect bone mineral density. The participant's bone speed of sound (SOS) was measured at the middle shaft tibia of the legs and distal radius of their arms for both dominant and non-dominant legs and arms. The system quality verification of the bone sonometer was performed prior to the measurements. Each participant was seated with the tested forearm supported on a table and ultrasound gel was applied at the measurement site to the skin surface. 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. Without lifting the probe from the skin surface, the transducers within the probe were rotated around the distal radius slowly by the tester. 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. At each measurement site, the measurements of both sites were repeated at least three times until the ultrasound speed of sound (SOS) (in $m.s^{-1}$) was determined by the built-in computer programme.

3.4.3 Physical Fitness Component Measurements

3.4.3.1 Muscular Strength and Power Measurements

i. Hand Grip Strength Test

A handgrip dynamometer (JAMAR J00105, USA) was used for hand grip strength testing. Firstly, the participants were required to hold the dynamometer using their dominant hand with arm at the side of the body. Then, with no other body motion involved, the dynamometer was gripped as hard as possible for 5 seconds and all the steps were repeated with the non-dominant hand. Three trials were performed, and the best score was recorded.

ii. Back and Leg Strength Test

Participants were required to stand upright with both feet positioned shoulder width apart on the base of a leg dynamometer (Takei TKK1858, Japan). Before doing the test, the dial was reset to zero. The arms of the participant hang straight down with both hands and palms facing toward the body to hold the handle of the bar. The length of the chain was adjusted so that both knees were bent at approximately 110 degrees. Participants were required to pull the chain as hard as possible and tried to keep the arms straight without bending their back. When the participant's legs were almost straightened at the end of the lift, the maximum performance was recorded. For each participant, three trials were repeated, and the highest score was recorded.

iii. Isokinetic Muscular Peak Torque (Strength) and Power Test

The isokinetic muscular performance test was conducted using an isokinetic dynamometer (Biodex multi-joint system 3 pro, New York) to determine the participant's isokinetic knee and shoulder extension and flexion peak torque (strength) and power. All the procedures were conducted in accordance with the assessment protocol suggested in the manual of the BIODEX isokinetic dynamometer. A warm-up session was held prior to performing Isokinetic testing and the descriptive data of the participants, such as height, weight, gender, date of birth, dominant and non-dominant part, were keyed into the computer programme.

a. Knee Extension and Flexion Peak Torque (Strength) and Power Test Protocol

The participants were seated in a comfortable position on the BIODEX accessory chair prior to the assessment while leaning from the horizontal plane against a backrest tilted at 85^{o}. Straps were applied to the chest, hip, and thigh at the tested position to minimise body movements during the test. To avoid excessive upper body movement, shoulder straps were applied diagonally across the chest, hip straps were applied through the pelvic, and thigh straps were applied across the dominant side. There was a knee attachment attached to the dynamometer. Then, the chair was moved approximately close to the dynamometer output shaft. The red dot dynamometer shaft was aligned subsequently with the red dot on the attachment. To match the axis rotation of the knee joint and the axis rotation of the dynamometer shaft, the lateral femoral epicondyle was palpated and used as a bony landmark. With the padded shin strap, the calf pad was placed 2 inches proximal to the lateral malleolus and secured. 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 performed five repetitions for the $60^{O}.s^{-1}$ 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. The participants were given 20 seconds to rest between each angular velocity at every velocity setting. To achieve the highest level of effort, verbal encouragement was given to the participants. The thigh strap was unstrapped when the test was done on one leg. Then, the same protocol for the opposite leg was followed.

b. Shoulder Extension and Flexion Peak Torque (Strength) and Power Test Protocol

Prior of the test, the participants were seated in a comfortable position on the BIODEX accessory chair same as knee extension and flexion peak torque (strength) and power test. To avoid excessive upper body movement, chest straps were applied diagonally across the chest. The chair was rotated to 15 degrees and moved approximately close to the dynamometer's input shaft. The humerus was aligned with the dynamometer's rotational axis. The length of the level arm was modified to make the dominant hand of the participant straight and comfortable. The participants were asked to lift the lever to set limit away at 90^0. The participants were instructed to grasp the sides of the chair during the test using an untested hand. Five maximum repetitions at $60^o.s^{-1}$ angular velocity were performed, 10 maximum repetitions at $180^o.s^{-1}$ angular velocity were performed, and another 10 maximum repetitions were performed at $300^o.s^{-1}$ angular velocity, both during extension and flexion. The participants were given 20 seconds to rest between each angular velocity at every velocity setting. During the test, the participants were encouraged verbally to achieve their best performance and for the opposite hand, the same protocol was followed.

3.4.3.2 Flexibility Measurement via Sit and Reach Test

The participants were performed a sit-and-reach test to measure the flexibility of the lower back and hamstring muscles. For this test, sit and reach box was used. Participants were required to take their shoes off and sat on the floor with straightened legs. Feet were placed with the soles flat against the box and shoulder-width apart. Next, the participants were required to reach forward as far as possible, and measurements were recorded three times. To reflect flexibility, the best results was used.

3.5 STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 26.0. Independent t-test was performed to determine differences of the measured parameters between the groups. All the data are presented as mean and standard deviation (mean ± SD). The acceptance level of significance was set at $p < 0.05$.

3.6 SAMPLE SIZE CALCULATION

The sample size used in this study was calculated by using GPower version 3.1.9.4. The power of study was set at 80% with 95% confident interval. The effect size was set at 0.95 with two study groups. The sample size calculation was 15 participants for one group. The actual number of participants recruited in the present study was 8 per group, with a total of 16 participants. This is the maximum number of participants we managed to achieve despite maximum effort has been put in for recruiting participants during this current COVID-19 pandemic period.

CHAPTER 4

RESULTS

4.1 ANTHROPOMETRY AND BODY COMPOSITION

A total of 16 male participants (8 participants from tenpin bowler group and 8 participants from inactive non-bowler control group) completed the present study. The mean age of all the participants was 27.81 ± 8.04 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 tenpin bowler and inactive non-bowler control groups.

There was statistically significant higher body height (p=0. 021; $p<0.05$) in tenpin bowlers compared to inactive non-bowlers control group. There were no statistically significant differences in body weight, body mass index, percentage of body fat and fat-free mass between tenpin bowler group and inactive non-bowler control group. Nevertheless, non-statistically significant lower percent body fat and higher fat free mass values were observed in tenpin bowlers compared to inactive non-bowlers control group.

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 inactive non-bowler control group and tenpin bowler group

	Inactive non-bowler control group (n=8)	Tenpin bowler group (n=8)	*p* values
			Tenpin bowler group versus control group
Age (years)	28.00 ± 8.67	27.63 ± 7.96	0.929
Body weight (kg)	77.35 ± 22.03	76.48 ± 14.06	0.926
Body height (cm)	**166.63 ± 4.17**	**171.38 ± 3.02***	**0. 021**
BMI ($kg.m^{-2}$)	27.60 ± 6.70	26.00 ± 4.48	0.583
% BF (%)	30.90 ± 11.92	27.83 ± 8.03	0.555
FFM (kg)	51.36 ± 6.67	54.26 ± 3.86	0.305

Values are expressed as means ± SD.
*, p< 0.05. significantly different from control group
Abbreviations: BMI = Body mass index; % BF = Percent body fat; FFM = Fat-free mass

4.2 QUANTITATIVE ULTRASOUND MEASUREMENTS OF BONE SPEED OF SOUND (SOS)

Table 4.2 illustrates the mean of the distal radius and midshaft tibia quantitative ultrasound measurements of bone speed of sound (SOS) of dominant and non-dominant arms and legs of all participants.

Comparison between tenpin bowler and inactive non-bowler control group showed that there were no statistically significant differences in all the bone SOS measured parameters in dominant and non-dominant arms and legs of the participants.

Table 4.2: Quantitative ultrasound measurements of the bone speed of sound (SOS) of dominant and non-dominant arms and legs in inactive non-bowler control group and tenpin bowler group

Bone SOS (m.s-1)	Inactive non-bowler control group (n=8)	Tenpin bowler group (n=8)	*p* values
			Tenpin bowler group versus control group
Radius of dominant arm	4154.88 ± 274.66	4029.00 ± 143.97	0.270
Radius of non-dominant arm	4153.50 ± 305.94	4011.75 ± 113.81	0.251
Tibia of dominant leg	3810.63 ± 162.44	3851 ± 149.95	0.606
Tibia of non-dominant leg	3787.50 ± 115.07	3896.63 ± 232.85	0.254

Values are expressed as means ± SD.