HEE ZIYU CORRELATION BETWEEN LLA AND PFPS 2023

CORRELATION BETWEEN LOWER LIMB ALIGNMENT AND PATELLOFEMORAL PAIN SYNDROME AMONG BADMINTON PLAYERS IN UTAR

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By

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A Research project submitted to the Department of Physiotherapy,
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CORRELATION BETWEEN LOWER LIMB ALIGNMENT AND PATELLOFEMORAL PAIN SYNDROME AMONG BADMINTON PLAYERS IN UTAR

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ABSTRACT

Background and Objective: Badminton is a low-risk sport when compared to other popular sports since most injuries do not require surgical intervention. However, injuries are more common nowadays in modern badminton such as injury to the lower limbs. There was a lack of studies on badminton players' lower limb alignment and the prevalence of PFPS. To find out regarding the correlation between lower limb alignment and PFPS among badminton players, a study will be conducted at UTAR to study the correlation between lower limb alignment and PFPS among badminton players in UTAR

Methods: Convenience sampling was used and 40 participants (Male=19, Female=21) were successfully recruited. The demographic data, Kujala Anterior Knee Pain Scale (AKPS) was filled up by the participants, while lower limb alignments (hamstring length, q-angle and navicular drop test) were measured. The data collected was analyzed using Pearson's Correlation Test hamstring length for and Spearman's Correlation Test for q-angle and navicular drop test using the IBM Statistical Package for Social Sciences (SPSS) software.

Results: High prevalence of hamstring tightness and normal readings of q-angle and navicular drop test can be found among badminton players. Prevalence of PFPS according to the Kujala AKPS is low (10.0%). The calculated r-values and p-values are as follows, right hamstring length (r=-0.108, p=0.506), left hamstring length (r=-0.171, p=0.292), right q-angle (r=0.015, p=0.925), left q-angle (r=0.040, p=0.807), right navicular drop (r=-0.221, p=0.171), left navicular drop (r=-0.273, p=0.088). All the p-values of the lower limb alignments were more than 0.05, which fails to reject the null hypothesis. Thus, the result of this research study is there is no significant correlation between lower limb alignment and patellofemoral pain syndrome

Conclusion: In conclusion, lower limb alignments (hamstring length, q-angle, navicular drop) had no significant correlation to patellofemoral pain

Keywords: Patellofemoral Pain, Badminton players, Lower Limb Alignments

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APPROVAL SHEET

This Research project entitled "**CORRELATION BETWEEN LOWER LIMB ALIGNMENT AND PATELLOFEMORAL PAIN SYNDROME AMONG BADMINTON PLAYERS IN UTAR**" was prepared by Hee ZiYu and submitted as partial fulfillment of the requirements for the degree of Bachelor of Physiotherapy (HONOURS) at Universiti Tunku Abdul Rahman.

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PERMISSION SHEET

It is hereby certified that **HEE ZIYU** (ID No: **19UMB04157**) has completed this research project entitled "CORRELATION BETWEEN LOWER LIMB ALIGNMENT AND PATELLOFEMORAL PAIN SYNDROME AMONG BADMINTON PLAYERS IN UTAR" under the supervision of Siti Hazirah Binti Samsuri (Supervisor) from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health Sciences.

Yours truly,

HEE ZIYU

(HEE ZIYU)

DECLARATION

I hereby declare that the Research project is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

Name: HEE ZIYU

Date: 23/12/2022

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LIST OF ABBREVIATIONS

UTAR	Universiti Tunku Abdul Rahman
SERC	The Scientific and Ethical Review Committee
PFPS	Patellofemoral Pain Syndrome
PFPS	Patellofemoral Pain Syndrome
AKPS	Anterior Knee Pain Scale
VMO	Vastus Medialis Obliques
M	Mean
SD	Standard Deviation
p	P value (Significance)
MPFL	Medial patellofemoral ligament
MPTL	Medial patellotibial ligament
MPML	Medial patellomeniscal ligament
MCL	Medial collateral ligament
LCL	Lateral collateral ligament (LCL)
ACL	Lateral collateral ligament (LCL)
PCL	Posterior cruciate ligament
AKE	Active Knee Extension Test
PA	Popliteal Angle
SLR	Straight Leg Raise
SR	Sit and reach
NEA	National Education Association's

ROC	Receiver-Operating Characteristics
MDC	Minimal detectable change
SEM	Standard Error of Measurement
PDP	Personal Data Protection
ASIS	Anterior Superior Iliac Spine
SPSS	Statistical Package for Social Sciences
ICC	Intraclass correlation coefficient
CDC	Centers for Disease Control and Prevention
BMI	Body Mass Index

CHAPTER 1

INTRODUCTION

1.1 Chapter Overview

The background of the study and the context of the overall research project are outlined in this chapter, followed by the importance and relevance, research objectives, hypotheses, and operational definitions in terms.

1.2 Background of study

1.2.1 Patellofemoral pain syndrome

According to a study by Smith et al. (2018), among the musculoskeletal conditions of Americans and British, knee pain is the second most prevalent, with one of the most common types of knee pain, the patellofemoral pain syndrome (PFPS). Other two studies, which are Peterson et al. (2013) and Gaitonde et al. (2019), also mentioned that one of the most frequent causes of knee pain in adolescents and people under 60 years of age is knee pain. Petersen et al. (2013) also mentioned that approximately 22 out of 1000 people experience anterior knee pain each year, with women experiencing it more than twice as frequently as men. While there is yet to be a gold standard to clinically diagnose PFPS at this current time, it can be identified as self-reported pain around or behind the patella that is exacerbated by knee flexion and weight bearing activities (Smith et al., 2018). These weight-bearing activities include prolonged sitting, running, stair climbing, jumping and squatting. Aside from symptoms of pain, other symptoms that can be found in patients with PFPS include patellofemoral crepitus, disturbance with activities of daily living, knee stiffness, decreased quality of life and restricted physical activity (Crossley et al., 2016).

1.2.2 Introduction of Badminton

Badminton is one of the most popular non-contact sports in the world, particularly in Malaysia. It can be played in two ways, either with individual opposing players called singles or with pairs of opposing players called doubles. The players are positioned on opposite halves of a $80m^2$ sized rectangular badminton court while being separated by a net. (Sonoda et al., 2018). A badminton match consists of three 21-point games. Throughout the match, players may hit the shuttlecock once and then continue playing back and forth until the opponent fails to return the shuttlecock, thereby winning a rally. When the badminton game reaches 20-all, the side scoring a 2-point lead first wins the game, while if the badminton game reaches 29-all, the side which scores the final 30th point first wins the game (*Badminton Scoring, Rules and Officials - Badminton - Factfile - GCSE Physical Education Revision - WJEC*, n.d.).

1.2.3 Lower limb malalignment in patellofemoral pain syndrome (PFPS)

A study by Collado & Fredericson (2010) mentioned the relationship between malalignment of the lower limbs and patellofemoral pain. In the study, they mentioned that the patellofemoral joint mechanics at the knee is affected by the torsional and angular malalignment of the lower limbs. For instance, one of the causes of PFPS is hyperpronation of the foot. This results in a series of biomechanical changes to the lower limb biomechanics, which leads to increased subchondral bone stress and eventually causing PFPS symptoms.

Aside from that, a study by Karukunchit et al. (2015) identified several measurements for lower limb malalignment, including abnormal q-angle, abnormal tibiofemoral angle, abnormal pelvic tilt angle, femoral ante-torsion, limb length inequality, tibial torsion, genu recurvatum, and foot pronation. The most common of these lower limb malalignments is foot pronation. In the same study, they also mentioned that PFPS can be caused by excessive q-angle, while Collado & Fredericson (2010) specifically mentioned that a q-angle greater than 16 degrees increases the chance of developing PFPS. Besides that, a study by Boling et al. (2009) stated that navicular drop is a risk factor for PFPS. A study that was conducted by Abbas et al.(2018) on the relationship between static lower limb alignment and PFPS. The study's goal was to observe if there was a link between static lower extremity alignment and PFPS. The findings of this study revealed that there is no effect on pain and function PFPS in patients, although the study's target participants were healthy people with PFPS.

1.2.4 Kujala Anterior Knee Pain Scale (AKPS)

The Kujala Anterior Knee Pain Scale (AKPS) is a self-report assessment of knee pain that was published by Urho M. Kujala et al. in 1993 (Kujala et al., 1993). The questionnaire consists of 13 questions in total, and each answer choice will award a different point, for a total score of up to 100 points. Kujala et al. developed and analyzed the Kujala AKPS based on three criterias. First, some of the questions should specifically assess the symptoms of anterior knee pain, followed by the next criteria, whereby the answerer should fill out the questionnaire independently to avoid bias from the researcher and allow outpatient clinics to use the questionnaire, and finally, the total score of the questionnaire should be easily and quickly calculated.

1.3 Problem Statement

According to Jørgensen & Winge (1990), badminton is a low-risk sport when compared to other popular sports since most injuries do not require surgical intervention. However, injuries are more common nowadays in modern badminton such as injury to the lower limbs. This is mainly owing to the increased pace of the sport and increased focus on the tactical side of the sport (Marchena-Rodriguez et al., 2020). The study by Erdoganoglu et al. (2020) stated that lower limb malalignment is a provoking factor of PFPS. By identifying and evaluating the lower limb alignment of badminton players, it helps in decreasing the risk of injury while also improving their performance. According to my literature review, there was a lack of study on badminton players' lower limb alignment and the prevalence of PFPS. To find out regarding the correlation between lower limb alignment and PFPS among badminton players, a study will be conducted at UTAR from October 2022 to December 2022.

1.4 Research Objectives

- To identify the correlation of lower limb alignment and patellofemoral syndrome.
- To identify the prevalence of PFPS among badminton players in UTAR

- To identify the prevalence of lower limb malalignment among badminton players
- To identify which of the lower limb alignment contributes more to the PFPS

1.5 Hypothesis

H01- There is no significant correlation between lower limb alignment and patellofemoral pain syndrome

HA1- There is a significant positive correlation between lower limb alignment and patellofemoral pain syndrome

HA2 - There is a significant negative correlation between lower limb alignment and patellofemoral pain syndrome

1.6 Operational definitions

Patellofemoral Pain Syndrome (PFPS)

- One of the most frequent causes of anterior knee pain among adolescents and people under 60 years of age

Badminton

- A racquet sport in which two opposing players (singles) or two opposing pairs (doubles) compete.

Kujala Anterior Knee Pain Scale

- A questionnaire used to diagnose anterior knee pain
-

1.7 Rationale of study

In badminton, as stated by Jørgensen & Winge (1990), recreational badminton players are more prone to injuries when compared to elite badminton players. Based on the study by Collado & Fredericson (2010) mentioned that there is a relationship between malalignment of the lower limbs and patellofemoral pain where the patellofemoral joint mechanics at the knee is affected by the torsional and angular malalignment of the lower limbs. Thus, understanding the relationship between lower limb alignment and PFPS is important as skeletal malalignment can lead to compensatory alignment changes at adjacent bone segments, which may induce irregular stress patterns or compensatory motions. Abbas et al. (2018) mentioned several measurements that can be done to identify lower limb malalignments, such as the tibial torsion, q-angle and navicular drop test. So, this study aims to figure out whether there is any correlation between lower limb alignment and PFPS among badminton players while increasing awareness regarding the prevalence of PFPS among badminton players.

1.8 Scope of study

The research study focuses on finding the correlation of lower limb alignment and PFPS among badminton players in UTAR. The study is conducted by distributing questionnaires and taking measurements of lower limb alignments. The questionnaire consists of the demographic data form, the consent form, the Personal Data Protection Notice form and the Kujala Anterior Knee Pain Scale (AKPS). For the lower limb alignment measurements, the hamstring length measurement, the q-angle and the navicular drop test will be taken.

1.9 Research Question

- What is the correlation between lower limb alignment and patellofemoral pain syndrome?
- What is the prevalence of PFPS among badminton players in UTAR?
- What is the prevalence of lower limb malalignment among badminton players?
- Which lower limb alignment contribute more to PFPS?

1.10 Organization of research project

Chapter 1 of this research paper will be covering the study's background, which will include the research questions, research objectives, importance and relevance of the study. Next, Chapter 2 provides the literature review on relevant themes based on previous studies. The methodology used will be discussed in Chapter 3, which include the research design, sampling design, research instrument and the procedure of data collection. The results of the data collected after descriptive and inferential analysis, as well as hypothesis testing, will be presented in Chapter 4. Lastly, Chapter 5 will be the overall conclusion of the research study, which includes the discussion of the study's findings, limitations, and finally recommendations for future research.

LITERATURE REVIEW

2.1 Chapter overview

In chapter 2, various themes related to the research study were explored through previous literature, which serves as the framework for the research study.

2.2 Anatomy and Biomechanics of lower limb

The knee joint is presented as two joints, which are the tibiofemoral joint and the patellofemoral joint (Goldblatt & Richmond, 2003). The tibiofemoral joint, which is the largest joint in the human body, is an articulation of the medial and lateral condyles of the femur with their corresponding plateau of the tibia bone. The tibiofemoral joint enables the transmission of body weight from the femur to tibia. Aside from that, it also enables sagittal joint rotation in a hinge-like manner with a slight amount of tibial axial rotation (Flandry & Hommel, 2011).

The patellofemoral joint is a saddle joint which provides stability through an extensor mechanism. This extensor mechanism consists of the quadriceps tendon which inserts at the base of the patella, the largest sesamoid bone found in the human body and envelops the patella. The tendon then merges with the patella tendon which originates from the apex of the patella and inserts to the tibial tubercle. Muscles are present at the knee to allow bending, stretching, and turning movements. For example, the rectus femoris muscle controls knee extension and the biceps femoris controls knee flexion (National Centre for Biotechnology Information et al., 2020). One of the quadriceps muscles, the vasus medialis obliques (VMO), merges with the medial patellofemoral ligament and acts as an active and passive stabilizing of the sesamoid bone, patella (Rhee et al., 2012).

Underneath the patella and cartilaginous surface of the femur comprises the trochlear groove. Soft tissue constraints, which are the medial patellofemoral ligament (MPFL), the medial patellotibial ligament (MPTL), the medial patellomeniscal ligament (MPML), the lateral retinaculum and the medial retinaculum are present in the trochlear groove. These soft tissue constraints mentioned, together with the bony structures surrounding the trochlea groove helps in maintaining stability of the patellofemoral joint. Besides that, two collateral ligaments, the medial collateral ligament (MCL) and the lateral collateral ligament (LCL), as well as two cruciate ligaments, the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL), aid in knee stabilization by limiting the extent of movement and providing support.

2.3 Biomechanics and Injuries of Lower Limb in Badminton

Lower Limb Biomechanics of Badminton

Badminton is known to be the fastest-paced racquet sport which requires players to equip themselves with strong aerobic stamina, great agility, strength, speed, precision and good motor coordination (Pardiwala et al., 2020). It is a sport that has combinations of movements such as jumps, lunges, rapid arm movements and sudden sharp change of directions. According to Vora et al. (2018), the biomechanics of badminton has been researched in the aspects of power strokes, forehand overhead jump smash, backhand overhead strokes, forehand serves and in general endurance and fitness.

A systematic scoping review was carried out by Lam et al. (2020) on the biomechanics of lower limb during the badminton lunge movement. The badminton lunge is a basic footwork method which is characterized by wide footstrike angles and extraneous movements. The study mentioned that the badminton lunge accounts for about 15% of kneethe game time. A badminton player can have an average of 46.1 forward lunges and 52.2 half lunges in a badminton match, with these movements involving diagonal movements.

During the badminton lunge movements, the badminton players must maintain a high level of core and bilateral knee dynamic stability as they have to accommodate the rapid change of body positions, where there will be alterations of center of mass displacement and center of pressure excursion. This is important as the badminton players can be in the most optimal position to hit the shuttlecock.

Common injuries in Badminton Sport

Injuries are not uncommon in the sport of badminton. According to Phomsoupha & Laffaye (2020), badminton accounts for 1-5% of all sports injuries, ranking it at number sixth after soccer, basketball, volleyball, long-distance running and cycling. According to Yung et al. (2007), the incidence of injury of elite badminton players is 5.04 injuries per 1000 playing hours. Another study by Jørgensen & Winge (1987) found an injury incidence of 2.9 injuries per 1000 playing hours.

Yung et al. (2007) mentioned that the common injuries of elite badminton players include injury to the back, shoulder, thigh and ankle sprains, with ankle sprains being the most prevalent among them. On the other hand, according to a study by Marchena-Rodriguez et al. (2020), the most common injury location for amateur or recreational badminton players is at the knee. Yung et al. (2007) cited a study by Fahlström et al. (2007) which found that among the badminton injuries, 51.3% of them were minor and 48% were moderate. Another study cited was Hoy et al. (1994), which stated that 17% of badminton injuries were minor injuries, 56% were moderate injuries, and 27% were severe injuries.

According to Lam et al. (2020), the demanding footwork in badminton puts the knee and ankle joints at risk, especially during a badminton lunge. Lam et al. found 3 studies which all agreed that there is a link between the badminton lunge and the risk of injury to the lower limb. This is due to the fact that badminton players may encounter high impact loads. up to 2.5 times their body weight. Sufficient muscle activity is required at that point in a badminton lunge to stabilize the lower limb joints. This high impact loading may result in muscle fatigue, discomfort and pain, which eventually lead to injuries.

2.4 Prevalence and risk factor of Lower limb Malalignment

A study was done by Karukunchit et al. (2015) on the prevalence of lower limb malalignments among rice farmers who have a mean age of 45 years old. The study found out that prevalence of lower limb malalignment among the rice farmers population was high, especially at the knee region and the foot region. Foot pronation was the most prevalent lower limb alignment with 36.14% prevalence, followed by abnormal Q-angle with 34.94% prevalence, tibiofemoral angle with 31.73% prevalence, pelvic tilt angle with 30.52% prevalence, femoral antetorsion with 28.11% prevalence, limb length inequality with 22.49% of prevalence, tibial torsion with 21.29% of prevalence and genu recurvatum with 11.24 prevalence. The study also mentioned a few risk factors for lower limb malalignment. First, the study mentioned that age was a significant risk factor for hip musculoskeletal conditions. Besides that, being overweight was related to chronic lower extremity musculoskeletal symptoms. Next, repetitive movements of bending, twisting, heavy carrying or lifting, prolonged standing or walking are risks of increasing lower limb instability and injury.

Koli & Anap (2018) did a study on the prevalence and severity of hamstring tightness among college students. The study targeted students aged between 18-25 years old. The study found out that prevalence of hamstring tightness is high in college students aged between 18-25 years. The average reading of the active knee extension (AKE) test is between 30-45 degrees.

Another study was done by Ganeb et al. (2021) on the prevalence of lower limb malalignment among primary school students. Unlike the older target population in the study by Karukunchit et al., the younger target population of study in Ganeb et al. 's (aged 6-12 years) had lower prevalence of lower limb malalignment, which is a prevalence value of 16.61%. The lower limb malalignments that were identified in younger populations were musculoskeletal pain, genu varum, genu valgum, genu recurvatum, limb length discrepancy, flexible flat food, rigid flat foot, pes cavus, in-toes, hallux varus and hallux valgus.

Following that, Khadanga & Kumar (2022) did a cross sectional study on prevalence of flat foot in college students. From the results of study, 20.0% of the college students had a positive navicular drop test, whereby 10.25% subjects had positive unilateral navicular drop test while 9.75% of them had positive bilateral navicular drop test. The study also mentioned that navicular drop was more prevalent in males compared to females, with 21.55% prevalence compared to 17.95% prevalence. Among these, 11.20% male and 8.98% females were having unilateral navicular drop, while 10.34% males and 8.98% males were having bilateral navicular drop.

2.5 Prevalence and Risk Factors of Patellofemoral Pain Syndrome

Patellofemoral pain syndrome (PFPS), according to Smith et al. (2008) being the most common form of knee pain around the world, has a prevalence of 22.7% in the general population. PFPS is prevalent among a wide range of population, ranging from adolescents, young active adults, elite athletes until military recruits. According to Dey et al. (2016), there is a 7.2% prevalence in a mixed gender adolescents' population, while according to another study by Fairbank et al. (1984), there is a 28.9% prevalence in the general adolescent population. Next, according to a study by Xu et al. (2018), the overall prevalence of PFPS is 20.7% in young adults, with 20.3% prevalence in males and 21.1% prevalence in females. For elite athletes, in the study by Smith et al. (2008), female athletes had a PFPS prevalence of 16.7% to 29.3%. For military recruits, the point prevalence is 13.5% (Boling et al., 2010). In terms of gender, females have been assumed to have a higher occurrence of PFPS when compared to males. For example, according to DeHaven & Lintner (1986), Boling et al. (2010) and Petersen et al. (2013), females are twice as likely to get PFPS.

There are a few risk factors for PFPS. These potential risk factors include the weakness of quadriceps muscles, particularly the Vastus Medialis Obliques muscle, hip muscle dysfunction (hip abductors and external rotators), poor core muscle endurance, hamstring tightness, iliopsoas and quadriceps tightness, iliotibial band tightness, triceps surae muscles (gastrocnemius and soleus) tightness, excessive foot pronation, patellar malalignment, patellar hypermobility, generalized joint laxity, genu varum, abnormal trochlear morphology, abnormal proprioception and gait abnormalities (Halabchi et al., 2017).

2.6 Relationship of lower limb malalignment and patellofemoral pain syndrome

According to White et al. (2009), people with PFPS will have shorter hamstring muscles. There are several ways to measure hamstring tightness, which include the knee extension angle (KEA), the sacral angle (SA), the straight leg raise (SLR) and sit and reach (SR). Among these tests, the KEA test with a plantarflexed ankle is chosen as the gold standard based on the current literature available (Davis et al., 2008). Previous study by Davis et al. (2005) mentioned that a KEA which is more than 20 degrees indicates hamstring muscle tightness. According to White et al. (2009), patients with PFPS have shorter hamstring muscles when compared to the control group. The study mentioned that there is a possibility that hamstring length tightness can actually be caused by PFPS. However, some studies, such as one by Witvrouw et al. (2000) contradict the findings of White et al., with their study finding no significant difference between hamstring length and PFPS.

Next is the quadriceps angle or the q-angle. The q-angle is an angle that is formed between the quadriceps and the patella tendon**.** It is a measurement done to assess the mechanical effect of the quadriceps muscle pull on the knee joint (Khasawneh et al., 2019). The normal q-angle values should be in between 12 degrees and 20 degrees. Men tend to have a lesser q-angle value which ranges between 8 degrees to 10 degrees while women can have up to 15 degrees. Another study stated that males usually have 13 degrees of q-angle while 18 degrees for females when the knee joint is extended (Q Angle - an Overview | ScienceDirect Topics, 2009).

Values that exceed the normative values are considered excessive and are considered high risk to knee problems such as patellofemoral pain (PFP), patellar subluxation or dislocation, ACL injury, patellar instability, and valgus deformity. The decrease in q-angle on the other hand may lead to chondromalacia, patellar instability, PFP and varus deformity (Skouras et al., 2022). If the patient's q-angle is less than 10 degrees, he or she has varus deformity. On the other hand, if the q-angle is greater than 20 degrees, the patient has valgus deformity. When genu varum deformity occurs, it may cause increased postural sway in the medial-lateral direction (frontal plane). Genu varum also causes medial rotation of the knee, which later turns into a pronation in the subtalar joint and the mid foot during weight bearing. The alternation of foot structure affects the function of ankle strategy in maintaining balance. Mizuno et al. (2001) found that an increase in q-angle could result in lateral patellar dislocation or increased lateral patellofemoral contact pressures, while a decrease in q-angle may not cause the patella to shift medially, but it may increase medial tibiofemoral contact pressure by increasing varus orientation. Besides of what has been mentioned, According to Biedert and Warnke (2001), high and low values of q-angles should be considered abnormal, and it may be an aetiological factor of patellofemoral disorders, with high values of q-angle indicating PFPS and low values indicating patellar instability.

The navicular drop test is used to assess foot pronation. It can be said as the distance of the subtalar joint moving from its neutral position to a relaxed position. Normative value of the navicular drop is from 5.0 to 9.0 mm (Eslami et al., 2014). The study also stated that values that are less than 4 mm indicate a high arch, while values that are greater than 10 mm indicate a low arch. The navicular drop has a positive correlation with ankle inversion and knee adduction. Piva et al. (2006) mentioned that the greater distances between the dots, the greater the foot pronation. As foot pronation increases, so does tibial internal rotation and internal tibiofemoral torque, thus resulting in more force being transmitted to the ACL, medial aspect of the tibial plateau, and femoral condyle. Eventually, these biomechanical changes of the lower limb cause knee pain. Based on the study by (Nielsen et al., 2009), the mean values among healthy adults range from 7.3 to 9.0 mm. Also, according to Karukunchit et al., (2015), excessive foot pronation may increase lower limb strain disorders such as compressive knee loading. These lower limb strain disorders eventually will also lead to lower limb musculoskeletal disorders such as plantar fasciitis, stress fractures of the foot and tibia, medial tibial stress syndrome and patellofemoral pain symptoms.

CHAPTER 3

METHODOLOGY

3.1 Chapter overview

In this chapter, the methodology used in the research project will be outlined, which include the research design, sampling design, research instrument and procedure in detail.

3.2 Research Design

This study's research design is a cross-sectional study design. It is a type of observational study design. With this study design, the researcher can find out the association between variables and estimate the prevalence of the outcome. Other than that, It is a relatively quick study design, which is advantageous given the limited time available for the data collection process. Besides that, as there is no study sponsor for the research study, thus the more economical cross-sectional study design is suitable for my research study as an unemployed undergraduate university student (Setia, 2016).

3.3 Ethical approval

The Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman approved the commencement of this research study. The participants were given a consent form and informed of the confidentiality of the collected information. Furthermore, participants were informed that they have the right to withdraw from the study at any time and that the relationship between the researcher and the participants will not be harmed.

3.4 Study Population

The study population for this research study are badminton players from Universiti Tunku Abdul Rahman (UTAR), Sg Long campus. The population size is obtained from emailing the badminton representative of UTAR Sungai Long Campus. The total number of badminton players in Sports Club (Badminton) is around 50 people.

3.5 Sample Size

The sample size of the study is determined by referring to the Krejcie and Morgan table. The Krejcie & Morgan Table was developed in 1970 by Robert V. Krejcie and Daryle W. Morgan as an easy reference for determining the sample size for a given population and can be applied to any population. This is due to the fact that prior to the development of the Krejcie & Morgan Table, a formula published by the National Education Association's (NEA) research division in 1960 is used to calculate sample size. Below is the mentioned formula,

$$s = \left[\frac{X^2 NP(1-P)}{d^2(N-1)} + X^2 P(1-P) \right]$$

Whereby:

$s =$ Number of sample size.

$X^2 =$ the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

$N =$ the population sizes.

$P =$ the population proportion (assumed to be .50 since this would provide the maximum sample size).

$d =$ the degree of accuracy expressed as a proportion (.05).

Unlike the formula by NEA, no calculations are required when using the Krejcie and Morgan Table (Krejcie & Morgan, 1970). Based on the table, the sample size needed for the research study will be 44 participants.

3.6 Sampling Method

The convenience sampling method was chosen as the sample method of this research study (Etikan, 2016). This method was chosen because it is simple, inexpensive and the participants are readily available and easily accessible. The participants are recruited and filtered based on the inclusion criteria and the exclusion criteria. The inclusion and exclusion criterias are as follows

Inclusion Criteria:

- UTAR badminton players
- Males and Females
- Ages in between 15-30 (Boling et al., 2010)
- Anterior knee pain during any two of these activities: Prolonged sitting; stair climbing; squatting; running; kneeling; and hopping/jumping (Abbas et al., 2018)
- Body Mass Index (BMI) under 30 (Abbas et al., 2018)

Exclusion Criteria:

- Current injury to the hip, lumbar spine, or other knee structures (Rathleff et al., 2012)
- Weekly use of anti-inflammatory drugs (Rathleff et al., 2012)
- Medical history of meniscal or other intra articular pathologic conditions; cruciate or collateral ligament involvement (Abbas et al., 2018)
- Traumatic patellar subluxation or dislocation (Abbas et al., 2018)
- Previous surgery in the knee, ankle and hip joints (Abbas et al., 2018)
- Knee, ankle and hip joints osteoarthritis (Abbas et al., 2018)
- Pregnancy (Selfe et al., 2013)

3.7 Instrumentation

- Kujala Anterior Knee Pain Scale (AKPS)

According to the study by Watson et al. (2005), the test-retest reliability for the AKPS is high (intraclass correlation coefficient (ICC2,1) = 0.95). Besides that, the receiver-operating characteristics (ROC) curve analysis is used in the study. The ROC curve analysis is used to test the sensitivity and the specificity of a given measure. The larger the area under the curve, the better the ability to distinguish a change. Based on the study, the ROC curve of AKPS has an area under the curve of 0.69 (95% CI = 0.47-0.91), meaning that AKPS is responsive to changes in a patient's condition over time. Also, the minimal detectable change (MDC) was used to calculate the standard error of measurement (SEM). The minimal detectable change (MDC) was 14 while the standard error value was 0.11. This means that a 14-point change or greater is required to reflect a genuine change in the patient's condition. Finally, the study mentioned that the AKPS has high reliability and high responsiveness.

Another study by Crossley et al. (2004) also mentioned the reliability, validity, and responsiveness of the AKPS. The study analyzed the reliability and validity of several outcome measures of patellofemoral pain. The outcome measures include the VAS-W which measures the worst pain experienced by a person, the VAS-U, which measures the usual pain experienced by a person, the AKPS and the Functional Index Questionnaire (FIQ). In terms of reliability, AKPS and all other questionnaires demonstrated moderate to good reliability. In terms of validity, the AKPS correlated moderately, closely correlating with VAS-W and VAS-U. Next, in terms of responsiveness, the AKPS was the most efficient among the outcome measures tested, with a relative efficiency of 1.24. The result of the study mentioned AKPS as one of the valid questionnaires to assess patellofemoral pain.

- Hamstring Length Test/ Knee Extension Angle (KEA) Test

According to Davis et al. (2008), the inter-tester reliability for the hamstring muscle length test is 0.99. Davis et al. did a pilot study which aims to validate the 4 common clinical tests for measuring hamstring length. These hamstring length measures include the knee extension angle (KEA), the sacral angle (SA), the straight leg raise (SLR) and the sit and reach (SR) test. According to the study, the KEA test has significantly less pelvic rotation than the other hamstring length tests, implying that the KEA test is more accurate for hamstring length testing. Based on another similar study by Gajdosik et al. (1993), the validity of the KEA test was reported to be -0.66, which is consistent with the 0.63 correlation reported in the study by Davis et al. (2008). At the conclusion of the study, they mentioned that the gold standard for hamstring length test is the KEA test with the ankle in the plantarflexed position.

- Q-angle

According to Piva et al. (2006), the q-angle is a moderate reliability outcome measure which has an intraclass correlation coefficient (ICC) of 0.70, which is in between the moderate reliability range of 0.45 to 0.91. According to a systematic study of the Q-angle by Smith et al. (2008), the Q-angle has a range of intra-tester reliability ranging from poor to almost perfect agreement. Among the studies mentioned, only two studies mentioned the poor intra-tester reliability, with an ICC value ranging from 0.22 to 0.37, while five other studies mentioned the near perfect agreement, with an ICC value of between 0.81 and 1.00. For inter-tester reliability, the Q-angle also demonstrates a range of agreement for inter-tester reliability, from poor agreement to significant agreement, ranging from 0.72 to 0.83. Based on the study, the Q-angle has an acceptable criterion validity which shows no significant difference between clinical and radiographic measurements of the Q-angle.

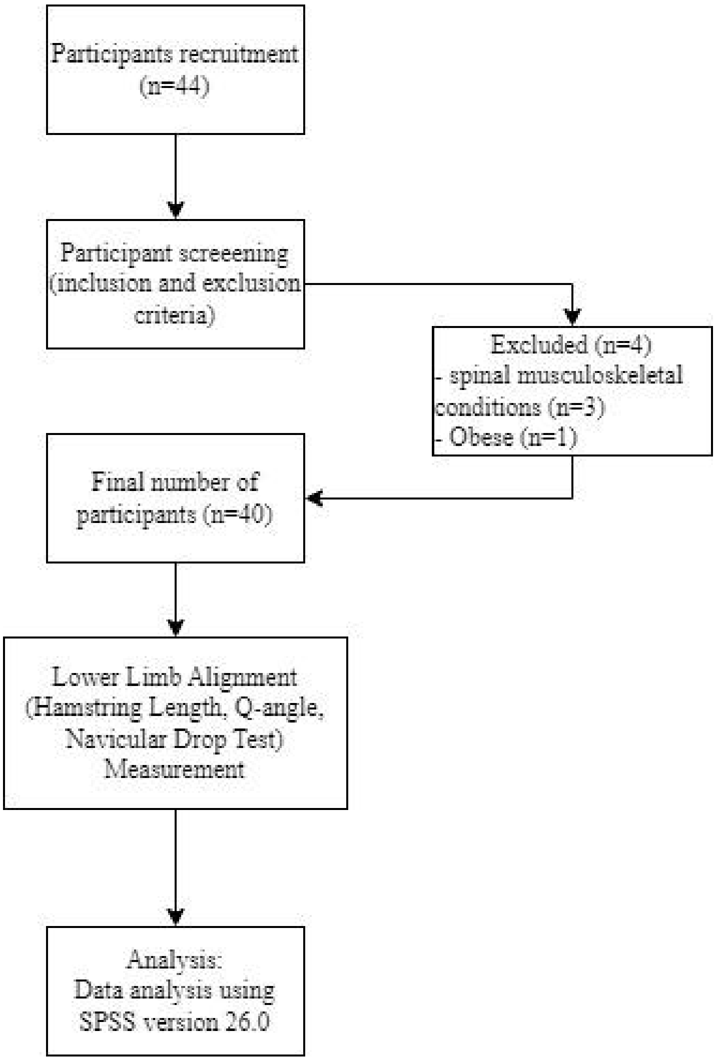
- Navicular Drop Test

According to Piva et al. (2006), the navicular drop test has an inter-tester reliability coefficient of 0.93, which is greater than 0.81, which indicates substantial agreement. According to another study by Sell et al. (1994), the navicular drop test is an instrument with good reliability, with an ICC value of 0.73 for the inter-tester reliability.

- Goniometer
- Measuring tape
- Ruler
- Paper (for measurement of navicular drop test)

3.8 Procedure

Figure 3.1 Flow chart of research project



The research project commences after the study has been approved by the UTAR Scientific and Ethical Review Committee. The participants were recruited from the visit to the UTAR badminton session on Tuesday. The volunteered badminton players will be required to fill up the consent form, demographic data form and the Personal Data Protection (PDP) notice form and the Kujala Anterior Knee Pain Scale (AKPS) (Abbas et al., 2018). Then, the volunteered badminton players will be screened through the inclusion and exclusion criteria and the suitable participants (meet with the inclusion criteria and free from the exclusion criteria) will be recruited. The researcher will contact the selected participants and they will be required to fill up an excel sheet regarding the time allocation for the data collection.

The research will be carried out at KA200A, UTAR Sungai Long campus. Before the commencement of the research, there will be a briefing given to the participants regarding the procedure of the research study and a final checking of inclusion and exclusion criteria will be done. After that, measurements for the lower limb alignment will be done, which include the hamstring length measurement, the q-angle measurement and the navicular drop test.

First, there is the hamstring length test. For this study, the knee extension angle (KEA) test will be taken. First, the participant will be in supine lying position with lower limbs in extended position. The contralateral lower extremity is stabilized on the plinth with a strap. Then, the ipsilateral hip will be flexed to 90 degrees and maintain this angle while the ipsilateral knee will be actively extended and the ankle in the plantarflexed position. When either the tester or the subject reports a strong but tolerable stretching sensation in the hamstring musculature, the endpoint has been reached. The KEA is then measured, which is the degree of knee flexion from terminal knee extension, with a goniometer. The tester can also measure the obtuse adjacent angle between the femur and the tibia. The obtuse adjacent angle refers to the popliteal angle (PA) (Davis et al., 2008).

Next, for the q-angle measurement, according to Smith et al. (2008), the participants should be in a supine lying position or in a standing position. Two lines will be drawn before the measurement. The first line will be drawn from the anterior superior iliac spine (ASIS) to the centre of the patella while the second line will be drawn from the centre of the tibial tubercle to the centre of the patella. The lines formed will have an intersection and the angle at the intersection is the q-angle. The same steps will be repeated on the contralateral limb

Finally, for the navicular drop test, the participant will be in standing or sitting position with their feet shoulder width apart. Remove any accessories such as shoes and socks and expose the foot of the participant. First, the navicular tuberosity will be palpated and marked with a pen. Next, the subtalar joint will be placed into neutral position. The distance from the marked navicular tuberosity will then be marked onto a piece of paper that is placed perpendicular to the ground. After that, the participant will be required to relax from the subtalar neutral position and the measurement will be repeated. The length between the two dots will be recorded in millimeters using a ruler or measuring tape (Piva et al., 2006).

The raw data collected from all tests were recorded in Microsoft Excel and then analyzed using the IBM SPSS software.

CHAPTER 4

RESULTS

4.1 Chapter Overview

In this chapter, the findings from the data collection process will be presented. These findings include the demographic data of participants, scoring and grouping of outcome measures, results of the inferential tests and the elaboration of hypothesis testing. Relevant graphs and tables will also be included, along with a brief description under them. Data analysis of the findings was done using the IBM SPSS software, while tables and charts were constructed using Microsoft Excel and Microsoft Words.

A total number of 44 participants were recruited. Out of them, 4 were excluded from the study. 3 of the participants were having spinal musculoskeletal conditions. One of them had sclerosis of the thoracic spine, one had spondylolisthesis of the lumbar spine and scoliosis, and one had it but didn't specify. The other participant, according to CDC (2021), was under the obese range category, which had a BMI value of more than 30.0. In the end, the final number of participants that were included into the study is 40.

4.2 Demographic data of the participants

4.2.1 Frequency, Mean and Standard Deviation of Demographic data of participants

Table 4.1: Demographic data of participants

Item	N (%)	Mean (μ)	Standard deviation (SD)
Age		**20.98**	**1.143**
Gender			
Male	**19 (47.5)**		
Female	**21 (52.5)**		
Height (cm)		**167.05**	**9.526**
Weight (kg)		**61.23**	**12.21**
Body Mass Index (BMI) (kg/m2)		**21.82**	**3.22**
Underweight (< 18.5)	**6 (15.0)**		
Normal weight (18.5 – 24.9)	**27 (67.5)**		
Overweight (25			

– 29.9)	**7 (17.5)**
Obese (≥ 30)	**0 (0.0)**

Note. **N=40**

Table 4.1 presented above shows the demographic data of 40 participants in terms of age, gender and body mass index (BMI). The data was collected from the demographic data form filled by the participants.

4.2.1 Age of participants

Figure 4.1 Age of participants

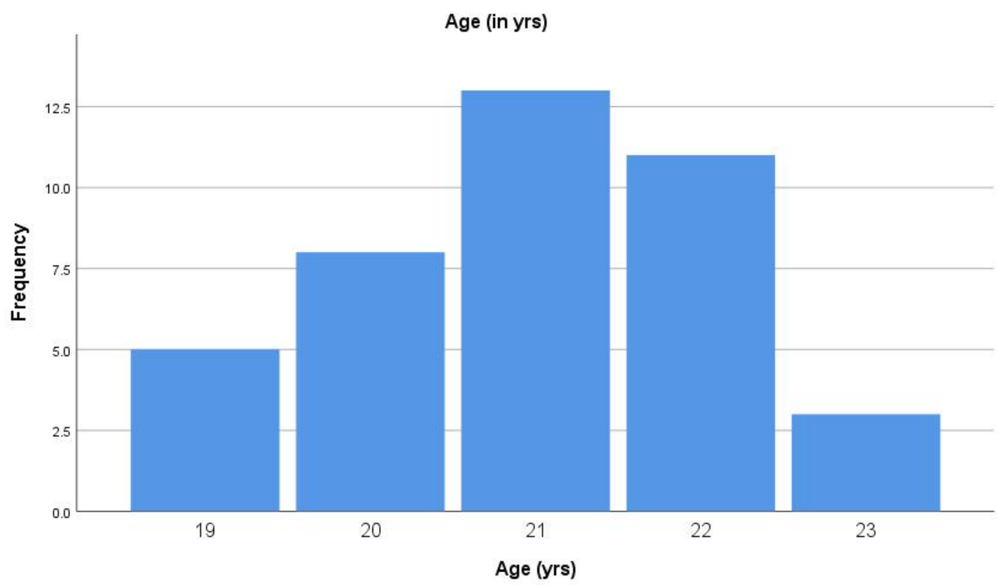


Figure 4.1 above shows the bar chart of age distribution of the participants from the research study. The mean and standard deviation of the age of the participants are 20.98 and 1.143 respectively. Based on Figure 4.1 above, the majority of the participants were under the age of 21, accounting for 32.5% of the total number of participants with 13 participants. The least number of the participants were under the age of 23, accounting for 7.5% of the total number of participants with only 3 participants. The other age groups include 19 years old which accounts for 5 participants (7.5%), 20 years old which accounts for 8 participants (20%) and 22 years old which accounts for 11 participants.

4.2.2 Gender of participants

Figure 4.2 Gender of participants

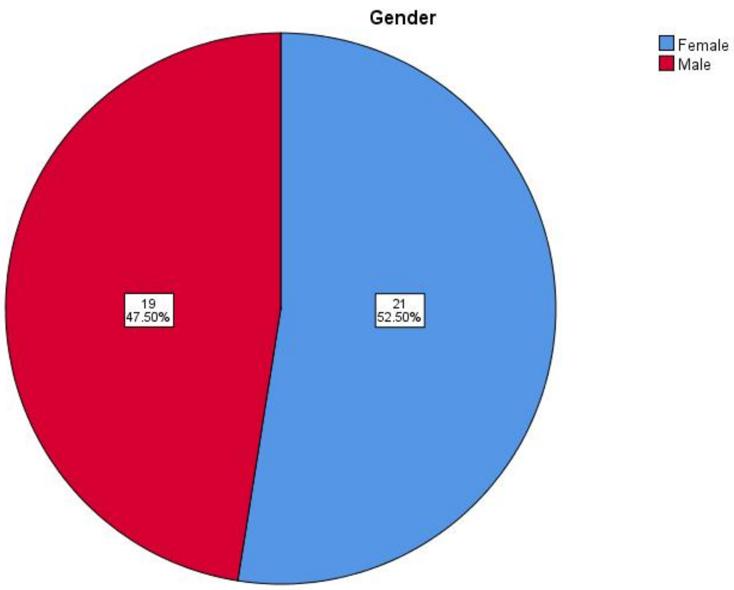


Figure 4.2 above shows the pie chart of gender distribution of the research study. Based on Figure 4.2 above, there are 19 male participants (47.5%) and 21 female participants (52.5%).

4.2.3 Height of participants

Figure 4.3 Height of participants

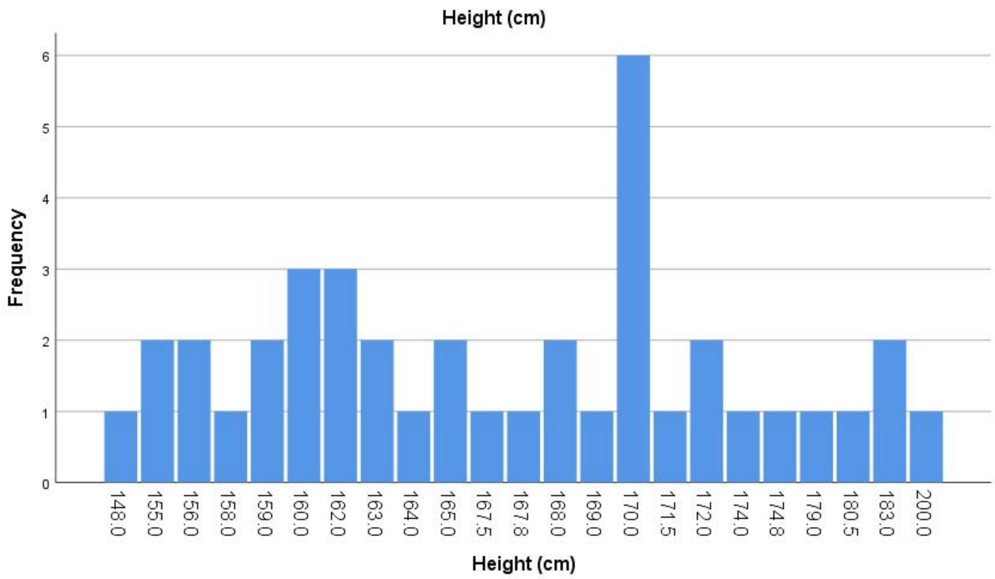


Figure 4.3 above shows the frequency distribution of the height (cm) of the participants. The mean and standard deviation of the height of participants are 167.05 and 9.5236 respectively.

4.2.4 Weight of participants

Figure 4.4 Weight of participants

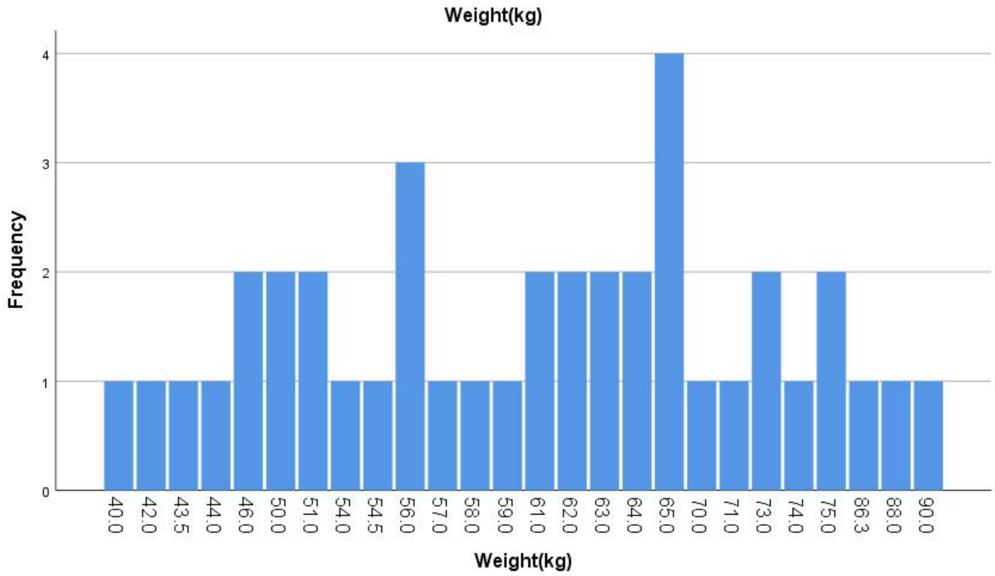


Figure 4.4 above shows the frequency distribution of the weight (kg) of the participants. The mean and standard deviation of the weight of participants are 61.23 and 12.21 respectively.

4.2.5 BMI of participants

Figure 4.5 Body Mass Index (BMI) Category of Participants

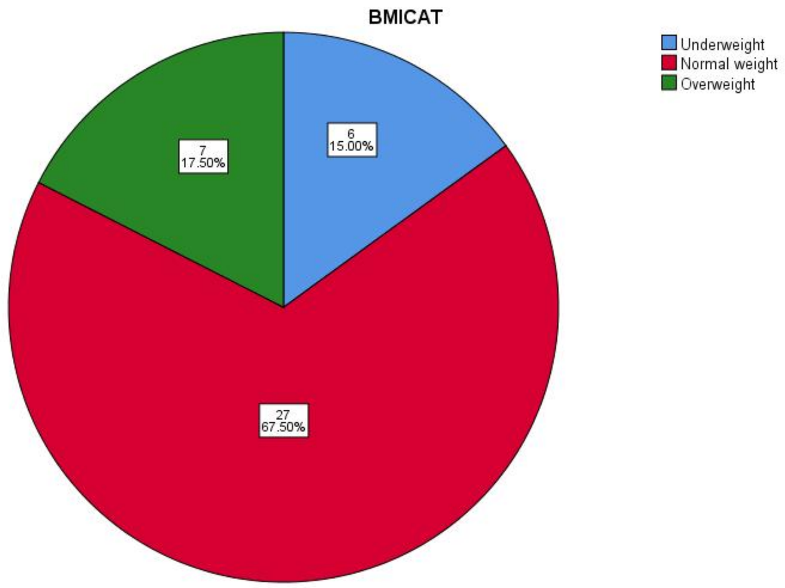
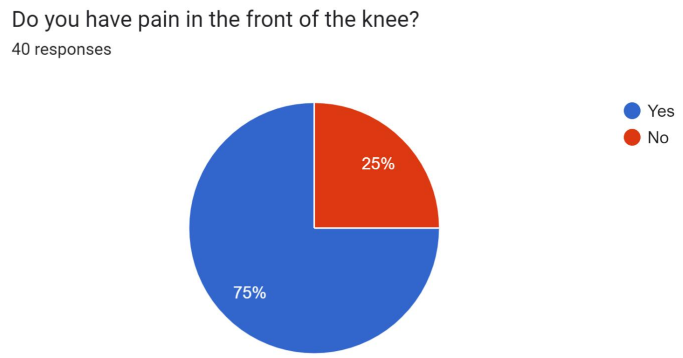


Figure 4.3 above shows the pie chart of Body Mass Index (BMI) of the participants. The BMI of the participants were calculated using the formula [weight (kg)/ height (m)²]. The mean and standard deviation of the BMI score is 21.82 and 3.22 respectively. According to CDC (2021), the BMI can is categorized into a few categories, which include the underweight category (<18.5kg), the healthy weight category (18.5kg-25.0kg), the overweight category (25.0kg - 30.0kg) and the obesity category (>30.0kg). Based on Figure 4.3 above, there are 6 participants who are under the underweight category, accounting for 15% of the total number of participants, 27 participants who are under the normal weight category, accounting for 67.5% of the total number of participants, and 7 participants who are under the overweight category, accounting for 17.5% of the total number of participants. There are no participants who were in the obese category as they were excluded during the participants screening.

4.2.6 Number of participants having knee pain

Figure 4.6 Question regarding anterior knee pain



Based on Figure 4.6 above, 30 participants (70.0%) had pain to the front of the knee, while the remaining 10 participants (10.0%) didn't.

4.3 Inferential Analysis

Figure 4.6 Kujala AKPS (Q1)

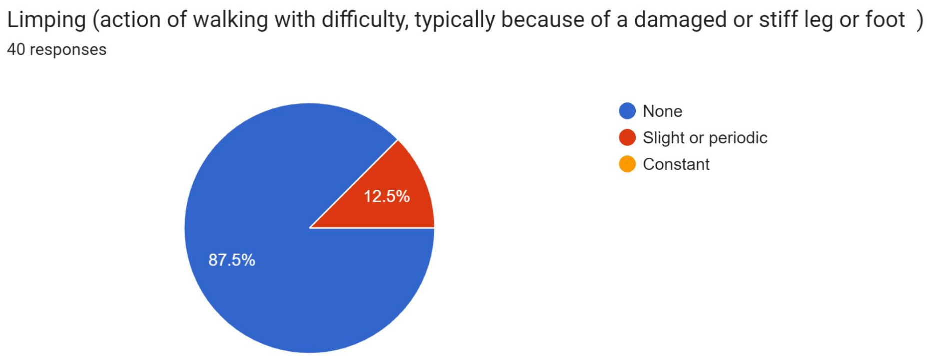


Figure 4.6 above shows the pie chart distribution for the first question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 35 (87.5%) participants didn't experience limping, whereas 5 (12.5%) participants experienced slight or periodic limping. None of the participants were having constant limping.

Figure 4.7 Kujala AKPS (Q2)

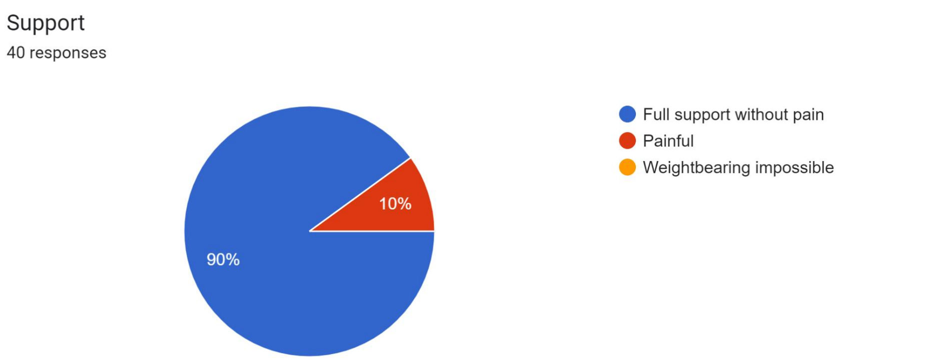


Figure 4.7 above shows the pie chart distribution for the second question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 36 (90.0%) participants can maintain full support without pain, whereas 4 (10.0%) participants complained that it was painful during weight bearing. None of the participants were unable to bear weight.

Figure 4.8 Kujala AKPS (Q3)

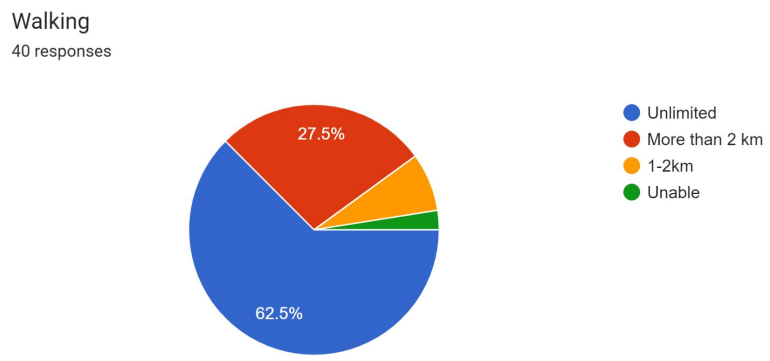


Figure 4.8 above shows the pie chart distribution for the third question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 25 (62.5%) participants were able to walk for an unlimited distance, 11 (27.5%) participants were able to walk for more than 2km, 3 (7.5%) participants were able to walk for only 1-2km, whereas only 1 (2.5%) participant claimed unable to walk

Figure 4.9 AKPS (Q4)

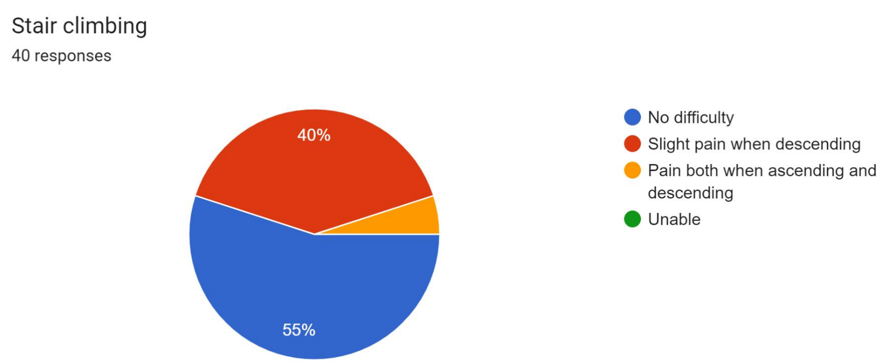


Figure 4.9 above shows the pie chart distribution for the fourth question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 22 (55.0%) participants had no difficulty in stair climbing, 16 (40.0%) participants had slight pain when descending the stairs, while 2 (5.0%) participants had pain both when ascending and descending.

Figure 4.10 AKPS (Q5)

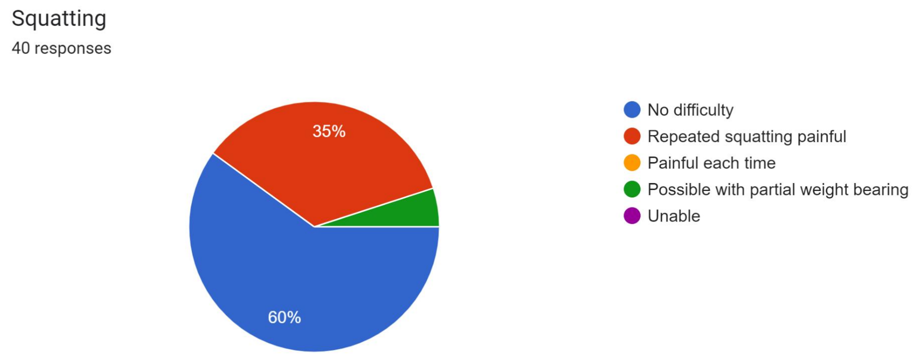


Figure 4.10 above shows the pie chart distribution for the fifth question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 24 (60.0%) participants had no difficulty in squatting, 14 (35.0%) participants had pain after repeated squatting, while 2 (5.0%) participants could only do squat if there was partial weight bearing.

Figure 4.11 AKPS (Q6)

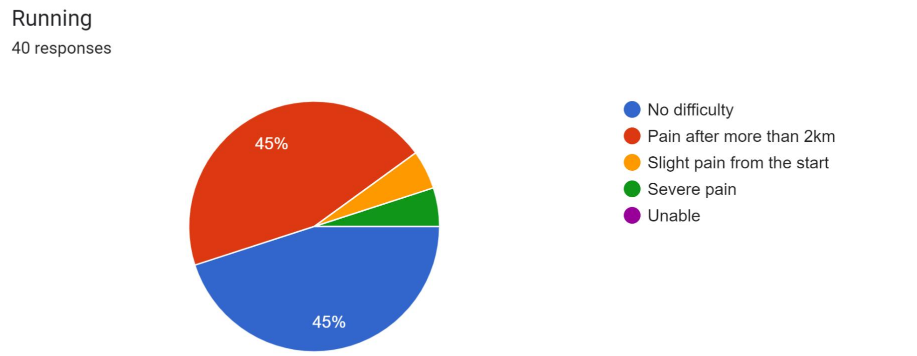


Figure 4.11 above shows the pie chart distribution for the sixth question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 18 (45.0%) participants were having no difficulty in running, 18 (45.0%) participants had pain after running for more than 2km, 2 (5.0%) participants had slight pain from the start of running while the remaining 2 (5.0%) participants had severe pain during running.

Figure 4.12 AKPS (Q7)

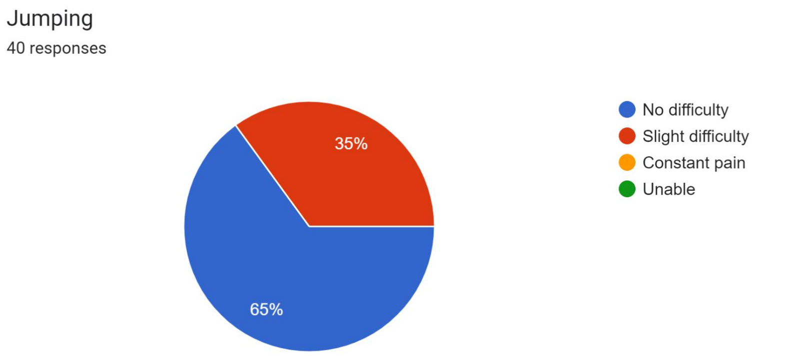


Figure 4.12 above shows the pie chart distribution for the seventh question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 26 (65.0%) participants had no difficulty in jumping and 14 (35.0%) participants had slight difficulty in jumping.

Figure 4.13 AKPS (Q8)

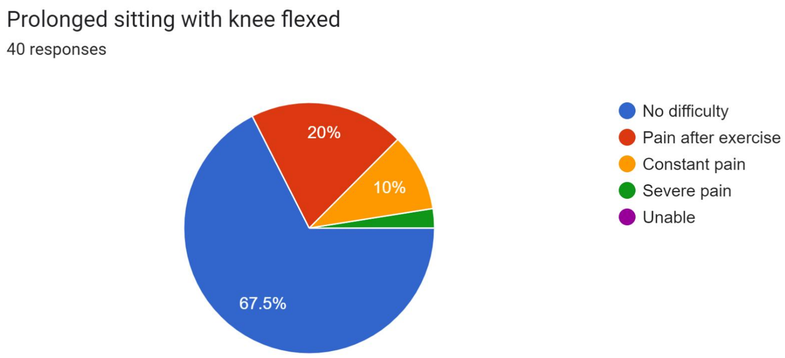


Figure 4.13 above shows the pie chart distribution for the eighth question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 27 (67.5%) participants had no difficulty in prolonged sitting with knee flexed, 8 (20.0%) participants had pain during prolonged sitting with knee flexed after exercise, 4 (10.0%) participants had constant pain during prolonged sitting with knee flexed and only 1 (2.5%) participant had severe pain during prolonged sitting with knee flexed.

Figure 4.14 AKPS (Q9)

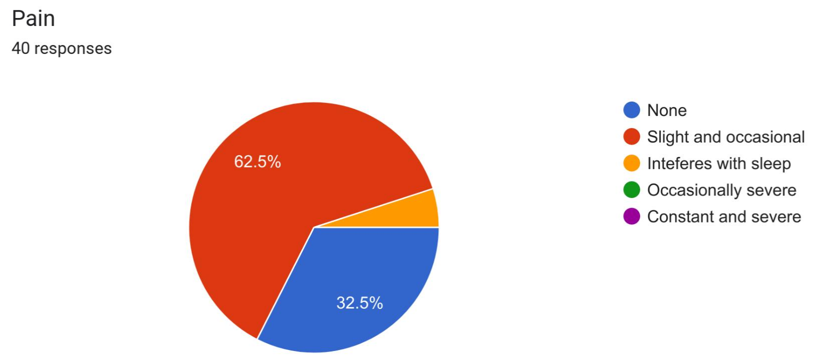


Figure 4.14 above shows the pie chart distribution for the ninth question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 25 (62.5%) participants had slight and occasional pain at the knee, 13 (32.5%) participants had no pain to their knee while 2 (5.0%) participants had knee pain that interferes with sleep.

Figure 4.15 AKPS (Q10)

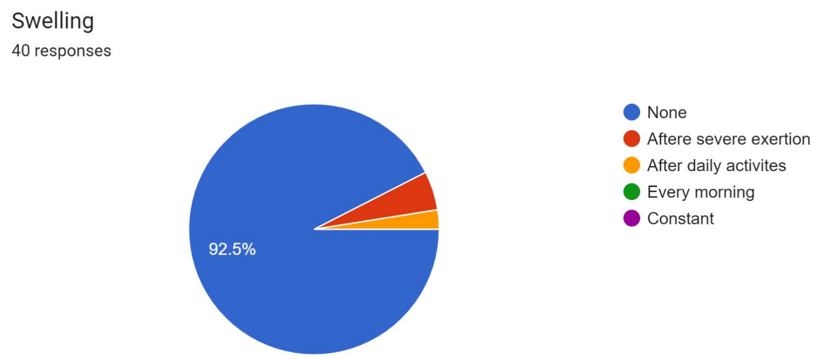


Figure 4.15 above shows the pie chart distribution for the tenth question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 37 (92.5%) participants did not have swelling to their knees, 2 (5.0%) participants had knee swelling after exertion, while 1 (2.5%) participant had knee swelling after daily activities.

Figure 4.16 AKPS (Q11)

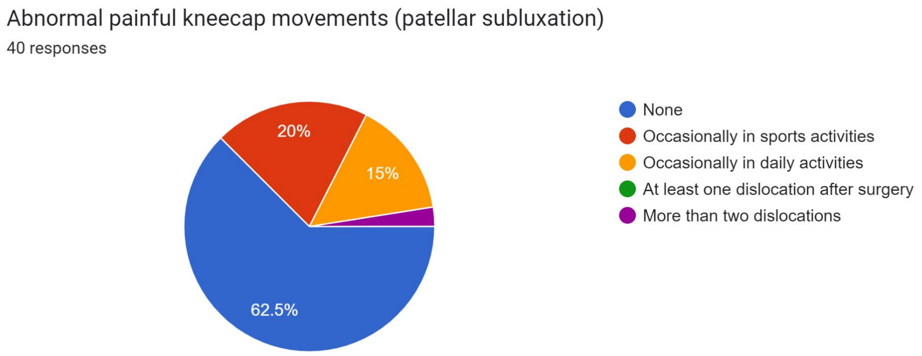


Figure 4.16 above shows the pie chart distribution for the eleventh question of the Kujala AKPS. Based on the pie chart, among the 40 participants, 25 (62.5%) participants did not have abnormal painful kneecap movements (patellar subluxation), 8 (20.0%) participants had abnormal painful kneecap movements (patellar subluxation) occasionally during sports activities, 6 (15.0%) participants had abnormal painful kneecap movements (patellar subluxation) occasionally in daily activities. while 1 (2.5%) participant had more than two dislocations of the kneecap

Figure 4.17 AKPS (Q12)

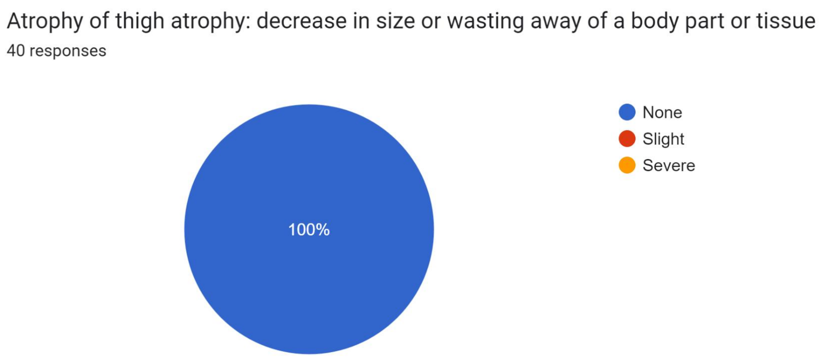


Figure 4.17 above shows the pie chart distribution for the twelfth question of the Kujala AKPS. Based on the pie chart, none of the participants had atrophy of the thigh.

Figure 4.18 AKPS (Q13)

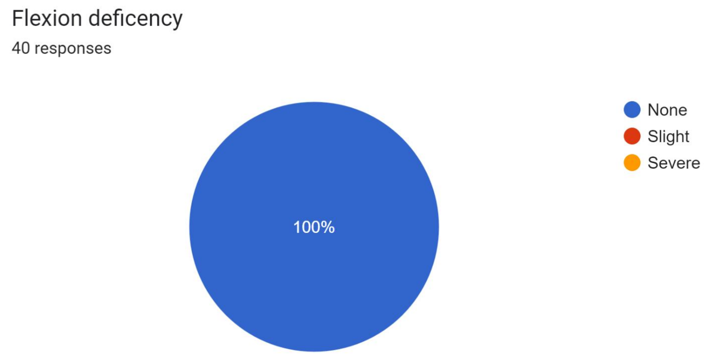


Figure 4.17 above shows the pie chart distribution for the thirteenth question of the Kujala AKPS. Based on the pie chart, none of the participants had flexion deficiency.

Figure 4.19 Kujala AKPS Category

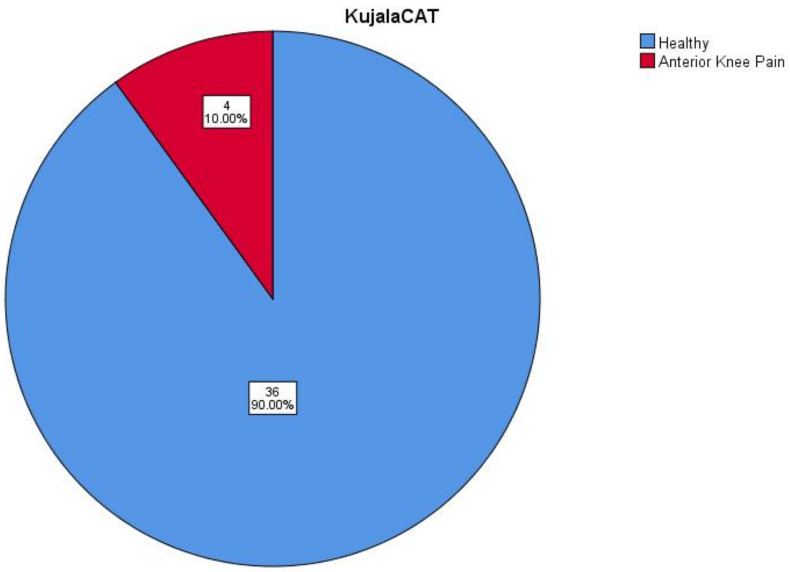


Figure 4.19 above shows the category of knee pain according to Kujala AKPS. The scores of the participants were categorized referring to a study by Dammerer et al. (2018). According to the study, the questionnaire's creator, Urho M. Kujala et al, stated average values of 99.9% for healthy individuals, 82.8% for patients with anterior knee pain, and 62.2 for patients with patella instability. According to the pie chart above, 36 (90.0%) participants are healthy while 4 (10.0%) participants are having patellofemoral pain.

Table 4.2 Lower Limb Alignment (overall)

Item	N (%)	Mean (SD)
Hamstring Length (R)		33.73 (16.496)
- **No Hamstring tightness**	14 (35.0%)	
- **Hamstring Tightness**	26 (65.0%)	
Hamstring Length (L)		33.45 (16.794)
- **No Hamstring tightness**	12 (30.0%)	
- **Hamstring Tightness**	28 (70.0%)	
Q-angle (R)		15.45 (6.218)
- **Varus deformity**	12 (30.0%)	
- **Normal**	23 (57.5%)	
- **Valgus deformity**	5 (12.5%)	
Q-angle (L)		17.43 (6.983)
- **Varus deformity**	6 (15.0%)	
- **Normal**	24 (60.0%)	
- **Valgus deformity**	10 (25%)	

Navicular Drop Test (R)		8.30 (4.740)
- **High arch**	5 (12.5%)	
- **Normal**	26 (65.0%)	
- **Foot pronation**	9 (22.5%)	
Navicular Drop Test (L)		8.18 (4.138)
- **High arch**	5 (12.5%)	
- **Normal**	23 (57.5%)	
- **Foot pronation**	12 (30.0%)	

Table 4.3 Lower Limb Alignment based on Gender

Item	Gender			
	Male		Female	
	N (%)	Mean	N (%)	Mean
Hamstring Length (R)		35.16		30.71
- **No Hamstring tightness**	26 (65.0)		28 (70)	
- **Hamstring Tightness**	14 (35.0)		12 (30.0)	
Hamstring Length (L)		36.68		30.57
- **No Hamstring tightness**	26 (65.0)		26 (65.0)	
- **Hamstring Tightness**	14 (35.0)		14 (35.0)	
Q-angle (R)		14.26		16.52
- **Varus deformity**	4 (10.0)		8 (20.0)	
- **Normal**	36 (90.0)		27 (67.5)	
- **Valgus deformity**	0 (0.0)		5 (12.5)	

Q-angle (L)		15.0		19.62
- **Varus deformity**	3 (7.5)		3 (7.5)	
- **Normal**	36 (90.)		28 (70)	
- **Valgus deformity**	1 (2.5)		9 (22.5)	
Navicular Drop Test (R)		8.47		8.14
- **High arch**	2 (5.0)		3 (7.5)	
- **Normal**	33 (82.5)		33 (82.5)	
- **Foot pronation**	5 (12.5)		4 (10.0)	
Navicular Drop Test (L)		8.05		8.29
- **High arch**	4 (10.0)		1 (2.5)	
- **Normal**	30 (75.0)		33 (82.5)	
- **Foot pronation**	6 (15.0)		6 (15.0)	

In this research study, lower limb alignment measurements were taken from 40 badminton players in UTAR. The lower limb alignment mentioned include hamstring length (R) (M = 33.73, SD = 16.496) and hamstring length (L) (M = 33.45, SD = 16.794), q-angle (R) (M = 15.45, SD = 6.218) and q-angle (L) (M = 17.43, SD = 6.983), and navicular drop test (R) (M = 8.30, SD = 4.740) and navicular drop test (L) (M = 8.18, SD = 4.138).

According to hamstring length test or the knee extension angle test, 14 (35.0%) participants had no tightness to the right hamstring and 12 (30.0%) participants had no tightness to the left hamstring, whereas 26 (65.0%) participants had tightness to the right hamstring and 28 (70.0%) participants had tightness to the left hamstring. In terms of gender, males had slightly more but similar prevalence of right hamstring tightness (35.0%) compared to females (30.0%). Both males and females have an equal prevalence of hamstring tightness (35.0%) in the left hamstring. The males have a higher mean hamstring length, 35.16 to the right lower limb while 36.68 to the left lower limb, while females have lower mean hamstring length of 30.71 to the right lower limb and 30,57 to the left lower limb.

Besides that, based on the q-angle measurement performed, the findings show that 23 (57.5%) participants had normal q-angle readings to the right lower limb and 24 (60.0%) participants had normal q-angle readings to the left lower limb. Varus deformity was seen in 12 (30.0%) participants on the right lower limb and 6 (15.0%) participants on the left lower limb. Varus deformity was seen in 5 (12.5%) participants on the right lower limb and 10 (25%) participants on the left lower limb. In terms of gender, females had a higher prevalence of varus deformity, with a prevalence of 20.0% at the right lower limb, and valgus deformity with prevalence of 12.5% at the right lower limb and 22.5% at the left lower limb, compared to males with a prevalence of 10.0% of right varus deformity, 0.0% prevalence of right valgus deformity and 2.5% of left valgus deformity. Both genders have similar percentages of varus deformity on the left lower limb (7.5%). Females have higher mean value of the q-angle which are 16.52 degrees at the right lower limb and 19.62 degrees to the left lower limb, while males have a lower mean value of q-angle, which are 14.26 to the right lower limb and 15.0 degrees to the left lower limb

According to the navicular drop test performed, 26 (65.0%) participants had normal navicular drop test readings to the right foot and 23 (57.5%) participants had normal navicular drop test readings to the left foot. 5 (12.5%) participants had a high arch in their right foot, while also 5 (12.5%) participants had a high arch in their left foot. 9 (22.5%) participants were having right foot pronation, while 12 (30.0%) participants were having left foot pronation. In terms of gender, males and females had similar prevalence of foot pronation. Males had 12.5% prevalence of right foot pronation and 15.0% prevalence of left foot pronation while females had 10.0% prevalence of right foot pronation and 15.0% prevalence of left foot pronation. Both genders also exhibit similar prevalence for high arch values. Males had 5.0% prevalence of high arch on the right foot and 10.0% prevalence of high arch on the left foot, while females had 10.0% prevalence of high arch on the right foot and 15.0% prevalence on the left foot. Males have a mean value of navicular drop test of 8.47mm to the right foot and 8.05mm to the left foot, while females had a mean value of 8.14mm to the right foot and 8.29 to the left foot.

Table 4.4 Normality Test

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HL(R)	.147	40	.029	.957	40	.137
HL(L)	.088	40	.200*	.968	40	.321
Q-angle (R)	.204	40	.000	.929	40	.015
Q-angle (L)	.186	40	.001	.915	40	.005
ND (R)	.225	40	.000	.810	40	.000
ND (L)	.212	40	.000	.880	40	.001
KujalaScore	.128	40	.097	.918	40	.007

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 4.5 Correlation between PFPS and Lower Limb Alignment

	Correlation Coefficient value (r)	**p-value**
Hamstring Length (R)	-0.108	0.506
Hamstring Length (L)	-0.171	0.292
Q-angle (R)	0.015	0.925
Q-angle (L)	0.040	0.807
Navicular Drop Test (R)	-0.221	0.171
Navicular Drop Test (L)	-0.273	0.088

A test of normality is done to the data collected using the IBM SPSS software. As the number of participants in this research study is less than 50, the Shapiro-Wilk Test will be referred to. In normality tests, The null hypothesis is that the data is normally distributed, whereas the alternate hypothesis is that the data is not normally distributed. When $p>0.05$, the null hypothesis is accepted and the data are normally distributed (Gupta et al., 2019).

According to the Shapiro-Wilk Test score of this research study (Table 4.2), only hamstring length (R) with a p-value of 0.137 and hamstring (L) with a p-value of 0.321 have p-values greater than 0.05, indicating that they are normally distributed. For the remaining lower limb alignments, which are the q-angle (R) with a p-value of 0.015, q-angle (L) with a p-value of 0.05, navicular drop test (R) with a p-value of <0.001 and navicular drop test (L) with a p-value of 0.001, all of them are not normally distributed as their p-value are less than 0.05. As the hamstring length (R) and hamstring length (L) are normally distributed, the Pearson Correlation Test will be done, while for the remaining lower limb alignments ((q-angle (R), q-angle (L), navicular drop test (R), navicular drop test (L))) which are not normally distributed, the Spearman Correlation Test will be done. Both tests were also done using the IBM SPSS software.

The calculated correlation coefficient value (r) of all the measured lower limb alignments are as follows, hamstring length (R) with a r value of -0.108, hamstring length (L) with a r value of - 0.171, q-angle (R) with a r value of -0.015, q-angle (L) with a r value of -0.040, navicular drop test (R) with a r value of -0.221, and navicular drop test (L) with a r value of -0.273.

The correlation coefficient values (r) of the lower limb alignments with the Kujala Score that were less than 0.3 indicate that the linear relationship between the lower limb alignments and the Kujala Score is weak and not significant.

4.4 Hypothesis Testing

H01- There is no significant correlation between lower limb alignment and patellofemoral pain syndrome

HA1- There is a significant positive correlation between lower limb alignment and patellofemoral pain syndrome

HA2 - There is a significant negative correlation between lower limb alignment and patellofemoral pain syndrome

The alpha value is set to 0.05. Based on the Pearson Correlation Test and Spearman Correlation Test, p-value of each lower limb alignment to the Kujala AKPS is calculated out. The p-values of each lower limb alignment are as follows, hamstring length (R) with a p-value of 0.506, hamstring length (L) with a p-value of 0.292, q-angle (R) with a p-value of 0.925, q-angle (L) with a p-value of 0.807, navicular drop test (R) with a p-value of 0.171, and navicular drop test (L) with a p-value of 0.088.

All the p-values of the lower limb alignments were more than 0.05, which fails to reject the null hypothesis. This indicates that the result of this research study is that there is no significant correlation between lower limb alignment and patellofemoral pain syndrome

CHAPTER 5

DISCUSSION

5.1 Chapter overview

In this chapter, the findings from the results section will be analyzed and discussed. Furthermore, the findings will also be compared with previous literature. Finally, at the end of this chapter, the limitations and future research recommendations will be discussed.

5.2 Discussion

5.2.1 Prevalence of lower limb malalignments among Badminton Players

<u>Prevalence of Hamstring Tightness Among Badminton Players</u>

According to the readings of the hamstring length measurement, the KEA measurement from this research study, most of the participants had hamstring tightness of both lower limbs. As has been mentioned by Davis et al, (2005) the knee extension angles that were more than 20 degrees were categorized as hamstring tightness, while the remaining were categorized as no hamstring tightness. When comparing the hamstring tightness for both sides of the lower limb, the left hamstring tightness was similar but slightly more prevalent with a number of 28 (70.0%) participants, while 26 participants (65.0%) had right hamstring tightness. Based on this research study, the prevalence of hamstring tightness is quite high among badminton players.

Badminton players tend to have greater patellofemoral joint loading due to the multidirectional joint movement of the sport. (Yu et al., 2021). The decrease of hamstring length may produce better knee flexion and patellofemoral joint force which may improve the performances of badminton players. Besides that, the hamstring tightness of badminton players may be due to overuse injuries that were caused by PFPS or muscle strain (Davis et al., 2005). Ah et al., (2009) mentioned that most of the injury badminton players suffered were knee injuries. According to Davis et al., the hamstring muscle is the most injured multijointed muscle in the human body, which may be the cause for the hamstring tightness.

When looking at the differences between gender, both males and females demonstrated similar low prevalence of hamstring tightness, whereby males had slightly more but similar prevalence of right hamstring tightness (35.0%) compared to females (30.0%), and both males and females have an equal prevalence of hamstring tightness (35.0%) in the left hamstring. These findings contradict the findings of Koli & Anap (2018) and Thakur & Rose (2016). Koli & Anap and Thakur & Rose mentioned in their respective studies that males have more right hamstring tightness while females have more tightness in left hamstring tightness.

Prevalence of Q-angle Malalignment Among Badminton Players

Next, the results of this research study shows that the majority of the participants had normal bilateral lower limb q-angle readings within the normative values of 10 - 20 degrees, whereby 23 (57.5%) participants had normal q-angle readings to the right lower limb and 24 (60.0%) participants had normal q-angle readings to the left lower limb. The prevalence of abnormal q-angle readings among the participants of this study is 45.5% on the right lower limb and 40.0% on the left lower limb. The results were quite similar to the study by Karukunchit et al. (2015) which mentioned abnormal Q-angle measurement of 34.94%

In terms of gender however, according to the results of this study, females had higher prevalence of right varus deformity (20.0% compared to 10.0%), right valgus deformity (12.5% compared to 0.0%) and left valgus deformity (12.5% compared to 2.5%) compared to males. Left varus deformity is similar on the left lower limb (7.5%). The research study findings were similar to the study by Mitani (2017), whereby females have higher q-angle reading. There were also less differences between the mean values of the q-angle between males and females, which are similar to the study by Grelsamer et al. (2005).

Prevalence of High Arch and Foot Pronation Among Badminton Players

Finally, for the navicular drop test, the majority of the participants had normal bilateral lower limb navicular drop test readings. The findings of the study were not similar to the study by Mitani (2017) where females had a higher height of the arch. Although, most of the female participants from the study by Mitani had a history of foot and ankle sport injuries. Other than that, in the study Khadanga & Kumar (2022), they mentioned a positive navicular drop test of 20.0%, which is much more prevalent than the 35.0% prevalence in this research study. For the gender comparison, the results of the research study contradict with the results of the study by Khadanga & Kumar (2022) whereby navicular drop was more prevalent in males compared to females. The prevalence of navicular drops or foot pronation when compared by gender in this research study was quite similar to each other.

5.2.2 Prevalence of Patellofemoral Pain Syndrome among Badminton Players

From the demographic data form, 70.0% of participants reported anterior knee pain. Symptoms of patellofemoral pain can be found from the participants, whereby 5 (12.5%) participants were having slight or periodic limping, 4 (10.0%) participants had pain during weight bearing, 15 (37.5%) participants had trouble in walking, 18 participants had pain during stair climbing, 24 (40.0%) participants had trouble with squatting due to pain, 55.0% participants had pain during running, 14 (35.0%) participants had trouble or pain during jumping, 13 (32.5%) participants had pain during prolonged sitting with knee flexed, 27 (67.5%) participants had sight and occasional pain and pain that interferes with sleep, 3 (7.5%) participants had knee swelling, 15 (37.5%) participants had abnormal knee cap movements

However, the study's findings contradict with the demographic data taken, whereby according to the Kujala AKPS, the prevalence of patellofemoral pain syndrome is 10%, with only 4 participants out of the total number of 40 participants. It is also significantly lower than the 20.7% prevalence in the study by Xu et al. (2018) for young adults. This may be due to several differential diagnoses of anterior knee pain available, in which the participants were not aware of themselves. According to Calmbach & Hutchens (2003), several differential diagnoses of patellofemoral pain include tibial apophysitis (OSgood-Schlatter lesion), patellar tendinitis (Jumper's knee) and patellar subluxation or dislocation. Next, the symptoms of anterior knee pain may be due to the overuse stress of the patellofemoral joint. The repetitive multidirectional and quick lunge movements in badminton causes the knee joint, especially the racket-handed side of the knee joint to be more prone to injury (Lin et al., 2015). In addition, the participants may have been active in other sports such as running/jogging or have daily activities of climbing and descending stairs (Smith et al., 2018).

5.2.3 Correlation of Lower Limb Alignment and Patellofemoral Pain Syndrome

The study's finding indicate that the lower limb alignments had no significant correlation to PFPS.

First, the result of the hamstring correlation with PFPS is compared with previous studies. Results of this research study contradicts with the studies as the result of my study was no significant correlation of hamstring length to PFPS, whereby r=-0.108 and p=0.506 for the right lower limb and r=-0.171 and p=0.292 for left lower limb. Kwon et al. (2004) found a strong correlation between PFPS and hamstring tightness. However, the study didn't mention the r-value and p-value from its Spearman correlation analysis. There were studies supporting the findings by Kwon et al., such as Piva et al. (2006) which mentioned that soft tissue restrictions such as shortening of hamstrings had been associated with PFPS as tight hamstrings may increase compression of the patellofemoral joint. White et al. (2009) stated that hamstring length is shorter in patients with PFPS compared to healthy asymptomatic individuals. According to Kwon et al., The shortening of hamstring muscles causes imbalance of hamstring-quadriceps muscles due to weakening of the quadriceps femoris muscle, eventually causing PFPS. Boiling et al. (2009) on the other hand reported that the hamstring tightness may be a compensatory strategy to decrease the amount of contact pressure of the patella to decrease pain. The proven significance of the studies mentioned may be due to several factors, one being the larger sample size in the study by Boiling et al. (2009), with 1597 participants. Oher than that, compared to this research study with only 4 participants with PFPS, Kwon et al. (2004) and Piva et al. had more samples with PFPS, with n=14 and n= 30.

Next the correlation of the q-angle was compared to studies by Abbas et al. (2018), Witvrouw et al. (2000), Lun (2004) and Park & Stefanyshyn (2011) regarding the correlation of q-angle and PFPS. In the study by Abbas et al. (2018), they concluded that there was no relationship between q-angle and anterior knee pain. Besides that, the study by Witvrouw et al. (2000) also didn't find any correlation between q-angle and PFPS (p=0.394). Lun (2004), which was also in agreement with the previous study mentioned, found no association between lower limb alignment with running injuries such as PFPS. Park & Stefanyshyn (2011) stated that static alignment measure such as Q-angle have no strong correlation to PFPS. The results of my research study were similar with the previous studies mentioned. Contradictory to the studies mentioned, Rauh et al. (2007) stated that runners that have a higher Q-angle has a higher risk of knee injury. In the study, a much larger study group was selected, where by 393 high school runners were recruited, while the study by Lun (2004) and Park & Stefanyshyn (2011) all have a smaller sample size (n=87, n= 31), excluding Witvrouw et al. (2000) with a large sample size (n=282).

Lastly, for the navicular drop, the result of the study was compared to Abbas et al. (2018), The comparison of my research study with Abbas et al. (2018) was similar. Abbas et al. concluded that there was no relationship between q-angle and navicular drop. Contradicting to this, in the study by Boling et al. (2009), which mentioned the proposal of foot pronation as a risk factor for PFPS. According to Boling et al. (2009) foot pronation may cause tibial internal rotation. For the knee to extend, the femur also internally rotates. This causes malalignment of the patella and compression of the lateral patellar facet. This may due to the sample size of the study was large (n=1597), which produced much more significant results.

5.3 Limitations of the study

For the limitation of the study, first, there was a small sample size in this study, thus the result of the study cannot be generalizable. Next, the data of participation in other sports and activities of daily living were missing. Following that, although the outcome measures for taking the lower limb alignments had validity and reliability, they are still prone to human error such as parallax error in taking measurements. Lastly, The results of the study that was not significant may be due to the low prevalence of PFPS among badminton players, whereby significant values may also not be produced from a small sample size.

5.4 Recommendations of future study

First, a larger population should be chosen so that the results will be more significant and generalizable to the target population. More research should be done in the future to study on the effect of lower limb malalignment on PFPS. Also, more lower limb measurements could be included in future studies for the more precise identification of lower limb malalignment. Next, outcome measures which are free from human error should be prioritized.

5.5 Conclusion

In conclusion, lower limb alignments (hamstring length, q-angle, navicular drop) had no significant correlation to patellofemoral pain. Based on the results, the occurrence of PFPS may be due to other factors besides structural abnormalities. The prevalence of hamstring tightness is high while the prevalence for abnormal q-angle and navicular drop was lower among badminton players in UTAR.

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APPENDIX A - ETHICAL APPROVAL FORM

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
10.	Comparison of Immediate Effect of Soft Tissue Manipulation (STM) and Ice Massage in Mechanical Neck Pain	Wong Hui Lin	Ms Kamala a/p Krishnan	4 November 2022 – 3 November 2023
11.	Association Between Forward Head Posture and Screening Programme of Scoliosis Among UTAR Undergraduate Students	Wong Shi Yi		
12.	Prevalence of Low Back Pain and Its Association with Ergonomic Usage Among UTAR Students	Ian Lee Haorong	Ms Swapneela Jacob Co-Supervisor: Mr Tarun Amalnerkar	
13.	Awareness, Knowledge and Attitude Towards Artificial Intelligence in Learning Among Faculty of Medicine and Health Science (FMHS) Students in UTAR	Hwang Ji Yen		
14.	Awareness & Knowledge of Breathing Exercise as Covid-19 Management Among UTAR Students	Low Wai Kit	Ms Menaka Naidu a/p Mohnaraju	
15.	Awareness on the Adverse Effects of Vaping on Health Among UTAR Students	Lim Yu Hui		
16.	Awareness Towards Bell's Palsy Among University Students	Pong Jia Shan		
17.	The Impact of Ocular Exercises on Headache Symptoms and Sleep Quality Among University Students with Refractive Error	Pea Wan Theng	Ms Kiruthika Selvakumar	
18.	A Study to Analyze the Impact of Balance Exercise Improving Hand to Eye Coordination Among University Students in Selangor	Ong Wesley		
19.	Prevalence of Adolescent Migraine in Malaysia and The Common Triggers for It: A Cross-Sectional Study	Ong Chuu Chyi		
20.	Correlation Between Carrying Angle of Elbow and Upper Limb Flexibility Among Basketball Players	Gienisha a/p Thanapalan	Ms Siti Hazirah Binti Samsuri	
21.	Correlation Between Lower Limb Alignment and Patellofemoral Pain Syndrome Among Badminton Players in UTAR	Hee Ziyu		
22.	Effectiveness of Mindfulness Meditation on Blood Pressure and Resting Heart Rate Among Pre-Hypertensive Young Adults	Toh Jen Min	Mr Imtiyaz Ali Mir	
23.	Comparison of Combined Effect of Aerobic Exercise Training and DASH Diet with DASH Diet Alone on Blood Pressure and Resting Heart Rate Among Physically Inactive Pre-Hypertensive Young Adults	Toh Xue Ying		
24.	Effectiveness of Continuous Moderate-Intensity Training and Mindfulness Meditation on Blood Pressure and Resting Heart Rate Among Physically Inactive Pre-Hypertensive Young Adults	Wan Cai Hui		
25.	Comparison between Inclined Treadmill Sprint Training and Plyometric Exercise in Improving Sprint Performance Among Healthy Young Adults	Jasmine Song Wen Hui	Ms Premala a/p Krishnan	
26.	Effect of Pilates-Based Exercise on Young Adults with Patellofemoral Pain	Jesslyn Ng Jee Cheng		
27.	Association Between Quadriceps Angle and Hamstring Flexibility with Knee Injuries Among Weight Lifters	Teh Wei Ze	Ms Ambusam a/p Subramaniam	
28.	Knowledge, Awareness and Perception of Prostate Cancer Among Undergraduate in University Tunku Abdul Rahman (UTAR)	Tan Kean Guan		
29.	Prevalence of joint Hypermobility and Association with Musculoskeletal Injuries Among University Students in UTAR	Khor Suky	Mr Nizar Abdul Majeed Kutty	
30.	Association of Social Physique Anxiety with Physical Activity and Body Image Satisfaction Among University Students: A Cross-sectional Study	Lau Hong Jie		

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APPENDIX B - INFORMED CONSENT FORM

INFORMED CONSENT FORM

CORRELATION BETWEEN LOWER LIMB ALIGNMENT AND PATELLOFEMORAL PAIN SYNDROME AMONG RECREATIONAL BADMINTON PLAYERS IN UTAR

You are invited to participate in a research study conducted by Hee ZiYu, from Bachelor of Physiotherapy (HONS) Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus. The purpose of this research study is to identify the correlation between lower limb alignment and patellofemoral pain syndrome among recreational badminton players in UTAR.

Participation

This study will provide useful evidence about which lower limb alignment contributes more to patellofemoral pain. Your participation in this study is completely voluntary. Withdrawal from this study is allowed at any time. The decision to withdraw will not influence your relationship with the researcher.

Benefits and Risk

By the end of the study, in case of injury, you will receive treatment and care which will be provided at the expense of the researcher.

Confidentiality

Your information and data will be kept confidential. All associated data collected will be immediately destroyed wherever possible.

Should you have any enquiries about this research study, you may contact me, Hee ZiYu at 0125831678 or email me at heeziyu@1utar.my. If you wish to participate in this study, please sign the form, below, and return it to the researcher.

Signature: Signature:

________________ ________________

Name of participant: Name of Witness:

Date: Date:

APPENDIX C - PERSONAL DATA PROTECTION NOTICE

PERSONAL DATA PROTECTION NOTICE

Please be informed that in accordance with Personal Data Protection Act 2010 ("PDPA") which came into force on 15 November 2013, Universiti Tunku Abdul Rahman ("UTAR") is hereby bound to make notice and require consent in relation to collection, recording, storage, usage and retention of personal information.

1. Personal data refers to any information which may directly or indirectly identify a person which could include sensitive personal data and expression of opinion. Among others it includes:

   a) Name
   b) Identity card
   c) Place of Birth
   d) Address
   e) Education History
   f) Employment History
   g) Medical History
   h) Blood type
   i) Race
   j) Religion
   k) Photo
   l) Personal Information and Associated Research Data

2. The purposes for which your personal data may be used are inclusive but not limited to:

   a) For assessment of any application to UTAR
   b) For processing any benefits and services
   c) For communication purposes
   d) For advertorial and news
   e) For general administration and record purposes
   f) For enhancing the value of education
   g) For educational and related purposes consequential to UTAR
   h) For replying any responds to complaints and enquiries
   i) For the purpose of our corporate governance
   j) For the purposes of conducting research/ collaboration

3. Your personal data may be transferred and/or disclosed to third party and/or UTAR collaborative partners including but not limited to the respective and appointed outsourcing agents for purpose of fulfilling our obligations to you in respect of the purposes and all such other purposes that are related to the purposes and also in providing integrated services, maintaining and storing records. Your data may be shared when required by laws and when disclosure is necessary to comply with applicable laws.

4. Any personal information retained by UTAR shall be destroyed and/or deleted in accordance with our retention policy applicable for us in the event such information is no longer required.

5. UTAR is committed in ensuring the confidentiality, protection, security and accuracy of your personal information made available to us and it has been our ongoing strict policy to ensure that your personal information is accurate, complete, not misleading and updated. UTAR would also ensure that your personal data shall not be used for political and commercial purposes.

Consent:

6. By submitting or providing your personal data to UTAR, you had consented and agreed for your personal data to be used in accordance to the terms and conditions in the Notice and our relevant policy.

7. If you do not consent or subsequently withdraw your consent to the processing and disclosure of your personal data, UTAR will not be able to fulfill our obligations or to contact you or to assist you in respect of the purposes and/or for any other purposes related to the purpose.

8. You may access and update your personal data by writing to us at_____________.

Acknowledgment of Notice

[ ] I have been notified and that I hereby understood, consented and agreed per UTAR above notice.

[ ] I disagree, my personal data will not be processed.

………………………………
Name:
Date:

APPENDIX D - DEMOGRAPHIC DATA FORM

DEMOGRAPHIC DATA AND SCREENING FORM

1. Name:

2. Age:

3. Gender: ☐ Male ☐ Female ☐ Others:____________

4. Contact number:

5. Are you a badminton player?
   ☐ Yes ☐ No

6. Do you have pain in the front of the knee?
   ☐ Yes ☐ No

7. Height:___________cm

8. Weight:___________kg

9. Do you have any of the conditions:
   (a) Recent fracture of lower limbs of 6-24 weeks
   Yes/No
   (b) Cardiovascular disease
   Yes/No
   (c) Spine musculoskeletal condition in the past 6 month
   Yes/No

Please specify your condition (if any) :____________________________________
____

APPENDIX E - KREJCIE AND MORGAN (1980) TABLE

TABLE I

Table for Determining Sample Size from a Given Population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size.
S is sample size.

APPENDIX F - KUJALA ANTERIOR KNEE PAIN SCALE

KUJALA SCORING QUESTIONNAIRE

Name: ____________ ____________ Date: ____________
First Last

Physician: ____________

1. Limp:
- a) None
- b) Slight or periodic
- c) Constant

2. Support:
- a) Full support without pain
- b) Painful
- c) Weightbearing impossible

3. Walking:
- a) Unlimited
- b) More than 2 km
- c) 1-2 km
- d) Unable

4. Stairs:
- a) No difficulty
- b) Slight pain when descending
- c) Pain both when ascending and descending
- d) Unable

5. Squatting:
- a) No difficulty
- b) Repeated squatting painful
- c) Painful each time
- d) Possible with partial weightbearing
- e) Unable

6. Running:
- a) No difficulty
- b) Pain after more than 2 km
- c) Slight pain from the start
- d) Severe pain
- e) Unable

7. Jumping:
- a) No difficulty
- b) Slight difficulty
- c) Constant pain
- d) Unable

8. Prolonged sitting with knee flexed:
- a) No difficulty
- b) Pain after exercise
- c) Constant pain
- d) Severe pain
- e) Unable

9. Pain:
- a) None
- b) Slight and occasional
- c) Interferes with sleep
- d) Occasionally severe
- e) Constant and severe

10. Swelling:
- a) None
- b) After severe exertion
- c) After daily activities
- d) Every morning
- e) Constant

11. Abnormal painful kneecap movements:
(patellar subluxations)
- a) None
- b) Occasionally in sports activities
- c) Occasionally in daily activities
- d) At least one dislocation after surgery
- e) More than two dislocations

12. Atrophy of thigh:
- a) None
- b) Slight
- c) Severe

13. Flexion deficiency:
- a) None
- b) Slight
- c) Severe

Score ______ Print Form Submit

APPENDIX G – TURNITIN REPORT

CORRELATION BETWEEN LOWER LIMB ALIGNMENT AND PATELLOFEMORAL PAIN SYNDROME AMONG BADMINTON PLAYERS IN UTAR

by Hee ZiYu

Submission date: 23-Dec-2022 09:51PM (UTC-0500)
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