TEH WEI ZE

RELATIONSHIP BETWEEN QUADRICEPS ANGLE AND HAMSTRING FLEXIBILITY WITH KNEE INJURIES AMONG WEIGHT LIFTERS IN SELANGOR, MALAYSIA

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BACHELOR OF PHYSIOTHERAPY (HONS) UNIVERSITI TUNKU ABDUL RAHMAN

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RELATIONSHIP BETWEEN QUADRICEPS ANGLE AND HAMSTRING FLEXIBILITY WITH KNEE INJURIES AMONG WEIGHT LIFTERS IN SELANGOR, MALAYSIA

By

TEH WEI ZE

A Research project submitted to the Department of Physiotherapy,
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RELATIONSHIP BETWEEN QUADRICEPS ANGLE AND HAMSTRING FLEXIBILITY WITH KNEE INJURIES AMONG WEIGHT LIFTERS IN SELANGOR, MALAYSIA

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ABSTRACT

Background and Objective: There are many potential risk factors for weight lifters to suffer knee injuries. Quadriceps angle and hamstring flexibility are proven risk factors in suffering knee injuries among athletes. However, no study has been performed to examine the association of these two factors with knee injuries among weight lifters. The purpose of this study is to examine the association between quadriceps angle and hamstring flexibility with knee injuries among weight lifters. It is hypothesised that there is an relationship between these two factors with knee injuries among the weight lifters.

Methods: 44 participants were recruited. A consent form and demographic data form were provided for the individuals to fill. Then, the participants were required to fill up the Modified Standardized Nordic Questionnaire, which involved occurrence of past knee injuries. Those who fit the inclusion criteria performed two tests, quadriceps angle measurement and sit and reach test. Data was then collected and analysed.

Results: Among recreational weight lifters, there is no significant relationship between Q-angle and knee injuries. There is no significant relationship between hamstring flexibility and knee injuries. There is a significant difference between the Q-angle on the dominant and non-dominant side with and without knee injuries. There is no significant relationship between quadriceps angle and hamstring flexibility, except for the Q-angle on the non-dominant side among recreational weight lifters with no history of knee injuries.

Conclusion: The study concluded Q-angle and hamstring flexibility have no significant relationship. The study also concluded that relationship between quadriceps angle and hamstring flexibility with knee injuries both not significant. More research needs to be done on the relationship between Q-angle and hamstring flexibility with knee injuries among recreational weight lifters. There is significant bilateral variability between the Q-angle on both legs for weight lifters regardless of injuries

Keywords: Quadriceps angle, Hamstring Flexibility, Knee Injuries, Weight Lifters

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APPROVAL SHEET

This Research project entitled **<u>RELATIONSHIP BETWEEN QUADRICEPS ANGLE AND HAMSTRING FLEXIBILITY WITH KNEE INJURIES AMONG WEIGHT LIFTERS”</u>**

was prepared by TEH WEI ZE and submitted as partial fulfilment of the requirements for the degree of Bachelor of Physiotherapy (HONS) at Universiti Tunku Abdul Rahman.

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FACULTY OF MEDICINE AND HEALTH SCIENCES

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Date: 23/12/2022

PERMISSION SHEET

It is hereby certified that **TEH WEI ZE** (ID No: **20UMB00569**) has completed this Research project entitled RELATIONSHIP BETWEEN QUADRICEPS ANGLE AND HAMSTRING FLEXIBILITY WITH KNEE INJURIES AMONG WEIGHT LIFTERS IN SELANGOR, MALAYSIA under the supervision of MS AMBUSAM A/P SUBRAMANIAM (Supervisor) from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health sciences.

Yours truly,

(TEH WEI ZE)

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: TEH WEI ZE

Date: 23/12/2022

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Q-angle	Quadriceps Angle
NMQ	Nordic Musculoskeletal Questionnaire
UTAR	Universiti Tunku Abdul Rahman
1RM	1 Rep Max
SNQ	Standardized Musculoskeletal Questionnaire
BMI	Body Mass Index
ASIS	Anterior Superior Iliac Spine
ACL	Anterior Cruciate Ligament
PCL	Posterior Cruciate Ligament
M	Mean
SD	Standard Deviation
p	P value (Significance)

CHAPTER 1

INTRODUCTION

1.1 Chapter overview

The first chapter introduces on the background information of the study and context for the whole research thesis followed by discussion on the significance and relevance of current study, research objectives as well as hypotheses and operational definition of terms.

1.2 Background of study

1.2.1 Weight Lifting

Weight lifting refers to the use of free weight equipment, such as barbells and dumbbells, weight machines, or other devices that provide resistance to movement performed for the purpose of exercise and/or the improvement of recreational and sport performance (Vaughan, 2020). It should not be confused with weightlifting (1 word), which is a sport in which 2 lifts, the snatch and the clean and jerk, are performed in competition (Stone et al., 2006). In order to achieve desired increases in muscle strength, endurance, and growth, the fundamentals of weight lifting require manipulating factors including repetitions, sets, tempo, types of exercise, and amount of weight lifted. An individual can manipulate these variables in order to achieve specific goals. Proper technique or ‘form’ should be practiced to ensure the target muscles are sufficiently challenged and to decrease risk of injuries.

Weight lifting has long been one of the most popular hobbies for people of all ages, and some do it recreationally, some do it for bodybuilding purposes, and others for competitive sport. Most weight lifters perform the activity at recreational gyms, where specific gym equipment is usually provided that each serve different purposes and help the individual to achieve different goals. Some perform the activity at home with store bought weights, while some go to private boutique gyms that offer higher quality equipment and more personalized services

1.2.2 Knee Injuries

The knees are among the most common sites of weight lifting injuries. The knee joint is susceptible to injuries during weight lifting as flexion and extension of the knee is performed repetitively while bearing heavy weights. Common lower limb exercises that involve flexion and extension are squat variations, such as barbell back squat, Bulgarian split squat, Goblet squat, deadlift variations, such as conventional deadlift, Romanian deadlift, single leg deadlift, and other exercises like leg presses, good mornings, leg extensions etc. A recent study found that knee injuries had an occurrence rate of 10-32% among weight lifters in the studies they reviewed (Keogh & Winwood, 2017). Another study also reported that the knees were among the 3 most common injured sites and 80% of knee injuries resulted in symptoms lasting for more than 4 weeks (Aasa et al., 2017). However, there is a lack of data on the occurrence of knee injuries among Malaysian weight lifters.

1.2.3 Q-angle

The quadriceps angle (Q-angle) is the angle established by the quadriceps muscles and the patella tendon. It is an important clinical metric for exhibiting the biomechanical effect of the quadriceps femoris on the knee and is also necessary for optimal posture and patella mobility (Khasawneh et al., 2019). It appears that the value of the Q-angle is anterior knee pain are related (Emami et al., 2007). According to the study, those who experience anterior knee pain have higher Q-angles than healthy counterparts. This is believed to be caused by an excessively high valgus angle, which is brought on by a higher Q-angle, increasing the lateral pull of the quadriceps femoris muscle on the patella. Because of this, there is a higher risk of mal-tracking and excessive pressure on the patellofemoral articulation., which may potentially result in anterior knee pain and eventual cartilage wearing on the underside of the patella (Emami et al., 2007). Although numerous studies have examined the relationship between Q-angle and knee injuries in healthy individuals, there is currently lack of studies investigating the relationship between Q-angle and knee injuries in weight lifters.

1.2.4 Hamstring flexibility

Hamstring flexibility is the range of motion the knee can undergo until resistance is encountered. It also presents as a possible risk factor in the occurrence of knee injury. Athletes with patellar tendinopathy were shown to have less hamstring flexibility than athletes without symptoms, which may have accelerated the condition by putting more strain on the knee extensor mechanism (Aiyegbusi et al., 2019). Posterolateral knee pain can occur when there is a mild strain of the distal hamstrings, which results from poor hamstring flexibility ("Common Pediatric Knee Injuries," 2021). Patellar tendonitis can also occur as a result of decreased hamstring flexibility (Fronterra et al., 2007). However, there is a lack of studies that have assessed the association between hamstring flexibility and knee injuries among weight lifters.

1.2.5 Concluding Remarks

Squatting and deadlifting are among the most popular exercises among weight lifters, and are 2 of the Big 3 exercises for bodybuilding and strength training (Morgan, n.d.). Both involve repetitive flexion and extension of the knee while bearing heavy weights, causing high knee joint torques especially when an individual is performing the exercises at 75% of 1RM (Kipp et al., 2011), high shear stress through the passive structures of the knee, and high peak patellofemoral joint compression forces, with maximum at 60-90 degrees of knee flexion (Neumann, 2010). As it can be seen, all these serve as risk factors for knee injuries. Currently, there is paucity of research done to examine the association between the Q-angle and hamstring flexibility with knee injuries among weight lifters. Therefore, there is a need to address the problem to prevent occurrence of injuries among them.

1.3 Research Objectives

1.3.1 General Objectives

1. To investigate the relationship between quadriceps angle and hamstring flexibility among weight lifters in Selangor, Malaysia

1.3.2 Specific Objectives

1. To investigate the bilateral variability of Q-angle value and hamstring flexibility among weight lifters in Selangor, Malaysia
2. To investigate the relationship between quadriceps angle and knee injuries among weight lifters with and without knee injuries in Selangor, Malaysia
3. To investigate the relationship between hamstring flexibility and knee injuries among weight lifters with and without knee injuries in Selangor, Malaysia
4. To investigate the relationship between quadriceps angle and hamstring flexibility among weight lifters with and without knee injuries in Selangor, Malaysia

1.4 Hypotheses

Null Hypothesis (H_0)

1. There is no significant relationship between quadriceps angle and hamstring flexibility among weight lifters in Selangor, Malaysia.

Alternate Hypothesis (H_A)

1. There is a significant relationship between quadriceps angle and hamstring flexibility among weight lifters in Selangor, Malaysia.

Null Hypothesis (H_0)

1. There is no significant bilateral variability of Q-angle value among weight lifters in Selangor, Malaysia

Alternate Hypothesis (H_A)

1. There is significant bilateral variability of Q-angle value among weight lifters in Selangor, Malaysia

Null Hypothesis (H_0)

1. There is no significant relationship between quadriceps angle and knee injuries among weight lifters in Selangor, Malaysia

Alternate Hypothesis (H_A)

1. There is a significant relationship between quadriceps angle and knee injuries among weight lifters in Selangor, Malaysia

Null Hypothesis (H_0)

1. There is no significant relationship between hamstring flexibility and knee injuries among weight lifters in Selangor, Malaysia

Alternate Hypothesis (H_A)

1. There is a significant relationship between hamstring flexibility and knee injuries among weight lifters in Selangor, Malaysia

1.5 Operational Definition

Quadriceps angle: The angle formed between the quadriceps muscles and the patella tendon by extending a line from the ASIS to the central patella and another line from the central patella to the tibial tubercle (Khasawneh et al., 2019).

Hamstring flexibility: The hamstrings' ability to move through their whole range of motion (Nikzad et al., 2020).

Weight lifters: An individual who performs exercise that involve movement against resistance from weights like dumbbells, barbells, or from machines, like the Smith machine, leg press machine, leg extension machine and so on (Vaughan, 2020).

Knee injuries: Trauma to one or more tissues that comprise the knee joint, including ligaments, tendons, cartilage, bones and muscles (“Knee Injuries”, n.d.).

1.6 Structure of research project

The main structure of the study consisting the research questions, research objectives, significance, and relevance of the study, will be covered in Chapter 1 of the current research thesis. This is followed by the literature review on related topics from prior studies is then included in Chapter 2. The methodology for this study is covered in Chapter 3, which also consists of research design, sampling design, research instrument, and data collection process. The data collected from the current study will be analysed using the descriptive analysis and further using the relevant inferential analysis to answer the research hypothesis in detailed of chapter 4. Chapter 5 will be concluded with a review of the study's findings, its limitations as well as recommendations for future studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Chapter overview

This chapter 2 emphasises the themes of the research issues that are connected, using earlier articles, evidences, and literature as the main basis and structure for the area under study.

2.2 Popularity of weight lifting

In recent years, the popularity of weight lifting has been steadily increasing, especially in children and early and late adolescents (Pierce et al., 2022). It is a form of resistance training in which weights are used as resistance when performing the movements. People lift weights for various different reasons, including for athletics, recreational purposes, for improvement of self-appearance, and for competition. More and more are starting to hire personal trainers to supervise their training in order to maximize their results, be more efficient with their time and reduce risk of injuries (Shahzad et al., 2021).

Weight lifting exercises and their variations have become a popular training modality among individuals to improve physical attributes and sports performance (Keogh & Winwood, 2017; Morris et al., 2022), and at least 45 million Americans participate in regular weight lifting (Golshani et al., 2018). One study found that young people in Kuantan, Malaysia find motivation in exercising from a desire to lose weight and improve self-appearance, which is associated with an improved self-esteem. In that study, 34 of 103 (33%) participants selected weight lifting as their method of exercise (Murad et al., 2016).

2.3 Mechanism of weight lifting

For weight lifting, due to the reduced mechanical torque and shorter distance from the weights, shorter heights and limb lengths have mechanical advantages while lifting heavy loads (Alabbad & Muaidi, 2016).

The two most common lower limb resistance exercises are the squat and deadlift, and are usually performed with barbells, dumbbells or kettlebells. For the biomechanics of the squat, one study examined the peak knee extensor moment of the knees of female recreational weight lifters at 3 squat depths, above parallel, parallel and full depths (Flores et al., 2020). Results show that at full depth, peak knee extensor moments were significantly greater compared with parallel depth and above-parallel depth with 50% 1RM and 85% 1RM loads (Flores et al., 2020). According to a previous study, low to moderate posterior shear forces and low anterior shear forces were produced throughout the full range of the squat, with the PCL acting primarily as a restraint on the posterior shear forces, which peak at maximum knee flexion, and the ACL acting primarily as a restraint on the anterior shear forces, which peak between 0° - 60° of knee flexion (Escamilla & Krzyzewski, 2001). During the squat, tibiofemoral and patellofemoral compressive forces were generated; which gradually increased as the knee flexed and decreased as the knee extended (Escamilla & Krzyzewski, 2001). Moreover, moderate to high quadriceps, hamstring, and gastrocnemius activity were produced during the squat, which generally progressively increased as the knee flexed and decreased as the knees extended (Escamilla & Krzyzewski, 2001).

The deadlift is another common lower limb exercise typically performed with weights, and it mainly targets the musculature of the posterior chain. There are multiple variations of deadlifts, namely the conventional deadlift, Romanian deadlift, sumo deadlift and so on. Each variation of the deadlift elicits greater activation of different lower limb muscles. The most common variation, the conventional deadlift, elicits greater activation on the vastus lateralis, vastus medialis, and the erector spinae, while another common variation, the Romanian deadlift, is associated with greater involvement of the biceps femoris and the gluteus maximus (Flandez et al., 2020; Martín-Fuentes et al., 2020).

One study found that the conventional deadlift demonstrated high knee extensor net joint moment, but was lower than the back squat, with 1.18 compared to the 2.14 of a back squat. Peak knee extensor moment was also lower with 0.46 for the conventional deadlift compared to 1.85 of a back squat. However, hip extensor net joint moment and peak joint moments were higher for the conventional deadlift compared to the back squat, with 3.22 for the conventional deadlift compared to the back squat (Choe et al., 2021). This data signifies that performing the back squat will be more beneficial for targeting the knee extensor muscles, and the conventional deadlift will be more beneficial for targeting the hip extensor muscles.

Another study found that different types of lower limb exercises, namely the clean and jerk, snatch, front squat and high bar back squats cause a large knee resistance arm and relatively low hip/lower back resistance, indicating that the front and high bar squat may require greater knee extensor torques and greater mean compressive patellofemoral forces (Keogh & Winwood, 2017).

Figure 1: Back squat technique (Gullett et al., 2009)

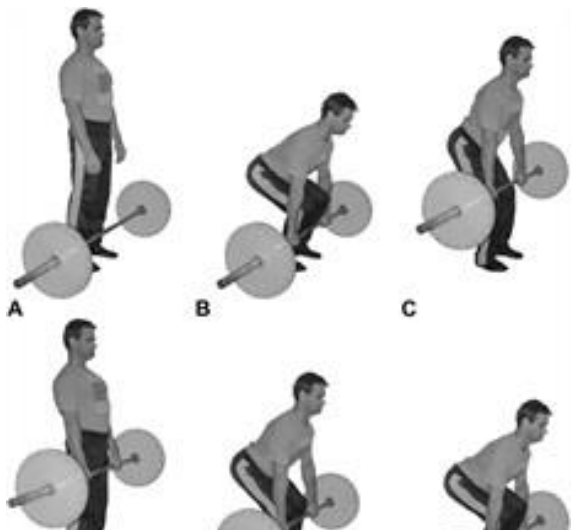

Figure 2: Conventional deadlift technique (Berglund et al., 2015)

2.4 Injuries associated with weight lifting

According to one study, there are 2.6 injuries caused by weight lifting per 1000 hours of activity. Sprains, strains, tendon avulsions, compartment syndrome, and overuse syndromes are the most frequent injuries, and the frequency of these conditions increases with the quantity of exercises performed (Shahzad et al., 2021). Another study reported similar findings, with 2.4-3.3 injuries per 1000 hours of training among weight lifters (Aasa et al., 2017). 60-75% of weight lifting related are acute injuries with varying types and severity and 30% are overuse injuries (Golshani et al., 2018).

The most frequent cause of acute injuries, accounting for 65.5% of injuries, is dropping heavy objects. 31% of them were due to technical faults, and 81% of injuries among weight lifters were brought on by tiredness or overload (Golshani et al., 2018). In terms of the equipment used, free weights are associated with a higher rate of incidence of fractures and dislocations than the use of resistance machines, accounting for 90% of them (Golshani et al., 2018).

According to one study, the proportion of knee injury in weight lifting is 9%, with injuries such as patellar disorders, meniscus injuries, ligament tears or sprains and knee instabilities (Alabbad & Muaidi, 2016). Overuse injuries would happen in the knee such as iliotibial band syndrome and anterior knee pain (Alabbad & Muaidi, 2016). Another study mentioned the rate of knee injuries for weight lifting was 10-32%, and suggested that higher loads predispose the weight lifters to acute muscle strain injuries, while lower loads increase risk of overuse connective tissue injuries (Keogh & Winwood, 2017).

2.5 Relationship of quadriceps angle and hamstring flexibility

According to a previous study, it was reported that there was a significant relationship between quadriceps angle and hamstring flexibility (Minoonejad et al., 2016). In that study, the difference of Q-angle for futsal players with and without hamstring tightness was statistically significant ($p = 0.043$). For futsal players with hamstring tightness, the recorded mean Q-angle was 15.06°± 5.03°, and for players without hamstring tightness, it was 10.4°± 8.04° (Minoonejad et al., 2016). Although there was no clear explanation for this relationship, it is believed that hamstring tightness reduces the ability of the quadriceps to contract, which reduces the strength of the quadriceps, which in turn increases the Q-angle value (Minoonejad et al., 2016). Therefore, understanding the relationship between quadriceps angle and hamstring flexibility among weight lifters will be crucial as it might affect the strength of quadriceps, leading to a reduction in performance capability during training or competition.

2.6 Association of Q-angle with knee injuries

The imaginary line from the anterior superior iliac spine of the pelvis to the centre of the patella and the proximal projection of the line from the tibial tubercle to the centre of the patella combine to generate the static Q-angle. For men, the static Q-angle is typically 10-15°, while for women it is typically 15-20° (Skouras et al., 2022).

According to one study, the Q-angle value is higher in patients with anterior knee pain, with the mean Q-angle in the case group being 18° and the control group being 14.4° (Emami et al., 2007). Moreover, it was also reported that females had a higher mean Q-angle than men, with 20.1° and 15.3° in the case group, and 16.7° and 12.1 in the control group respectively (Emami et al., 2007), suggesting that female athletes face a higher risk of injury (Khasawneh et al., 2019). Due to the fact that girls often have wider hip compared to males, leading to the femur being positioned more obliquely than one of a male's (Fatahi, 2017).

Bilateral differences of the mean Q angle value exist between the right and left leg, and is more often seen in males compared to females (Raveendranath et al., 2010). In both males and females, the Q-angle on the right side was more frequently larger than the left (Raveendranath et al., 2010; SS et al., 2019). One study found that the mean Q-angle among male subjects were 12.30 ± 4.0 and 10.38 ± 3.49 for the right and left lower limbs respectively, while the mean Q-angle among female subjects were 17.06 ± 3.64 and 14.84 ± 3.47 for the right and left lower limbs respectively (SS et al., 2019). This has been linked to quadriceps muscle strength and the relative position of the centre of the patella as well as the tibial tubercle.

When performing repetitive motions with the knee, an abnormal Q-angle indicates a propensity for greater biomechanical stress because it prevents the patella from moving smoothly in the femoral groove (Khasawneh et al., 2019). Muscle imbalances may develop over time, and on the underside of the patella, the cartilage will eventually wear away, causing loosening of the articular surface of the knee and thus long-term injury to the knee (Khasawneh et al., 2019). Furthermore, an excessive Q-angle might affect the quadriceps mechanism and the patella's lateral tracking by causing excessive foot pronation, which in turn can excessively increase internal rotation of the tibia (Khasawneh et al., 2019). An increased Q-angle may cause malalignment of the patella, leading to an increased risk of patellar dislocations, patellofemoral pain, knee osteoarthritis (Miranda-Comas et al., 2021). Moreover, femoral anteversion is also a possible result of an increased Q-angle, which often presents itself in individuals as in-toeing while walking as well as bowed legs (Scorcelletti et al., 2020). On the contrary, a reduced Q-angle may be associated with chrondromalacia patella, patella alta, patellar instability and patellofemoral pain (Skouras et al., 2022).

One study found that there was a significant association between Q-angle value and occurrence of knee injuries among healthy elite volleyball players (Fatahi, 2017). Although volleyball is thought to be a non-contact sport, intense jumping and landing frequently occur during practice sessions or over the course of a game. Prolonged repetition of those movements, especially for individuals with excessive Q-angle values, serve as a risk factor for developing various types of knee injuries (Fatahi, 2017). Therefore, understanding the relationship between quadriceps angle and knee injuries will be important in order to minimize risks of injuries which may negatively impact performance in weight lifting.

2.7 Association of hamstring flexibility with knee injuries

The hamstring muscles are a group of muscles located at the posterior side of the thigh. They consist of 3 muscles, namely the semitendinosus, semimembranosus, and biceps femoris. They primarily function to flex the knees, extend the hip, externally rotate the lower leg when the knee is slightly flexed, and also assist in externally rotating the thigh when the hip is extended (Stępień et al., 2019).

The hamstrings serve as active stabilizers for the knee in preventing anterior translation (English & Perret, 2010). Hamstring flexibility presents as a potential risk factor in developing semimembranosus tendinopathy, which usually manifests as an aching pain localized to the posteromedial knee, with tenderness on palpation inferior to the joint (English & Perret, 2010).

Chronic posterior knee pain can suggest hamstring tendinopathy (Bunt et al., 2018). As a risk factor for patella tendinopathy, tight hamstrings are also thought to increase the need for quadriceps force production to compensate for the hamstring's passive resistance during weight-bearing activities. Decreased hamstring length is also associated with posterior tibial translation, as it shortens the quadriceps moment arm, causing a compensatory increase in quadriceps force to counteract the ground reaction forces (Miranda-Comas et al., 2021; Scattone Silva et al., 2016). In short, the relationship between hamstring flexibility and knee injuries should be thoroughly investigated in order to understand the risks of injuries poor hamstring flexibility carries during weight lifting.

2.8 Effects of injury on time loss

According to Aasa et al, 80% of knee injuries among weight lifters had symptoms that persisted for longer than 4 weeks. 33% of all injuries among weight lifters did not result in any impairment, 30% lasted 1 day to 2 weeks, 34% between 2 months and 2 years, and 5% lasted for more than 2 years (Aasa et al., 2017).

The larger part of weight training injuries had symptoms that persisted for less than 2 weeks (Keogh & Winwood, 2017) . Most injuries (78-99%) range from mild to moderately severe, causing a need for modification of exercise execution, to suspending performance of the exercise (Keogh & Winwood, 2017).

Another study reported that about 95% of weight lifters who missed training reported that knee pain lasting for more than one week (Joseph et al., 2020). Up to 43% of elite weightlifters and powerlifters who retired over a span of 5 years did so as a result of injuries. Injuries also predispose to recurrent injuries and residual effects in the future, as among Korean weight lifters, 145 of 207 injuries reported were recurrent injuries (Keogh & Winwood, 2017).

CHAPTER 3

METHODS

3.1 Chapter overview

This chapter will cover the research methodology with a focus on the study design, sampling design, research tools, and process in great depth.

3.2 Research design

This study used a cross-sectional, observational research approach.

3.3 Research Setting and Duration

The current study was conducted at UTAR KA200A classroom. The duration of this research was 7 weeks in total. This study was conducted from 24th October 2022 to 9th December 2022. During this period, 4 weeks in total were used for the process of data collection. Recruitment of participants of this study was performed mainly through face-to-face as well as social media platforms such as WhatsApp and Instagram.

3.4 Participants' Characteristics

The targeted population for this study were recreational weight lifters around Selangor, Malaysia. A total of 44 participants were recruited regardless of gender. Participants in the current study were recruited based on the predefined inclusion and exclusion as shown below.

The participants of focus were recreational weight lifters aged between 18 to 40 and the sampling method was convenience sampling.

For the inclusion criteria of this study, participants were included if they met the following criteria:

1. Both genders
2. Recreational weight lifters
3. Age of 18-40 years old
4. 6 months – 4 years of experience in weightlifting
5. Perform at minimum of 1 lower limb exercise with weights per week
6. Able to write and read English
7. Voluntary participation

As for the exclusion criteria of this study, participants were excluded if they have the following conditions:

1. Usage of steroid or other sports enhancing drugs
2. Recent surgical procedures or health condition which causes weightlifting training regimen to be contraindicated
3. Presenting injuries not caused by weightlifting training
4. Actively participating in other sports beside weightlifting
5. Occupation involves heavy manual work

6. History of hip, knee or ankle surgeries and disorder

3.5 Ethical approval

This study was performed after obtaining the ethical approval from the Scientific and Ethical Review Committees (SERC) of UTAR (Appendix A). Informed consent was obtained from all participants upon recruitment. Purpose of the study, length of participation, procedure, benefits and data confidentiality, was well-informed to the participants.

3.6 Sampling Method

Convenient sampling method was used for this study.

3.7 Sample Size

The participants of focus were recreational weight lifters aged between 18 to 40. By using G Power version 3.1.9.4. the input parameters including effect size d which is 0.8, alpha error problem 0.05 and power 0.8 are set. The total sample size after calculation showed a minimum of 52 participants. The sample size in the current study was calculated based on the previous established guideline (Sharma et al., 2020). However, only 44 participants were recruited based on the predefined inclusion and exclusion criteria and agreed to participate in the current study.

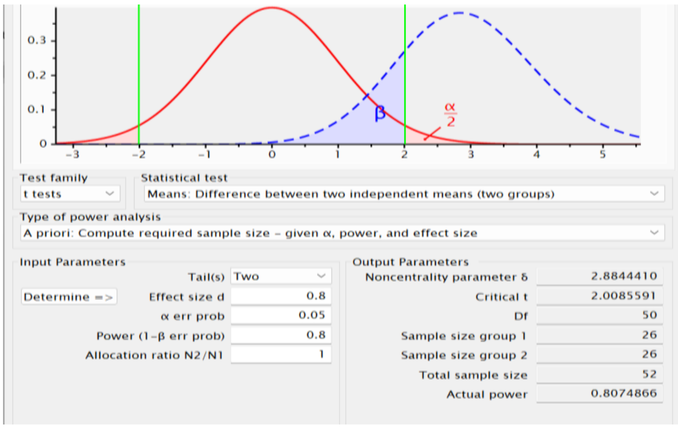

Figure 3: G Power Sample Size Calculation

3.8 Research instrument

3.8.1 Modified Standardized Nordic Questionnaire

The Standardized Nordic Musculoskeletal Questionnaire (NMQ) was developed from a project financed by the Nordic Council of Ministers to screen for all musculoskeletal injuries (Crawford, 2007). It is frequently used in epidemiological surveys in industry and in the community, and gathers data on the period prevalence of symptoms and how much they interfere with work and leisure (Palmer et al., 1999).

The prevalence of knee injuries among the weight lifters will be screened using Standardized Nordic Questionnaire (SNQ). This questionnaire has been validated (Baron et al., 1996) and used extensively to screen for all musculoskeletal injuries (Abas et al., 2020; Crawford, 2007). The questions will be taken from NMQ to screen for knee injuries among the participants. SNQ has been proven to be highly repeatable (kappa = 0.63-0.90) and sensitive (range = 0.33-0.38) (Palmer et al., 1999). Validity tested against clinical history and the SNQ found a range of 0-20% disagreement (Crawford, 2007).

The questions below (Q1, Q2, and Q3) were taken from the SNQ. These extracted questions aim to screen for the presence of knee injuries among weight lifters.

Q1: Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort) in one / both knees?

Q2: During the last 12 months have this trouble prevented you from doing your normal activity (such as job, hobbies, or housework)?

Q3: During the last 7 days do you have any trouble with your knees?

3.8.2 Quadriceps Angle (Q-angle) measurement

Among individuals with anterior knee pain, the Q-angle is regarded as a significant factor in assessing the function and health of the knee joint. It can also provide valuable information about the alignment of the pelvis, leg and foot (Khasawneh et al., 2019). Misalignments can negatively affect the function of the knee, thus assessment of Q-angle is especially crucial for individuals who are physically active. According to a study done by Khasawneh et al, the normative values of Q-angle for males is between 8 to 10°, while females should have a higher value of up to 15° due to anatomical differences (Khasawneh et al., 2019).

Regarding comparing Q-angle measurement between standing or supine, there was no difference in the reading when the relaxation and contraction of the quadriceps were constant (Cuerra & Cajdosik, 1994). The same study also indicated that there was no significant difference in the Q-angle measurement when the quadriceps muscle contracts or relaxes. Moreover, a study showed no statistically significant difference between clinical and radiographic measurement of Q-angle (Smith et al., 2008). Therefore, this suggests that Q-angle has justifiable criterion validity.

Based on the measurement protocol performed by Khasawneh et al in a study from 2019, the equipment needed for Q-angle measurement: Universal goniometer, white masking tape and measuring tape, and the Q-angle measurement procedure will be (Khasawneh et al., 2019):

1. Asking the participant to be in an upright weight-bearing standing position with the hip in a neutral position; both feet placed shoulder-width apart, with toes pointing forward and parallel with each other; bilateral quadriceps muscle is relaxed with knee extended (not hyperextended); bilateral ASIS are aligned with each other (Khasawneh et al., 2019).
2. Lower limb dominance will be determined based on the participant's preference when asked to kick a ball.
3. The ipsilateral ASIS, midpoint of the patella and tibial tubercle of the dominant lower limb will be palpated and marked with white masking tape to be used as a reference point for the universal goniometer placement.
4. The centre point of the universal goniometer will be placed on the midpoint of the patella with the stationary arm and movable arm pointing towards the ASIS and tibial tubercle respectively.
5. The small angle on the universal goniometer will be documented as "Q-angle".
6. The procedure from step 3 to 5 is then repeated on the other leg.
7. Each side will be measured for a total of 3 times and the average value of the "Q-angle" is calculated.
8. The measurement will be documented as "Q-angle of dominant LL" and "Q-angle of non-dominant LL".
9. The white masking tape will then be removed once the measurement is complete.

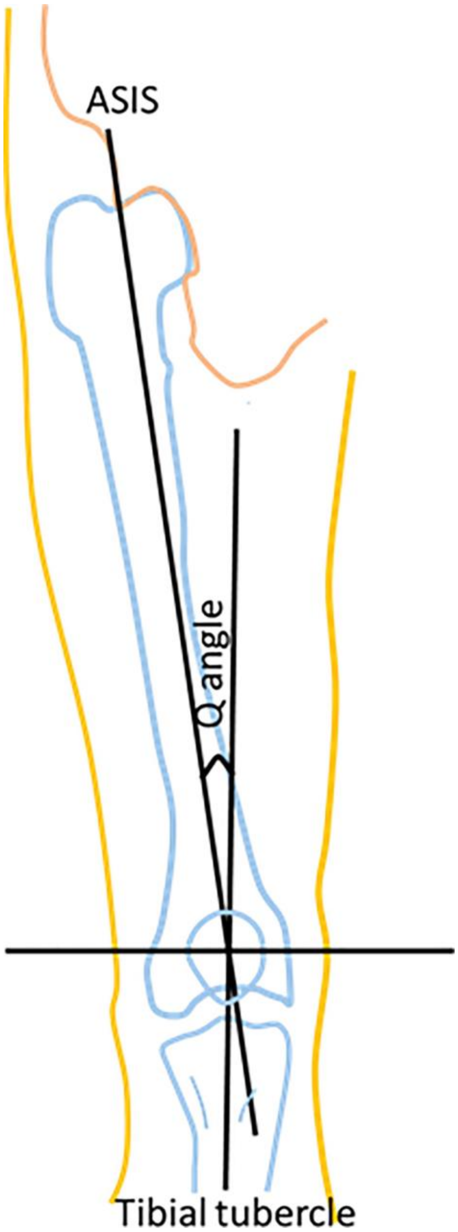

Figure 4: Q-angle measurement (Khasawneh et al., 2019)

3.8.3 Sit and reach test

Poor hamstring flexibility is a potential risk factor for knee injuries. Disorders associated with poor hamstring flexibility include patellar tendinopathy, patellar tendonitis, posterolateral knee pain. Therefore, hamstring flexibility will be assessed with the sit and reach (SR) test. The SR test has been proven to have clinically acceptable intrarater and interrater reliability, as well as having moderate validity (Ayala et al., 2012; Baltaci et al., 2003). A study by Ayala et al demonstrated acceptable reproducibility measures for the SR test with a coefficient of variation (CV) of 8.74% and an intraclass correlation coefficient (ICC) of 0.92 (Ayala et al., 2012).

Based on the measurement protocol performed by Ayala et al in a study from 2012, equipment needed for the SR test will be a standard SR box, and the SR test measuring procedure will be (Ayala et al., 2012):

1. Placing a standard sit and reach box on the floor, and placing tape at a right angle to the 126cm mark.
2. The participant then sits down on the floor with the shoes off, keeping the legs together with knees extended, and placing the soles of the feet against the box.
3. The participant then slowly reaches forward with extended arms as far as possible while placing the dominant hand on top of the other facing palms down, and also not bending the extended leg.
4. The participant then holds this position for 2 seconds, making sure to keep the hands parallel and not leading with one hand. Throughout this process, the foot should not move away the end of the box.

5. The score is then taken down, which is the most distant point (cm) reached with the fingertips. The “zero” point is set at the 126cm mark. If the participant cannot reach the 126cm mark, then deduct from 126cm, the distance of the fingertips from the mark. If the participant reaches over the 126 cm mark, then add from 126cm, the distance of the fingertips from the mark.
6. Three trials will be performed, then the average of the three trials on each side will be used for documentation.
7. The measurement will be documented as “Sit and reach test score”.

3.9 Procedure

This study uses a cross-sectional design which requires 57 participants. Individuals who are aged between 18 to 40, are able to write and read English, was sent an online questionnaire (Google Form). The questionnaire consists of 4 parts;

I Personal Data Protection Statement (refer to APPENDIX B)

II, Informed Consent Form (refer to APPENDIX D)

III Demographic Data (refer to APPENDIX E)

IV Modified Standardized Nordic Questionnaire (refer to APPENDIX F)

This demographic data form was used to obtain the individual’s name, age, gender, height, weight. It mainly aims to screen the individuals based on the inclusion criteria of this study, requiring the individual to answer questions based on their weight lifting activity and experience, occupation, injury history, medical history and surgical history.

A convenience sample of participants was recruited through social media platforms, such as Instagram and WhatsApp. Furthermore, face-to-face recruiting was performed around Selangor. After that, participants who met the inclusion criteria then filled up the informed consent form to give their consent after reading the information sheet.

The data was collected at KA200A classroom of UTAR. Within a span of four weeks, each participant approached at the KA200A classroom will be briefed about the purpose of the study, and asked for their willingness and consent to take part in the current study. Eligible and included participants provided their demographic and relevant information while the non-eligible participants were excluded from this study. Included participants went through SNQ screening and were categorized into two groups (with knee injuries and without knee injuries). Then Q-angle and hamstring flexibility were assessed on the spot according to the procedures explained above.

3.10 Data analysis

Data collected will be analysed using IBM Statistical Package for Social Science (SPSS) software version 26.0 and Microsoft Excel to produce study outcomes. Demographic data including height, age, body weight, body mass index will be analysed by descriptive statistics and reported as mean (M) and standard deviation (SD). Descriptive statistics were analyzed based on their frequencies and percentages according to the categories. The normal distribution of the variables was tested with skewness test and Shapiro-Wilk methods.

All the data in Q angle were normally distributed. For the bilateral variability between Q-angle of dominant and non-dominant leg within subjects, paired t-test were used. Whereas for comparison of bilateral variability of participants with and without knee injury (between subjects), independent t-test were used. The statistical significance value was set at P-value of <0.05.

The data on the hamstring flexibility (sit and reach test) were not normally distributed. Thus, the results were reported using the median for score value and non-parametric test, Mann-Whitney U test was used to examine the differences between the injured and non-injured participants. The statistical significance value was set at P-value of <0.05.

The relationship between quadriceps angles, hamstring flexibility and knee injuries accordingly were examined using the point biserial correlation as well as the spearman correlation test. The statistical significance value was set at P-value of <0.05. Detailed of the analysis of each test were shown in the Table 1 below according to the objectives tested.

Table 1

Statistical tests used

Objectives	**Statistical test**
To examine the bilateral variability of Q-angle value and hamstring flexibility among weight lifters in Selangor, Malaysia	
1. To examine bilateral variability of dominant and non-dominant leg in injured participants	Paired t-test
2. To examine bilateral variability of dominant and non-dominant leg in non-injured participants	Paired t-test
3. To examine bilateral variability of dominant legs between injured and non-injured participants	Independent t-test
4. To examine bilateral variability of non-dominant legs between injured and non-injured participants	Independent t-test
5. To examine differences of hamstring flexibility between injured and non-injured participants	Mann- Whitney U-test
To examine the relationship between quadriceps angle and knee injuries among weight lifters with and without knee injuries in Selangor, Malaysia	Point biserial correlation
To examine the relationship between hamstring flexibility and knee injuries among weight lifters with and without knee injuries in Selangor, Malaysia	Point biserial correlation

To investigate the relationship between quadriceps angle and hamstring flexibility among weight lifters in Selangor, Malaysia	Spearman correlation

CHAPTER 4

RESULTS

4.1 Chapter overview

This chapter presents the findings after the data collection process for the research project. Data was collected from a total of 44 participants who are recreational weight lifters.

Descriptive statistics were used to report the demographic data of the participants. Following that, the score and grouping of the outcome measures, results of the inferential tests and lastly hypothesis testing is elaborated. The results are being presented in the sequence of a brief description followed by the tabulation.

4.2 Demographic data of the participants

A total of 44 participants were selected through convenience sampling from the UTAR gymnasium. There were no missing data documented in each section of the questionnaire answered by the included participants. For this study, as stated in Table 2, there are more male participants than female participants (n=37, 84.1%,). For the age subcategory, most of the participants were in the age group of 18-24 (n=41, 93.2%), with the mean age being 21.14 ± 2.29. Furthermore, majority of the participant's BMI are under the "Healthy Weight" category (n=31, 70.5%), with the mean BMI being 22.74 ± 3.97.

As stated in Table 2, majority of the participants answered they lift weights 1-2 days per week (n=26, 59.1%). Furthermore, for the years of experience subcategory, majority of participants (n=20, 48.1%). responded with "6 months to 1 year" Moreover, majority of the participants (n=37, 84.1%) responded that did not have any coaches or trainers. Besides, majority of the participants (n=39, 88.6%) responded that they do perform warm ups before a workout session. Half of the participants (n=22, 50%) responded that they did perform cool-down after a workout session, while the other half responded that they did not.

Table 2

Demographic data of the participants

Demographic data				
Demographic Variables	**Subcategory**	**Mean ± SD**	**Frequency (n)**	**Percentage (%)**
Gender	**Male**		37	84.1
	Female		7	15.9
Age		21.14 ± 2.29		
	18-24		41	93.2
	25-30		3	6.8
BMI		22.74 ± 3.97		
	Underweight		5	11.4
	Healthy Weight		31	70.5
	Overweight		6	13.6
	Obese		2	4.5
Weight lifting days per week	**1-2**		26	59.1
	3-4		13	29.5

	5-6	4	9.1
	7-8	1	2.3
Years of experience	**6 months to 1 year**	20	45.5
	1 year to 2 years	8	18.2
	2 years to 4 years	16	36.4
Do you have any coaches or trainers?	**Yes**	7	15.9
	No	37	84.1
Do you perform warm-ups before a workout session?	**Yes**	39	88.6
	No	5	11.4
Do you perform cool-down after a workout session	**Yes**	22	50
	No	22	50

BMI categorization: <18.5 (Underweight), 18.5-24.9 (Healthy weight), 25-29.9 (Overweight), 30-39.9 (Obese) (NHS.uk, 2019)

4.3 Distribution of knee injuries

In order to screen for knee injuries among the participants, the Modified Nordic Musculoskeletal Questionnaire was used. As stated in Table 3, majority of the participants (n=25, 56.82%) reported no trouble (ache, pain, discomfort) in one or both knees in last 12 months. Besides, majority of the participants (n=36, 81.8%) reported that they have not been prevented from doing their normal work at or away from home in the last 12. Furthermore, majority of the participants (n=40, 90.9%) reported that they have not had any trouble during the last 7 days.

Table 3

Modified Nordic Musculoskeletal Questionnaire

Distribution of knee injuries			
Variables	**Subcategory**	**Frequency (n)**	**Percentage (%)**
Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in ONE or BOTH knees in last 12 months?	**Yes**	19	43.18
	No	25	56.82
Have you at any time during the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble?	**Yes**	8	18.2
	No	36	81.8
Have you had trouble at any time during the last 7 days?	**Yes**	4	9.1
	No	40	90.9

4.4 Quadriceps angle of the participants

In the analysis within group, the mean Q-angle on the dominant leg of participants with knee injuries was higher compared to the non-dominant leg, with the difference being statistically significant ($p = 0.003$). This is also concurrent for participants without knee injuries, whereby there is a significant difference between dominant and non-dominant leg as well (p = 0.000) (Table 4).

For the analysis between groups, independent t test was performed to compare means of Q angle between both injured and non-injured participants. For the Q-angle on the non-dominant side, there was no significant difference between the two means among participants with and without knee injuries (p = 0.752). As for the Q-angle on the dominant side, there was also no significant difference between the means among participants with and without knee injuries (p = 0.848).

Table 4

Quadriceps angle

Quadriceps angle (QA) of the participants						
	Injured Dominant Leg (n=19)	**Injured Non-Dominant (n=19)**	**P value**	**Non-Injured Dominant (n=25)**	**Non-Injured Non-Dominant (n=25)**	**P value**
Mean ± Std. Deviation	18.63 ± 5.52	16.37 ± 5.28	0.003	18.32 ± 5.121	16.80 ± 3.72	0.000

4.5 Sit and reach test of the participants

In Table 5, the median of sit and reach score of the participants with knee injuries were 7.50cm whereas for the participants without knee injuries the median were 6.17cm. No significant differences noted in the analysis.

Table 5

Sit and reach test score

Sit and reach test of the participants (cm)			
	Injured players (n=19)	**Non-Injured (n=25)**	**P value**
MEDIAN	7.50	6.17	0.619

4.6 Relationship between quadriceps angle and hamstring flexibility

In Table 6, a Spearman correlation test performed between the Q-angle on dominant leg of participants with knee injuries and hamstring flexibility (sit and reach test score) indicated the relationship was not statistically significant (r = 0.086, p = 0.726). Furthermore, the relationship between the Q-angle on dominant leg of participants without knee injuries and hamstring flexibility (sit and reach test score) was also not statistically significant (r = 0.174, p = 0.405).

Similarly, the relationship between the Q-angle on the non-dominant leg of participants with knee injuries and hamstring flexibility (sit and reach test score) was also not statistically significant (r = 0.309, p = 0.198). However, the Q-angle on the non-dominant leg of participants without knee injuries and hamstring flexibility (sit and reach test score) was statistically significant (r = 0.410, p = 0.042).

Table 6

Relationship between quadriceps angle and hamstring flexibility

Relationship between quadriceps angle and hamstring flexibility				
Sit and Reach test	**Q-angle dominant**		**Q-angle non-dominant**	
With knee	**r**	**p**	**r**	**p**
injuries	0.086	0.726	0.309	0.198
Without	r	p	r	p
knee injuries	0.174	0.405	0.410	0.042*

p value <0.05

4.7 Relationship between quadriceps angle and knee injuries

In Table 7, a Pearson correlation test performed between Q-angle value on the dominant leg and knee injuries, and the Q-angle value on the dominant leg and knee injuries indicated that the relationship was not statistically significant (r = -0.03, p = 0.848). Moreover, the relationship between the Q-angle value on the non-dominant leg of participants and knee injuries was also not statistically significant (r = 0.049, p = 0.752).

Table 7

Relationship between quadriceps angle and knee injuries

Relationship between quadriceps angle and knee injuries				
	Q-angle dominant		**Q-angle non-dominant**	
Knee	**r**	**p**	**r**	**p**
injuries	-0.03	0.848	0.049	0.752

p value <0.05

4.8 Relationship between hamstring flexibility and knee injuries

In Table 8, a Spearman correlation test performed between sit and reach test score average and knee injuries indicated that the relationship was not statistically significant (r = -0.076, p = 0.624).

Table 8

Relationship between hamstring flexibility and knee injuries

	Sit and reach test score average	
Knee injuries	**r**	**p**
	-0.076	0.624

p value <0.05

CHAPTER 5

DISCUSSION

5.1 Chapter overview

This chapter will provide an overview of the discussion on important findings from the results sections in accordance with the research objectives, followed by the limitations of the study as well as recommendations for future research

5.2 Discussion

5.2.1 Comparison of bilateral variability of quadriceps angle of the participants

In this study, the mean of the Q-angle on dominant leg of participants with knee injuries was 18.63, whereas on the dominant leg of participants without knee injuries, the mean and standard deviation was 18.32 respectively, meaning there was a minor difference of 0.31 between the two means, and this difference was not statistically significant ($p = 0.752$). Moreover, the mean of the Q-angle on the non-dominant leg of participants with knee injuries was 16.37, whereas on the non-dominant leg of participants without knee injuries was 16.80, leading to a minor difference of 0.43 between the two means, which was also not statistically significant ($p = 0.848$).

Furthermore, in this study, when the Q-angle of the dominant and non-dominant side of participants with and without knee injuries were compared, there were significant differences in both groups, indicating there is bilateral variability between the Q-angle values among individuals, which is consistent with the findings from previous studies (Raveendranath et al., 2010; SS et al., 2019). Furthermore, the Q-angle value on the dominant leg was larger than non-dominant leg in both participants with or without knee injuries in this study, and this is also consistent with findings from previous studies (Khasawneh et al., 2019; Raveendranath et al., 2010).

The Q-angle is an angle formed between the quadriceps muscle and the patellar tendon. When evaluating the function of the knee joint, the Q-angle is frequently considered to be an important factor. Clinically, it is used as a measure of the alignment of the quadriceps femoris musculature relative to the alignment of the underlying skeletal structures of the pelvis, femur and tibia (Fatahi, 2017). The normative values for Q-angle are 8°- 10° for males, and 15°-20° for females (Khasawneh et al., 2019). However, normative values for Q-angle are highly variable, as different studies have reported different normative Q-angle values (Emami et al., 2007; Skouras et al., 2022; Smith et al., 2008). Furthermore, values taken from these studies do not reflect the normative values of the Asian population as there is a lack of studies done on that population. Most of the studies performed have focused on other populations and might not imply with the value projected in the current study (Emami et al., 2007; Khasawneh et al., 2019a; Merchant et al., 2020). Two different studies examining the Q-angle values of different populations, one being Arabian, the other being the US population, had different mean values of the Q-angle for both males and females (Emami et al., 2007; Merchant et al., 2020). Therefore, it cannot be concluded that the Asian population has similar normative values for the Q-angle than the values stated in those studies.

An abnormally large Q-angle is considered indicative of extensor mechanism misalignment, and has been associated with multiple knee injuries, such as patellofemoral pain syndrome, hypermobile knee joint and patellar instability (Fatahi, 2017). Alterations to the patellofemoral articulation and knee joint biomechanics are also possible, due to the presence of an abnormally high valgus angle, which exerts a laterally directed force that can potentially lead to mal-tracking and excessive pressure on the patellofemoral articulation, eventually causing anterior knee pain.

It has been suggested that a number of various factors, including the Q-angle, contribute to a variety of knee problems. An unusually large Q-angle presents as one of the primary causes of anterior knee discomfort and patellofemoral instability (SS et al., 2019). More often than not, there are minor bilateral variations in bodily structures or errors in measurement, but significant variations demand closer examination.

Moreover, there are multiple theories on why there is bilateral variability of Q-angle values. One study mentioned a possible cause being a bilateral difference in quadriceps strength, and it was found that the magnitude of the Q-angle varied inversely with the peak torque angle during active knee extension (Byl et al., 2000). The same study also theorized that hypertrophy of the quadriceps musculature can contribute to a decrease in the respective Q-angle (Byl et al., 2000). However, this is contradictory to the results of this study, as the Q-angle on the dominant lower limb was found to be on average higher than the non-dominant side.

For there to be a bilateral difference in the angle, the three bony points that were utilised to measure the Q-angle had to move in relation to one another. It seems doubtful that the anterior superior iliac spine, which occupies a location that is generally fixed, is the source of bilateral variability (Raveendranath et al., 2010). As a result, the variability can be explained by a shift in the relative locations of the tibial tubercle and the patellar centre. In one study, it was discovered that there was a significant positive relationship between the dominant's larger mean value and the bilateral variability of the relative lateral positioning of the tibial tubercle with respect to the centre of the patella in males compared to females.

5.2.2 Relationship between quadriceps angle and knee injuries among weight lifters

In this study, results show that the relationship between quadriceps angle and knee injuries is not statistically significant for both the Q-angle on the dominant side ($p = 0.848$), as well as for the non-dominant side ($p = 0.752$). These findings suggest that the occurrence of knee injuries among recreational weight lifters is not related to changes of the Q-angle, and also that knee injuries are not a factor in the changes of Q-angle values among recreational weight lifters. However, this is contrary to the findings of multiple studies that state abnormally high Q-angle values have an apparent relationship with knee injuries (Emami et al., 2007; Khasawneh et al., 2019), although these studies did not specifically state under which physical activities or conditions is the risk of the knee injuries increased.

One study investigating the relationship between Q-angle and knee injuries among elite volleyballers did mention that due to high intensity nature of the sport when performing forceful jumping and landing, there is a heightened risk of knee injuries among elite volleyballers, as an abnormally large Q-angle may also lead to an increase in the pressure between the patella and the underlying lateral femoral condyle upon activation of the quadriceps (Fatahi, 2017). For this study in which the targeted population is recreational weight lifters, due to the no-contact nature of the activity and absence of intense and rapid movements such as jumping, landing, or change of direction, the Q-angle value may not be a factor in the occurrence of knee injuries.

5.2.3 Comparison of hamstring flexibility among weight lifters with and without knee injuries

In this study, as the data was not normally distributed, median was used as a measure of central tendency. Furthermore, the difference of the median of the sit and reach test score between participants with and without knee injuries was not statistically significant ($p = 0.619$), with the participants with knee injuries having a median score of 7.50, while the participants without knee injuries have a median score of 6.17.

The results of this study are in contrast to those of a prior study, which found that athletes with patellar tendinopathy had less hamstring flexibility than athletes without symptoms (Scattone Silva et al., 2016). However, another study found that athletes with bilateral patellar tendinopathy had more flexible hamstrings than those without symptoms (Crossley et al., 2007). One of these studies included athletes with bilateral patellar tendinopathy, while the other only included those with unilateral patellar tendinopathy, which may have contributed to the conflicting findings, as different types of patellar tendinopathy are suggested to have distinct characteristics (Scattone Silva et al., 2016). There is limited research comparing the hamstring flexibility of weight lifters with knee injuries with uninjured weight lifters. Therefore, there is difficulty comparing the results of this study with other studies.

The hamstrings are a group of muscles located at the posterior side of the thigh, which are mainly involved in knee flexion and hip extension. They also aid in external rotation of lower leg when the knee is slightly flexed, and assisting in external rotation of the thigh during hip extension (Stępień et al., 2019). Additionally, in order to prevent anterior translation, the hamstrings also serve as an active stabilizer for the knee (English & Perret, 2010). Hamstring flexibility is the ability of the hamstring muscles to complete their full joint range of motion (Nikzad et al., 2020).

Poor hamstring flexibility presents as a risk factor in developing a variety of knee injuries, especially those caused by overuse of the muscle. Recently, hamstring flexibility has been shown to be a factor in the angle-torque relationship for the knee flexors, which can result in an increase in knee flexion during the stance phase, which may predispose an individual to patella tendinopathy (Kipp et al., 2019).

Furthermore, it has been discovered that the optimal lengths of the hamstring muscles are positively correlated to hamstring flexibility. According to a previous study, females with the same flexibility score as males had comparatively shorter hamstring muscle optimal lengths (Wan et al., 2017). On the contrary, hamstring strength was not correlated with hamstring flexibility (Wan et al., 2017). The same study backs up the idea that hamstring flexibility being a risk factor for hamstring strain injuries, as muscle strain injury is defined as the ratio of muscle length deformation to muscle optimal length, indicating that with the same muscle length deformity, the shorter the muscle optimal length, thus the greater the muscle strain (Wan et al., 2017).

In a prior study, it was discovered that there was no discernible difference between athletes with prior hamstring injuries and athletes without such injuries in terms of hamstring flexibility. However, static stretching resulted in significant short-term increase in hamstring flexibility for both groups, which reduced after 15 minutes rest, but was still higher than baseline, and these increases are able to be maintained with consistent training, whereby dynamic stretching resulted in improvements in other performance measures such as agility, speed and strength (O'Sullivan et al., 2009).

5.2.4 Relationship between hamstring flexibility among weight lifters with knee injuries

In this study, the relationship between sit and reach test score average and presence of knee injuries was not statistically significant ($p = 0.624$). Interestingly, this directly contradicts research from earlier studies that found a link between less hamstring flexibility and a higher risk of knee injury (English & Perret, 2010; Scattone Silva et al., 2016). Even though that is the case, there is a paucity of research in addressing the relationship between hamstring flexibility and knee injuries specifically among recreational weight lifters, thus we could only assume that this may be possible due to the nature of recreational weight lifting, in which there is an absence of intense and rapid movements, reducing the chances of individuals suffering injuries. It may also be a limitation of the current study, due to the relatively small sample size.

Acute hamstring injuries are involved in a significant part of absences from sports and physical activity. There are multiple theories on why poor hamstring flexibility may cause knee injuries. According to a previous study, poor hamstring flexibility is theorized to necessitate a greater production of force by the quadriceps to counteract the passive resistance generated by the hamstrings when bearing weight (Scattone Silva et al., 2016). Additionally, posterior tibial translation related to reduced hamstring length may reduce the quadriceps moment arm, requiring the quadriceps to compensate by producing more force to counteract the ground reaction forces (Whyte et al., 2010). However, the exact relationship between hamstring flexibility and knee injuries is still inconclusive.

The hamstring muscles need to withstand a maximum peak force while being stretched between 85% and 95% of the gait cycle during the late swing phase of a sprint, with the knee at or near full extension. As a result, a significant amount of force will be required to withstand for the hamstrings in this position. (Doormaal et al., 2017). Furthermore, flexibility of the hamstring and peak hamstring muscle strain are negatively correlated during the late swing phase of sprinting (Koumantakis et al., 2020). Therefore, an individual with poor hamstring flexibility can be assumed to be at a higher risk of hamstring strain injury during a sprint than an individual who has better flexibility. According to previous studies, it was found that there was no significant relationship between hamstring flexibility and risk of hamstring strain injuries (Opar et al., 2012;

Doormaal et al., 2017). Knowing that, we can assume that hamstring flexibility may not be as big of a risk factor for lower limb injuries as previously thought, including for knee injuries.

5.2.5 Relationship between quadriceps angle and hamstring flexibility among weight lifters with and without knee injuries

In this study, it was determined that there was no statistically significant relationship between the Q-angle on the dominant side and hamstring flexibility among recreational weight lifters with knee injuries ($p = 0.726$). The relationship between the dominant Q-angle and hamstring flexibility among recreational weight lifters without knee injuries was also not statistically significant ($p = 0.405$). For the non-dominant Q-angle on recreational weight lifters with knee injuries, the relationship was also not statistically significant ($p = 0.198$). However, the relationship between the non-dominant Q-angle of recreational weight lifters without knee injuries and hamstring flexibility was statistically significant ($r = 0.410$, $p = 0.042$).

In a prior study, futsal players with less hamstring flexibility had greater Q-angle values (Minoonejad et al., 2016). According to the same study, muscle imbalance between the hamstrings and quadriceps, repeated muscle strain, immobility of the lower limb, as well as the presence of scarring in the tissue, can all contribute to poor hamstring flexibility and hamstring injuries. Tightness in the hamstrings against quadriceps may lead to misalignments such as an increased Q-angle (Minoonejad et al., 2016).

The primary source of muscular imbalances that begin a predictable pattern of kinetic dysfunction is frequently muscle tightness or hyperactivity (Minoonejad et al., 2016). Normal force-couple relationship between antagonist and agonist is altered when antagonist muscles are weak and repressed and antagonist muscles are tense and hyperactive. An initial disruption of this relationship can stimulate a chain of events that further influences the altered relationship. The joint will tend to position itself in the direction of the tight agonist muscle, which could negatively impact the body's natural postural alignment (Minoonejad et al., 2016). Even so, there is a lack of research on the relationship between Q-angle and hamstring flexibility, thus we could only assume that this relationship is caused by a decreased hamstring flexibility may worsen the ability of the quadriceps to contract, thus maximum strength may not be achieved. As previously mentioned in this study, quadriceps strength is negatively correlated with Q-angle value, thus if poor hamstring flexibility is present, quadriceps strength is reduced, causing the Q-angle to increase.

5.3 Limitations of the study

There are a few limitations in this study. The gender difference in this study may affect the reliability and validity of this study, as there are more male participants compared to female participants. Additionally, the relatively short duration of time used for the recruitment process may affect the representation of the targeted population. Besides, data regarding risk factors and injury mechanism of knee injuries were unable to be analyzed further due to the potential recall bias of the participants. Moreover, there were more non-injured participants than injured participants in this study. In addition, convenience sampling method, which was used in this study, may introduce sampling bias into this study, as unexpected or uncontrolled factors may be introduced (Sedgwick, 2013).

5.4 Recommendation for future research

For future studies, a larger sample size is recommended to obtain more accurate data and outcomes. Furthermore, a sample size with evenly distributed gender, age group, BMI, weight lifting experience and frequency would help to prevent potential sampling bias, hence improving the generalisability of this study. Recruiting recreational weight lifters that perform similar exercises can help to reduce sampling bias. Random sampling method should also be used to reduce the influence of uncontrolled factors.

In addition, future studies can be conducted to determine the association between Q-angle and hamstring flexibility among professional weight lifters. As professional weight lifters have more experience and commitment to the sport than recreational weight lifters, the effects of abnormal Q-angle and hamstring flexibility may be more prevalent among them.

CHAPTER 6

CONCLUSION

In conclusion, the study showed there is no significant relationship between Q-angle and knee injuries among recreational weight lifters. Furthermore, the study also showed that there is no significant relationship between hamstring flexibility and knee injuries among recreational weight lifters. Moreover, this study also showed that there is a significant difference between the Q-angle on the dominant and non-dominant side for both recreational weight lifters with and without knee injuries, with the dominant side more often than not having a larger Q-angle than the non-dominant side. In addition, this study also showed that there is no significant relationship between quadriceps angle and hamstring flexibility among recreational weight lifters, except for the Q-angle on the non-dominant side among recreational weight lifters with no history of knee injuries. Further research is required to investigate the relationship between Q-angle and hamstring flexibility with knee injuries among weight lifters, as well as the relationship between Q-angle with hamstring flexibility.

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APPENDIX A – ETHICAL APPROVAL FORM

UNIVERSITI TUNKU ABDUL RAHMAN

Wholly Owned by UTAR Education Foundation (Company No. 578227-M)

Re: U/SERC/224/2022

4 November 2022

Mr Muhammad Noh Zulfikri Bin Mohd Jamali
Head, Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
Universiti Tunku Abdul Rahman
Jalan Sungai Long
Bandar Sungai Long
43000 Kajang, Selangor

Dear Mr Muhammad Noh,

Ethical Approval For Research Project/Protocol

We refer to your application for ethical approval for your students' research project from Bachelor of Physiotherapy (Honours) programme enrolled in course UMFD3026. We are pleased to inform you that the application has been approved under Expedited Review.

The details of the research projects are as follows:

<table>
<tr><th>No</th><th>Research Title</th><th>Student's Name</th><th>Supervisor's Name</th><th>Approval Validity</th></tr>
<tr><td>1.</td><td>Knowledge and Attitude Towards Overweight and Obesity Among Physiotherapy and Medical Students: A Cross-Sectional Study</td><td>Ching Yung Shan</td><td rowspan="3">Mr Muhammad Noh Zulfikri Bin Mohd Jamali</td><td rowspan="9">4 November 2022 – 3 November 2023</td></tr>
<tr><td>2.</td><td>Effects of Different Gluteal Strengthening Programs on Strength, Pain, Functional Disability and Balance Among University Students with Non-specific Chronic Low Back Pain: A Randomized Controlled Trial</td><td>Lee Kah Yi</td></tr>
<tr><td>3.</td><td>Effects on Menstrual Cycle on Dynamic Balance and Muscle Strength Among Recreational Players</td><td>Ler Chai Hong</td></tr>
<tr><td>4.</td><td>Knowledge and Awareness Towards Pneumonia Among UTAR Non-Health Sciences Undergraduate Students</td><td>Chooi Yan Yee</td><td rowspan="2">Pn Nurul Husna Binti Khairuddin</td></tr>
<tr><td>5.</td><td>The Effect of Active Video Games on 6-Minute Walk Test in Overweight and Obese Children</td><td>Chin Jay Ven</td></tr>
<tr><td>6.</td><td>Association of Functional Ability of Upper Extremity and Scoliosis Among College Students: A Correlational Study</td><td>Sammi Leong Sing Yee</td><td rowspan="3">Dr Deepak Thazhakkattu Vasu</td></tr>
<tr><td>7.</td><td>A Correlation Study Between Achilles Tendon Contracture and Posterior Tibial Tendon Dysfunction on Ankle Instability Among Young Adults with Pes Planus</td><td>See Wan Ni</td></tr>
<tr><td>8.</td><td>A Correlational Study of the Relationship Between Flat Foot with Anterior Pelvic Tilt and Sacroiliac Joint Dysfunction Among Undergraduate Students</td><td>Tan Bee Thong</td></tr>
<tr><td>9.</td><td>Association Between Physical Activity, Learning Style and Academic Performance Among UTAR Health Science Undergraduates</td><td>Yeoh Zhe Yi</td><td>Ms Kamala a/p Krishnan</td></tr>
</table>

Kampar Campus : Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
Tel: (605) 468 8888 **Fax:** (605) 466 1313
Sungai Long Campus : Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor Darul Ehsan, Malaysia
Tel: (603) 9086 0288 **Fax:** (603) 9019 8868
Website: www.utar.edu.my

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
31.	Association of Postural Awareness with Sedentary Behavior and Back Pain During the Hybrid Study Among Undergraduate Students	Low Xin Yuen	Mr Martin Ebenezer Chellappan	4 November 2022 – 3 November 2023
32.	Impact of Social Media Addiction on Physical Activity Among Undergraduate Students	Mak Kai Nan		
33.	Tibial Torsion and Leg Length Discrepancy in Idiopathic Scoliosis Among UTAR Students	Khoo Wan Qi	Pn Nadia Safirah Binti Rusli	
34.	Prevalence of Patellofemoral Pain Among University Students	Khoo Wen Han		
35.	Prevalence of Varicose Veins Among Fast Food Employees in Cheras, Selangor: A Cross Sectional Study	Ropheca Phuah Su Hui		
36.	The Effect of Unstable Modified Wall Squat on Dynamic Balance Among Recreational Athletes	Chu Sin Jiet	Mr Sathish Kumar Sadagobane	
37.	Knowledge, Perception, and Attitude Towards Breast Cancer and Breast Self-Examination (BSE) Among Non-medical Private University Students	Foo Jes Mynn		
38.	Perception, Knowledge and Attitude Towards the Impact of Daytime Nap on the Risk of Stroke Among Non-Healthcare Undergraduate Students: A Cross-Sectional Study	Chan Chi Kuan	Mr Tarun Amalnerkar Co-Supervisor: Ms Swapneela Jacob	
39.	Awareness, Knowledge and Attitude Toward Orthostatic Hypotension Among Elderlies	Ch'ng Hui Kee		
40.	Effect of TikTok on Student Learning Among Physiotherapy Students	Tan Eng Jing	Mr Avanianban Chakkarapani	
41.	Awareness Towards Tourette Syndrome Among Health Science and Non-health Science Students in A Private University, Malaysia	Tan Kai Xuan		
42.	Effect of Scapular Retraction Exercise on Forward Head Posture Among University Students	Tay Kai Wei	Ms Mahadevi A/P Muthurethina Barathi	
43.	Comparison Between Effect of Lower Limb Cyclic Stretching and Ballistic Stretching on Jumping Distance Among Undergraduate Students: A Comparative Study	Ng Zi Ru		
44.	Relationship of Physical Activity with Anxiety and Depression Among University Students	Ong Aiwei		
45.	Gender Discrepancy and Its Association with Shoulder Pain Among Malaysian Recreational Badminton Players	Khoo Je-Yique	Pn Nur Aqliliriana Binti Zainuddin	
46.	Obesity, Eating Habits and Physical Activity Before and During Covid-19 Pandemic Among University Lecturers	Khoo Tze Sean		

The conduct of this research is subject to the following:

(1) The participants' informed consent be obtained prior to the commencement of the research;

(2) Confidentiality of participants' personal data must be maintained; and

(3) Compliance with procedures set out in related policies of UTAR such as the UTAR Research Ethics and Code of Conduct, Code of Practice for Research Involving Humans and other related policies/guidelines.

(4) Written consent be obtained from the institution(s)/company(ies) in which the physical or/and online survey will be carried out, prior to the commencement of the research.

Kampar Campus : Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
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Tel: (603) 9086 0288 **Fax:** (603) 9019 8868
Website: www.utar.edu.my

Should the students collect personal data of participants in their studies, please have the participants sign the attached Personal Data Protection Statement for records.

Thank you.

Yours sincerely,

Professor Ts Dr Faidz bin Abd Rahman
Chairman
UTAR Scientific and Ethical Review Committee

c.c Dean, M. Kandiah Faculty of Medicine and Health Sciences
Director, Institute of Postgraduate Studies and Research

Kampar Campus : Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
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APPENDIX B – PERSONAL DATA PROTECTION STATEMENT

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 C – GANTT CHART

	JUL 2022	AUG 2022	SEPT 2022	OCT 2022	NOV 2022	DEC 2022
Research Proposal preparation						
Research proposal presentation						
Ethical approval from SERC UTAR						
Review and amendment						
Data collection						
Data analysis						
Report writing						
Submission of thesis						
Presentation of thesis						

APPENDIX D – INFORMED CONSENT FORM

Association Between Quadriceps Angle and Hamstring Flexibility with Knee Injuries among Weight Lifters

Dear participants,

Student Investigator: Teh Wei Ze
Department: Department of Physiotherapy
Course Name and Course Code: UMFD3026 RESEARCH PROJECT
Year and Semester: Year 3 Semester 3
Research Supervisor: Ms Ambusam a/p Subramaniam

You are being asked to volunteer for this research study that is being conducted as part of the requirement to complete the above-mentioned Course

Please read this information sheet and contact me to ask any questions that you may have before agreeing to take part in this study

Purpose of the Research Study

The purpose of this study is to examine the association between quadriceps angle and hamstring flexibility with knee injuries among weight lifters.

Approximately 57 individuals will participate in this study.

Procedures

If you agree to be in this study, you will be asked to fill up a questionnaire regarding past knee injuries. The questionnaire will take 5-10 minutes to complete. Then, two tests will be performed: Q-angle measurement & the sit and reach test. Q-angle measurement and the sit and reach test will take 10-15 minutes to complete. The relevant data will then be collected and analysed.

Length of Participation

One time participation only

Risks and Benefits

No risk will be involved throughout in the current study.

The benefits of participating in this study include increased awareness on importance of quadriceps angle and hamstring flexibility in enhancing the performance and prevent injuries.

Confidentiality

No information that will make it possible to identify you, will be included in any reports to the University or in any publication.

Voluntary Nature of the Study

Participation in this study is voluntary. If you withdraw or decline participation, you will not be penalized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at any time.

Contacts and Questions

If you have any questions, clarifications, concerns and complaints, about the research, the researcher conducting this study can be contacted at 016-4487453, or by email with archerteh@gmail.com.

My Research Supervisor, Ms Ambusam a/p Subramaniam, can be contacted at 010-3736373, or by email with ambusam@utar.edu.my if there any inquiries, concerns, or complaints about the research and there is a wish to talk to someone other than individuals on the research team.

If you wish to participate in this study, please tick the checkbox below.

If you have read the above statements and agree to participate in this study, please tick the checkbox *

☐ I have read the above statements and agree to take part in this study

APPENDIX E – DEMOGRAPHIC DATA FORM

Demographic data

Please fill the areas below to the best of your ability

Name *

Short answer text

Age *

Short answer text

Gender *

- ◯ Male
- ◯ Female
- ◯ Other...

Height *

Short answer text

Weight *

Short answer text

How many sessions per week do you perform lower limb weight lifting exercises? *

*Session: Defined as a visit to the gym for a workout/training

◯ 1-2

◯ 3-4

◯ 5-6

◯ 7-8

How much experience do you have in weight lifting? *

◯ < 6 months

◯ 6 months to 1 year

◯ 1 year to 2 years

◯ 2 years to 4 years

Do you have any physical disabilities? (If "No" is selected, please skip the next question) *

◯ No

◯ Yes

If you answered "Yes" to the previous question, please state the disabilities here

Short answer text

Do you regularly use steroids or other sports enhancing drugs? (If "No" is selected, please skip the next question) *

◯ No

◯ Yes

If you answered "Yes" to the previous question, please state the drugs here

Short answer text

Have you had any recent surgeries? (If "No" is selected, please skip the next question) *

◯ No

◯ Yes

If you answered "Yes" to the previous question, please state the surgeries here

Short answer text

Do you regularly participate in other sports besides weight lifting? (If "No" is selected, please skip the next question) *

◯ No

◯ Yes

If you answered "Yes" to the previous question, please state the sport(s) here

Short answer text

Does your occupation involve heavy manual work? (If "No" is selected, please skip the next question) *

◯ No

◯ Yes

If you answered "Yes" to the previous question, please state your occupation here

Short answer text

Have you had any hip, knee or ankle surgeries or disorders? (If "No" is selected, please skip the next question) *

- No
- Yes

If you answered "Yes" to the previous question, please state the surgeries or disorders here

Short answer text

Do you have any coaches or trainers?

- No
- Yes

Do you perform warm-ups before a workout session?

- No
- Yes

Do you perform cool-downs after a workout session?

- No
- Yes

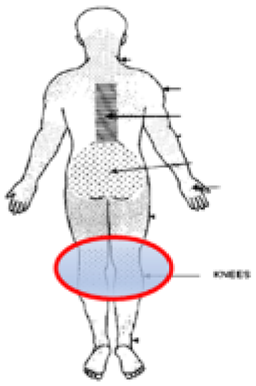
APPENDIX F – MODIFIED STANDARDIZED NORDIC QUESTIONNAIRE

Modified Standard Nordic Questionnaire

How to answer the questionnaire: In this picture below (highlighted in blue), you can see the approximate position of the part of the body referred to in the questionnaire. By knee trouble is meant ache, pain or discomfort in the shaded are whether or not it extends from there till the front or side portion the knee joints bilaterally

Please answer by checking the appropriate box. You may be in doubt as how to answer but please do your best anyway.

Area of Knee



Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in ONE or BOTH knees? (If "No" is selected, can proceed to next section) *

- ◯ No
- ◯ Yes

Have you at any time during the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble? *

- ◯ No
- ◯ Yes

Have you had trouble at any time during the last 7 days? *

- ◯ No
- ◯ Yes

APPENDIX G – TURNITIN ORIGINALITY REPORT

Ambu edit 3

ORIGINALITY REPORT

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