CHU SIN JIET

THE EFFECT OF UNSTABLE MODIFIED WALL SQUAT ON DYNAMIC BALANCE AMONG RECREATIONAL BADMINTON PLAYERS

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By

CHU SIN JIET

A Research project submitted to the Department of Physiotherapy,
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THE EFFECT OF UNSTABLE MODIFIED WALL SQUAT ON DYNAMIC BALANCE AMONG RECREATIOAL BADMINTON PLAYERS

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ABSTRACT

Background and Objective: Badminton players require a lot of footwork and quickness in changing direction while playing badminton. In order to achieve peak performance, dynamic balance is important for recreational badminton players. Previous research showed that squat is considered as one of the strengthening exercise for lower limb muscles which helps to improve dynamic balance. With the improvement of dynamic balance of a recreational player, risk of getting injury can be reduced. Therefore, the objective of this study is to compare the effect between stable and unstable modified wall squat on dynamic balance among recreational badminton players.

Methods: This is a randomized controlled trial (RCT) experiment study. The sampling method used in the study was convenience sampling and the sample size was calculated to be at 40 participants with 10% drop off rate by using G*power 3.1 software. 40 participants who met the inclusion criteria and voluntary participate in this study were randomly assigned into control and experimental group, 20 participants in a group. Participants in control group performed stable modified wall squat whereas participants in experimental group performed unstable modified wall squat. Star Excursion Balance Test (SEBT) was used as the pre- and post-test to measure the dynamic balance of all the participants. Pre-test was done on first week whereas the post-test was done on sixth week. There were three sessions per week, lasted for 6 weeks. The data collected were then analyzed by using Paired Sample T Test in IBM SPSS software statistics version 26.

Results: There are 40 participants with the age range 18 to 23 years old participated in this research. In the control group, there are 16 males and 4 females with the mean age of 20.40±1.27. In experimental group, there are 12 males and 8 females. The mean weight and height of the participants in control group are 66.27±17.07kg and 172.95±5.94cm respectively whereas the mean weight and height of the participants in experimental group are 59.00±10.08kg and 168.30±7.98cm respectively. The normality test showed that all the data collected are normally distributed. According to the paired sample T test, it

showed significant difference on the effect of unstable modified wall squat on dynamic balance among recreational badminton players ($p<0.05$). However, there is no significant difference on the effect of stable modified wall squat on dynamic balance among recreational badminton players ($p>0.05$). According to the independent T test, it showed that there is significant difference on effect between both groups on dynamic balance among recreational badminton players ($p<0.05$). The hypothesis of the study is supported.

Conclusion: Through this study, there is no significant effect of stable modified wall squat on dynamic balance among recreational badminton players. But, there is significant effect of stable modified wall squat on dynamic balance among recreational badminton players. Besides that, there is significant effect between stable and unstable modified wall squat on dynamic balance among recreational badminton players. The hypothesis of this study is accepted.

Keywords: Unstable modified wall squat, dynamic balance, recreational badminton players

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APPROVAL SHEET

This Research project entitled **"THE EFFECT OF UNSTABLE MODIFIED WALL SQUAT ON DYNAMIC BALANCE AMONG RECREATIONAL BADMINTON PLAYERS"** was prepared by CHU SIN JIET and submitted as partial fulfilment of the requirements for the degree of Bachelor of Physiotherapy (HONOURS) at Universiti Tunku Abdul Rahman.

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Date:

PERMISSION SHEET

It is hereby certified that **CHU SIN JIET** (ID No: **19UMB01096**) has completed this Research project entitled "THE EFFECT OF UNSTABLE MODIFIED WALL SQUAT ON DYNAMIC BALANCE AMONG RECREATIONAL BADMINTON PLAYERS" under the supervision of MR SATHISH KUMAR SADAGOBONE (Supervisor) from the Department of Physiotherapy, Faculty of Medicine and Health sciences.

Yours truly,

(CHU SIN JIET)

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: CHU SIN JIET

Date:

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LIST OF ABBREVIATIONS

UTAR	Universiti Tunku Abdul Rahman
IPAQ	International Physical Activity Questionnaire
M	Mean
SD	Standard Deviation
p	P value (Significance)
n	Number of participants
SEBT	Star Excursion Balance Test

CHAPTER 1

INTRODUCTION

1.1 Chapter Overview

This chapter will outline the background of the study, providing context for the overall research project before proceeding to the problem statement, rationale, scope, research question, research objectives as well as operational definition of terms and structure for this research study.

1.2 Background

The background will give a brief description about squat, wall squat, recreational badminton players, biomechanics of lower limbs in badminton, injuries in recreational badminton players, dynamic balance and the importance of dynamic balance for recreational badminton players.

1.2.1 Squat

Squat is a key component of many training programs that focus on performance, rehabilitation, health as well as other goals. Squat is widely applied in training program in order to improve strength and power for the lower limb muscles (Wu et al., 2020). The strength of the lower limb muscles such as quadriceps, gluteus maximus and adductor muscles can be improved after performing squat. Besides that, a study has proven that there is an increase

activation of the core muscles such as erector spinae, rectus abdominis and oblique external after performing squat exercise (Van Den Tillaar & Saeterbakken, 2018). Strengthening of the hip, thigh and back muscles are crucial in improving the jumping, lifting and running performances as well as minimizes injury potential.

Squat is considered as a closed-chain exercise because the distal segment of the lower extremities are fixed. There are two phases of squatting which are the eccentric (lowering) and concentric (standing) phases. Eccentric phase where lesser force is needed to generate the muscles to overcome the gravitational force whereas concentric phase a larger force is needed to generate the muscles in order to lift the body up by opposing the gravitational force (Schoenfeld, 2010). According to a study, the strength of the quadriceps muscles has better increment after performed closed kinetic chain exercises compared to open kinetic chain exercises (Nadeem et al., 2022).

1.2.2 Wall squat

Squats come in a variety of forms, including wall squats, partial squats, full squats, isometric squats, single-leg squats and others. Wall squat is a modified version of squat exercises which can prevent possible lower back or knee damage(Y. Lee, 2015). Wall squats are a specialized sort of squat that begin with the back directly against the wall. The distance between the feet and the wall is approximately one foot distance, and your shoulders should be

approximately shoulder-width apart. The toes are required to point forward. As you continue to lean against the wall, you should lower your body by sliding down the wall until your knees are bent to a 90-degree angle. Wall squat can improve balancing in body. A possible explanation for the gain in balance in the experimental group could be an increase in lower extremity muscular strength, facilitation of rapid twitch motor units, and an increase in muscle coordination (Mohammadi et al., 2012).

According to the study of Lee (2015), unstable modified wall squat is done to improve the posture of the female university students. Since unstable modified wall squat can improve the dynamic balance and recreational badminton athletes require dynamic balance for moving within the court during the game, the effect on modified wall squat on dynamic balance among the recreational badminton athletes can be determined. Through this study, recreational badminton athlete and physiotherapists able to determine whether the unstable modified wall squat brings improvement on dynamic balance or not. Besides, the athletes who participate in other sport can take this research as a reference on improving dynamic balance.

1.2.3 Recreational Badminton Players

Badminton is a well-known sport game in the world nowadays which requires high level of technical skills, tactics, and physical capacities during training and competition (Lees et al., 2008). Badminton can be played

individually (woman single and man single) or in a group of two (women double, men double and mixed double). Differ from professional badminton players, recreational badminton players is the person who participate in badminton as a way to meet their own fitness needs and do not receive any professional training (Izadpanah & Südkamp, 2020). In order to improve performance and prevent injury during quick movements around the court, badminton players require a high level of dynamic balance (Hamed & Hassan, 2017). Since recreational badminton players do not receive any professional training, improvement in dynamic balance is important for the recreational badminton players.

1.2.4 Biomechanics of lower limbs in badminton

Several physically demanding actions, including lunging, twisting, sprinting, leaping, jumping as well as landing are important while playing badminton (Kuntze et al., 2010). Badminton players have to maintain a high level of core and knee dynamic stability in order to accommodate the quick changes in body position during lunges (Wai-Chi Wong et al., 2020).

In addition, badminton players constantly and quickly modify their body position in response to the shuttlecock's motion. They must conduct extremely quick and asymmetrical movements of their upper limbs while keeping their centre of gravity within the base of support. Therefore, an improved body balance is essential for developing badminton skills, improving sports performance, preventing falls and avoiding injuries (Wong et al., 2019).

1.2.5 Injuries in recreational badminton players

Injuries are prevalent in badminton. Marchena-Rodriguez et al. (2020) conducted a cross-sectional study to analyse the frequency, site and severity of injuries of a total of 150 badminton players drawn from the 2018 BWF European Senior Championships. There were 221 injuries found and about 40.3% were lower limb injuries (22.44% were to the knee and 18.3% to the leg). This study also found out that female are more likely to suffer in injuries (Marchena-Rodriguez et al., 2020).

1.2.6 Dynamic balance

Balance is defined as the ability to maintain stability of the body with at least motion. There are two types of balance which are static balance and dynamic balance. Capacity to maintain the body in a specific position is known as static balance whereas capacity to maintain balance of the body during movement is known as dynamic balance (Dunsky et al., 2017).

1.2.7 Importance of dynamic balance for recreational badminton players

Maintaining dynamic balance is important for the recreational badminton players as they have to perform several proficient postural adjustments and motions such as jumps, lunges, quick changes in direction and rapid arm movements in order to reach the shuttlecock in the badminton court (Malwanage et al., 2022).

Since dynamic balance can be improved by performing lower limb strengthening exercises and is important for recreational badminton players, this research is carried out to determine whether or not the unstable modified wall squat can be used to improve dynamic balance of recreational badminton players after six weeks of training.

1.3 Problem statement

A study has proven that unstable modified wall squat can improve the posture in female university students. However, there is no research has been done to examine the effect on unstable modified wall squat on dynamic balance among recreational badminton athletes. Hence, this research will be carried out in order to examine whether or not the unstable modified wall squat has greater improvement on dynamic balance among recreational badminton athletes than the stable modified wall squat. This research is conducted to allow the recreational badminton athletes to determine which type of squat should be chosen in order to improve dynamic balance during the game.

1.4 Rationale of the study

A study has carried out on examining the effect on unstable modified wall squat on posture among female university students (Y. Lee, 2015). A study mentioned that modified wall squat can improve the balance of the body (Mohammadi et al., 2012). In badminton sport, players need to change their direction within the court in a short period of time in order to hit the shuttlecock,

dynamic balance is an important component for them to balance themselves so as to prevent falls and injuries. Hence, this study will be conducted to examine the effect on unstable modified wall squat on dynamic balance among recreational badminton athletes. According to Hyong and Kim (2014), star excursion balance test (SEBT) is an effective measure outcome for the dynamic balance as it has intraclass correlation coefficients (ICC) range is from 0.78 to 0.96. This research enables the badminton recreational athlete to decide the better squat type to be used in training session in order to improve the vertical jumping height. This research also can be used as a reference for athletes who are in different sport.

1.5 Scope of Study

This research will be conducted in Physiotherapy Center (KA345), Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus. The population will be recreational badminton athletes who aged between 18 and 25. In this study, a pre-test and a post-test will be done by using star excursion balance test (SEBT) to evaluate the dynamic balance of the recreational badminton athletes. The data will be compared between the experimental group and the control group. Each participants have to participate in this research for 3 days a week which will be lasted for 6 weeks.

1.6 Research Question

Does unstable modified wall squat bring a greater improvement in dynamic balance than the stable modified wall squat among recreational badminton athletes?

1.7 Objectives of Study

1. To determine the effectiveness of unstable modified wall squat on dynamic balance among recreational badminton athletes.

2. To determine the effectiveness of stable modified wall squat on dynamic balance among recreational badminton athletes.

3. To compare the effects between stable and unstable modified wall squat on dynamic balance performance among recreational badminton athletes.

1.8 Hypotheses of the study

H_0: There is no effect on unstable modified wall squat on dynamic balance among recreational badminton players.

H_1: There is effect on unstable modified wall squat on dynamic balance among recreational badminton players.

1.9 Operational Definition

- Modified wall squat: It is a modified version of wall squat to prevent damage to the lower back or knee. The weight of the subject is supported against the wall while squatting.
- Unstable modified wall squat: The modified wall squat is performed on an unstable surface such as balancing boards, therapy balls and BOSU ball.
- Stable modified wall squat: The modified wall squat is performed on a stable surface such as ground.
- Dynamic balance: It is an ability to stabilize the body while changing position or change of base of support (Karimi & Solomonidis, 2011).
- Recreational badminton athlete: A person who participates in badminton sport for physically fitness, socially involved and enjoying the sports. He or she does not receive same level of intensity of training for competition as a competitive badminton athlete (Laquale & Uk, 2009).
- Star Excursion Balance Test (SEBT): It is one of the common methods to measure the dynamic balance during clinical assessment.

CHAPTER 2

LITERATURE REVIEW

2.1 Chapter Overview

This chapter will outline the different themes explored through past journal and literature which provides the framework for the research project.

2.1.1 Relationship between squat and dynamic balance

Dynamic balance is the ability to stabilize the body during movement. Muscle strength is one of the crucial parameters of balance performance (Fransson et al., 2000). Thus, increasing the muscle strength will improve the dynamic balance. Squat is considered as one of the closed kinetic chain exercises which is usually used in strengthening the lower limb muscles especially for the quadriceps, gluteus maximus and adductor muscles. Open kinetic chain (OKC) and closed kinetic chain (CKC) exercises are the two types of strength training

for the lower extremity muscles (Dannelly et al., 2011). While performing open kinetic chain exercise, the distal segment can be moved freely while the proximal segment is fixed whereas during closed kinetic chain exercise, the distal segment is fixed and with contact with the ground or the exercise equipment (Kwon et al., 2013).

According to Kwon et al. (2013), 33 college healthy students who met the inclusion criteria were recruited and randomly divided into the OKC and CKC group. Participants in OKC group performed knee extension exercise on a knee extensor machine whereas participants in CKC group were required to extend their knees by pushing the foot stand on the Shuttle 2000-1 (Contemporary Design Company, USA). 80% of 1RM resistance was given to both groups. Each exercise session consisted of three sets of ten repetitions and the sessions were held three times per week for six weeks. The result of this study showed that dynamic balance of the healthy adults in CKC exercise group was significantly improved after 6 weeks, while OKC exercise group showed slightly increment in dynamic balance but not significantly improvement. Since squat is a closed kinetic chain exercise, it would show improvement in dynamic balance.

A study performed by a University from Iran uses multiple exercises as strengthening exercises for static and dynamic balance training, which includes squatting as one of its strengthening exercises. The researchers perform the experimental study by recruiting young male athletes as participant and the

variable group of the participants have been given strengthening exercises for the period of six weeks. Starting from the first session, the training program uses Delorme's program, which uses 10RM and increases weight by 5% after each week of training. By using the outcome measures of Star Excursion Balance Test (SEBT) in all eight directions, the results were used to evaluate the dynamic balance of the participants of both control and variable groups. The results show significant differences in five directions during the Star Excursion Balance Test, which are Posterior-Medial, Posterior, Posterior lateral, Lateral and Medial (Mohammadi et al., 2012).

According to the study of Eylen et al. (2017), it showed that strength training which including squat exercise can improve the results of static and dynamic balance among the volleyball players. In this research, the researchers recruited a total of 20 male volleyball players, which were equally randomly divided into two groups, the experimental group and the control group. Participants in the experimental groups received different strength training program for 3 days a week for 8 weeks. The players from both groups continued their regular volleyball training. After 8 weeks of intervention, the result showed that there is significant difference in the dynamic balance scores of the Right Leg-OSI and Left Leg-OSI of the experimental group. Hence, it can be concluded that strength training can be applied in volleyball training in order to improve dynamic balance and leg strengths (Eylen et al., 2017).

Moreover, another study which is done in Korea is to determine squatting in different speeds on the muscle activation and balance of the lower limb muscles. In this study, thirty-eight healthy adults were recruited and required to perform squat exercises 3 times per week, lasted for 4 weeks. All of the participants were randomly assigned to 4 groups which are slow squats on stable ground surface, fast squats on stable group surface, slow squats on unstable ground surface and fast squats on unstable ground surface. The outcome measures of this study were surface electromyography (sEMG) and Y-balance test (TBT). The result showed that there was significant difference in fast squats on activating lower limb muscles and the dynamic balance of the participants who performed squats on unstable ground surface have greater improvement compared to those who performed squats on stable ground surface (J. Y. Lee & Lee, 2018).

In conclusion, closed kinetic chain exercise such as squats can be applied in lower limb strengthening program and dynamic balance training. Several studies have proven that different types of squat exercises can be used to improve dynamic balance not only for the athletes in different fields but also for a healthy individual.

2.1.2 Effectiveness of unstable modified wall squat on dynamic balance

Recent study stated that a variety tools such as unstable ground, balancing boards, therapy balls and sponge pads are widely used in body trunk

stabilization exercise (Arokoski et al., 2001). Body trunk stabilization exercises have the effect of stabilizing the spine and pelvis, increasing muscle strength, regaining muscle and balance control (Richardson et al., 2002). Hence, by theoretically speaking, stabilization exercises can be used to improve balance more effectively when combining with the variable of dynamic or unstable environment, such as unstable surface (O'Sullivan, Phyty, Twomey & Allison, 1997).

A study in Korea have further showed that modified wall squat on unstable support surface have a positive effect on improving dynamic balance when comparing to modified wall squat on stable support surface. To be more precise, it improves dynamic balance by strengthening abdominal and back muscles, which are the muscles that plays a major role in maintaining trunk stability and body trunk posture (Lee, 2015).

Gonçalves et al. (2020) has conducted a research to analyse the effects of unstable bodyweight neuromuscular training on dynamic balance control. Seventy-seven physically active young adults, including male and female, were recruited and assigned into three different groups which were unstable training group (UTG), stable training group (STG) and control group (CG). For the UTG and STG, a complete of 9 weeks were required for the training program. There were three supervised sessions per week and each session lasted for approximately 45 minutes. A 5-10 minutes of warm up was performed before the training. Squat, lunge, hip abduction, quick side—push away, skiing

mogulus, single-leg balance and lateral front run were the exercises for lower limbs strengthening. The difference between UTG and STG was that participants had to perform the exercises on a BOSU ball with 25 inches in diameter. Dynamic balance was tested using Y-Balance Test before and after intervention. It is clearly proven that conduct training on unstable surface showed more improvements in Y-Balance Test in each of the directions which indicated that the participants in unstable training group have better dynamic balance control (Gonçalves et al., 2020).

As a short conclusion, it has proven that performing exercises on an unstable surface can improve dynamic balance more compared to the one who perform exercises on stable ground surface. Hence, this research used the protocol of unstable modified wall squat which was conducted by Lee (2015) so as to investigate the effect on dynamic balance among recreational badminton players.

2.1.3 Dynamic balance and star excursion balance test

Based on a study from Spain, postural control or dynamic balance is defined as the ability to maintain stable posture with minimal movement and the ability to maintaining a stable position while performing tasks. Dynamic balance requires an individual to have relatively good control of their own motor skills, which in another words, good muscle coordination in order to achieve high dynamic balance. As the study also stated a simple method to measure the

dynamic balance, is the Star Excursion Balance Test (SEBT), which is also commonly used among multiple studies that requires to measure the dynamic balance of participants as an outcome (Ricotti, 2011).

Furthermore, according to a study performed in Korea, the Star Excursion Balance Test (SEBT) is functional as an instrument to measure the outcome of testing dynamic balance among healthy individuals. SEBT requires the tested individual to perform closed-kinetic chain exercises, particularly single leg squat in a total of eight directions, which are anterior, anterior-medial, medial, posterior-medial, posterior, posterior-lateral, lateral and anterior-lateral. It has been reported that its intraclass correlation coefficients (ICC) range is from 0.78 to 0.96, which makes it a high ICC range and a high reliability test to measure dynamic balance among health athletes and individuals (Hyong & Kim, 2014).

As a short conclusion, Star Excursion Balance Test is a commonly used instrument to assess the dynamic balance of healthy athletes and individuals.

2.1.4 Importance of dynamic balance to recreational badminton athletes

Injuries especially at the lower limbs are common in badminton players. Since badminton requires a lot of footwork with sudden and frequent acceleration and deceleration, badminton players more likely will suffer in strains, sprains and ligament injuries (Pardiwala et al., 2020).

According to a cross-sectional study which is done in 2018, badminton players who with the younger age group have the higher risk to get injured in lower limb compared to badminton players who with the older age group. 42 participants from the case group have reported a total of 60 lower limb injuries. Among this 60 lower limb injuries reported, ankle joint injuries were the most common injuries reported, followed by the knee and hip injuries (Kang & Ramalingam, 2018).

Badminton have a lot of rapid and sudden movements that involves the lower extremities, it is crucial that a badminton athlete have a high level of dynamic balance in order to have peak performance and minimal risk of getting knee injury (Hamed Ibrahim Hassan, 2017). Since dynamic balance allows athletes to maintain their base of support during movement, it is also significant to know that visual and vestibular stimulus, combining with proprioceptive system, the body will be able to achieve a high level of dynamic balance. This will further prevent anterior cruciate ligament (ACL) injuries to occur among badminton athlete (Alikhani et al., 2019).

Besides, according to the study from Canada, they found that ACL rupture is a very severe but can be seen commonly among young athletes, and most of the cases were due to non-contact injury mechanisms. They also stated that ACL injury does not only requires high cost treatment, but will also lead to

several complications such as loss of athlete participation, development of osteoarthritis and other physical and psychological issues (Alikhani et al., 2019).

Furthermore, a study has proven that dynamic balance and on-court sport-specific footwork performance of the adolescent competitive badminton players were improved with the addition of 30-minute balance training program into a regular badminton training program. A total of thirty healthy male badminton players between 13 and 15 years old were recruited in this study and randomly assigned into two groups, the intervention group (n=15) and the control group (n=15). For the intervention group, the participants received 30 minutes balance training and 1 hour 30 minutes ordinary badminton training whereas the participants in the control group received only the 2 hours ordinary badminton training. Both the intervention and the control group were trained for 2 days per week for 8 weeks. The result showed that the intervention group had significant improvement in footwork performance while the control group showed no improvement in footwork performance (Malwanage et al., 2022).

To perform well during the badminton competition, agility is considered as one of the essential factors. Lu et al. (2022) has conducted a study to determine the effect of combined balance and plyometric training on dynamic balance and quickness performance of elite badminton athletes. Sixteen male badminton athletes who voluntary participated in the research were recruited. There were two groups which were balance-plyometric group and plyometric group. All the participants were randomly assigned into both of the groups. The intervention

was lasted for three times a week for 6 weeks. The result showed that balance-plyometric training improve the dynamic balance and quickness performance of the participants (Lu et al., 2022). A good dynamic balance can improve the agility performance of the badminton players as they can control body posture in order to conquer the inertia effect brought on by acceleration and deceleration while changing direction (Gomez et al., 2019).

As a short conclusion, balance training can improve the dynamic balance and the footwork performance of the badminton players. With the improvement of dynamic balance, occurring ACL injuries would be prevented in badminton players which may lead to achieve a peak performance for the competitive sport.

CHAPTER 3

METHODOLOGY

3.1 Chapter Overview

This chapter will outline the research methodology used, by highlighting the research design, sampling design, research instrument and show the procedures done in detail.

3.2 Research Design

This is a randomized controlled trial (RCT) experimental study. The participants are randomly assigned in to one of two groups: the experimental group which receiving intervention that is being tested and the control group which receiving a conventional treatment (Kendall, 2003).

3.3 Ethical Approval

This study is subjected to ethical approval by the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman (UTAR).

An informed consent will be given to all the participants who meet the requirements before they participate in the study. The interventions and procedures of the study are well explained to the participants. It is compulsory to make sure that the participants join the research voluntary.

The benefits of this research are the participants may strengthen the lower limb muscles especially for the quadriceps muscle and also improve dynamic balance after the intervention. However, participants may experience muscle soreness after 24 hours of exercise. If the participants do the squats with an inappropriate position, it will harm their knees or back. Hence, while conducting this research, the position of the participants should be always monitored.

3.4 Sampling Design

By using G*power 3.1 software, the F tests family and mixed method analysis of variance (ANOVA) are chosen with the 0.05 error probability and 80% power, a total of 34 participants are required in this research. However, a 10% of dropout rate should be considered. Thus, 38 participants are needed to be recruited which 19 participants in a group.

3.5 Research instruments

a) Consent form, demographic data and screening form. This is to obtain participant's consent and screen participants.

b) Measuring tape will be used to measure the distance where the participants can reach during SEBT and true limb length of the participants.

c) Stopwatch will be used to calculate the time for the participants while performing the squat exercises (maintain 5 seconds while knees are flexed up to 90°; maintain 3 seconds while the knees are extended back to 10°; 15 seconds rest between sets).

d) Bosu ball will be used to act as unstable surface for the experimental group.

3.6 Inclusion Criteria

The inclusion criteria of this study are:

a) Recreational badminton athletes.

To identify recreational badminton athletes, they are required to fill in the IPAQ-SF. For recreational badminton athletes, participants are to meet at least category 2 or above in the IPAQ screening. Participants in minimally active (category 2) are expected to have i) 3 or more days of vigorous activity of at least 20 minutes per day or ii) 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day or iii) 5 or more days of any combination of walking,

moderate-intensity or vigorous intensity activities achieving minimum of at least 600 MET-min/week. Moreover, participants who are having i) vigorous intensity activity at least 3 days or ii) any combination of walking, moderate intensity or vigorous intensity acitivties for 7 or more days.

b) Recreational badminton athlete who aged between 18 and 25.

c) Both female and male recreational badminton athletes.

3.7 Exclusion Criteria

The exclusion criteria of this study are:

a) Recreational athlete in other sports.

b) Recreational badminton athletes who have lower limb fracture recently. The duration of bone healing in lower limb fracture is between 6 to 24 weeks, depends on the types of lower limb fracture (Kumar et al., 2018).

c) Recreational badminton athletes who have cardiovascular disease. For example, arrhythmias, heart failure, heart valve disease, stroke, vascular disease, heart attack, coronary artery disease, deep vein thrombosis and pulmonary embolism. Students with cardiovascular disease is not suitable to participate in this research because they might have angina, shortness of breath, nausea, fatigue, dizziness, high blood pressure as well as cold sweats (Felman, 2019).

d) Recreational badminton athletes who have spine injury recently. To avoid further injured in the spine while doing the squat.

3.8 Procedure

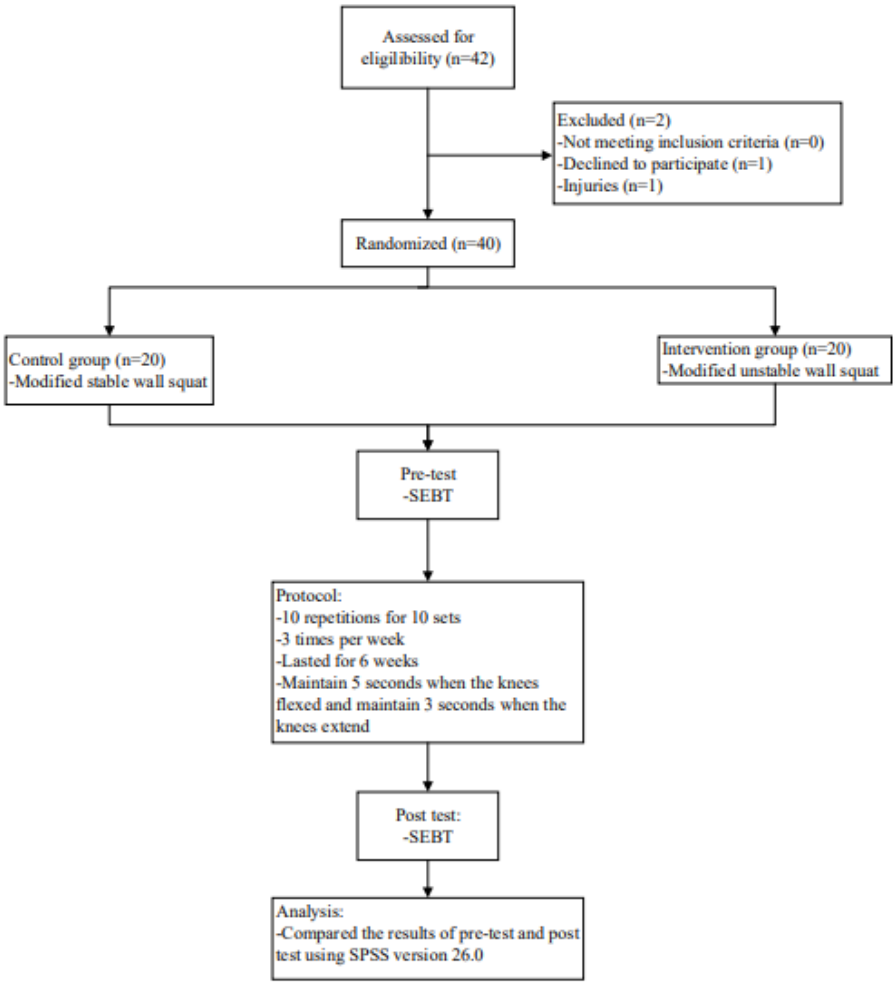

Figure 1: This flow chart shows the procedure of the research.

Participants were recruited by using convenience sampling method one week before the research started. After one week of recruitment, a total of 42 participants who meet the inclusive criteria have been recruited. 2 participants (1 participant from Group A and 1 participant from Group B) dropped out from the research. Participant in group A drop out due to injury in the ankle whereas participant in group B drop out sue to schedule problem. After comfirming all the participants who were willing to join this research project, they are required to fill up the demographic data and screening form (refer to APPENDIX C) and IPAQ SF (refer to APPENDIX D). All the study procedures, possible risks and benefits of the study are well explained to the participants before they signed the consent form (refer to APPENDIX B). All the participants are invited to the UTAR physiotherapy centre (KA200A). The participants will then randomly be assigned to one of the two groups: experimental group and control group. There were 21 participants in each of the group. The participants are advised to have a proper sport attire and footwear throughout the whole duration of the research so as to avoid any injuries throughout the research.

On the first day of research, a pre-test (SEBT) was done. This is to measure balance of each of the participants. Before the test was started, demonstration of performing SEBT was given to the participants. All the participants performed a total of eight directions (anterior, anteromedial, medial, posteromedial, posterior, posteromedial, lateral and anterolateral) with three trials. While performing the SEBT, participants were required to take off the shoes. Both hands were placed on the waist. While performing the SEBT, heel of the standing leg should be in contact with the ground when another leg was

trying to reach the measuring tape on the floor. The centre of gravity of the participants was remained at the central. If the participant could not balance themselves during the SEBT, he or she must redo again. The reach distance for all three trials of all the directions were recorded. After pre-test had been done, 6 weeks of intervention was started. Participants in the control group will be performing the stable modified wall squat whereas participants in experimental group will be performing unstable modified wall squat. Both groups need to perform 10 repetitions for 10 sets, 3 days a week, for 6 weeks. A post-test which is same as the pre-test was done on sixth week after the intervention. The reach distance was also be recorded.

3.9 Experimental group and control group

There will be two groups in this study which is experimental and control group. The protocol of this research was obtained from the study of Lee (2015). According to the study of Lee (2015), experimental group need to perform unstable modified wall squat whereas the control group need to perform stable modified wall squat.

To perform modified wall squat, the participants need to stand about a foot away from the wall. The legs should spread to shoulder-width apart. The pelvis and the lumbar spine should be in neutral position. While performing the squat, both of the feet should not leave the ground. When the knees are flexed up to 90 degrees, participants have to remain the position for 5 seconds and when

the knees are extended back to 10 degrees, participants have to remain the position for 3 seconds. Participants need to perform 10 repetitions for 10 sets during each session. The resting duration between each sets will be 15 seconds. This research will be conducted for 3 days a week, for 6 weeks.

The difference between the experimental group and the control group is that the participant in the experimental group is standing on the BOSU ball which act as unstable surface whereas the participants in the control group just stand on the ground.

3.10 Outcome Measure

The star excursion balance test (SEBT) was used to evaluate the dynamic balance of the participants. There are eight directions (anterior, anterior-lateral, lateral, posterior-lateral, posterior, posterior-medial, medial and anterior-medial) in SEBT with the angle of 45° between each line. The participants are required to perform SEBT by standing on single leg and using the contralateral leg to reach the line as far as possible while the centre of gravity remained at the central. A total of eight measuring tapes were sticked on the floor which is convenience for researcher to directly measure the distance where the participants can reach. SEBT is an effective balance test with intraclass correlation coefficients (1,1) ranged from 0.86 to 0.92 (Gribble et al., 2013). SEBT can be calculated by formula:

Average reach distance in each direction (cm) = Reach 1 + Reach 2 + Reach 3

$$Normalized\ reach\ distance\ in\ each\ direction(\%) = \frac{Average\ reach\ distance\ in\ each\ direction\ (cm)}{True\ limb\ length} \times 100\%$$

$$Composite\ score(\%) = \frac{Sum\ of average\ distance\ in\ each\ direction}{True\ limb\ length * 8} \times 100$$

3.11 Statistical Analysis

The data of the research will be by using Microsoft Excel and analyzed by using IBM Statistical Package for the Social Science (SPSS) version 26 (SPSS, Inc., Chicago, IL, USA). The mean, standard deviation, percentage and significant difference between pre-test and post-test within each group and between the experimental and control group can be generated by using SPSS so as to determine the effectiveness of the research results.

CHAPTER 4

RESULTS

4.1 Chapter overview

This chapter will be presenting the findings collected during the data collection phase of this research project. Firstly, the demographic data of the participants are presented. Then, the outcomes of this research are compared with paired sample t-test and independent t-test. The hypothesis testing will be the last step of this chapter. All the findings are shown using graphs. Lastly, a brief discussion of the findings is written.

In this research, a total of 42 participants were recruited at first. 2 participants drop off because of personal reason and got injured due to fell down respectively. All the participants who meet the inclusion criteria were randomly assigned into two groups. All the participants had the consent for data processing.

4.2 Demographic of population

Demographic data of the participants is going to be presented in this section using a descriptive table.

There are 20 participants in each of the groups. According to table 4.1, the age range of the participants in this research is 18 to 23 years old. The mean

and standard deviation in stable modified wall squat group and unstable modified wall squat group are 20.40 years old (SD=1.27) and 20.85 years old (SD=1.14) respectively. In the stable modified wall squat group, majority of the participants are aged 20 (35.0%). It is then followed by 5 participants who aged 22 (25.0%) and 4 participants who aged 21 (20.0%). There are same number of participants (n=2, 10.0%) with the aged of 18 and 19. In the unstable modified wall squat group, the eldest participant is 23 years old (n=1, 5.0%). Majority of the participants in this group are 21 years old (n=9, 45.0%). The number of participants with the age of 20 years old and 22 years are the same (n=4, 20.0%). Only 1 (5.0%) participant is aged 18, 19 and 23 respectively.

In this research, majority of the participants are male (n=28). In stable modified wall squat group, there are 16 males (80.0%) and 4 females (20.0%) whereas in unstable modifies wall squat group, there are 12 males (60.0%) and 8 females (40.0%). All 40 participants are Chinese.

In the stable modified wall squat group, participants have the mean weight of 66.27 kg (SD=17.07). There are total of 5 participants are in the weight group of 50-59 kg (25.0%). It is then followed by weight group of 60-69kg and 70-79kg which have 4 (20.0) participants respectively. There are 3 participants in the weight group of 40-49 kg (15.0%), 2 (10.0%) participants in the weight group of 90-99 kg, 1 (5.0%) participant in the weight group of 80-89 kg and 100-109 kg. In the unstable modified wall squat group, participants have the mean weight of 59.00kg (SD=10.08). There are no participants weight 80kg and above.

Majority participants in this group have the weight of 50kg to 59 kg (45.0%), followed by 70kg to 79kg (n=5), 60kg to 69kg (n=4) and 40kg to 49kg (n=2).

The mean height of the participants in stable modified wall squat group and unstable modified wall squat group are 172.95±5.94cm and 168.30±7.98cm respectively. In stable modified wall squat group, majority of the participants have the height between 170cm and 179cm (n=13) whereas majority of participants in unstable modified wall squat group have the height between 150cm and 159cm (n=8).

Demographic data	Stable Modified Wall Squat n=20		Unstable Modified Wall Squat n=20	
	n (%)	M (SD)	n (%)	M (SD)
Age		20.40		20.85
18	2 (10.0)	(1.27)	1 (5.0)	(1.14)
19	2 (10.0)		1 (5.0)	
20	7 (35.0)		4 (20.0)	
21	4 (20.0)		9 (45.0)	
22	5 (25.0)		4 (20.0)	
23	0 (0.0)		1 (5.0)	
Gender				
Male	16 (80.0)		12 (60.0)	
Female	4 (20.0)		8 (40.0)	
Race				
Chinese	20 (100.0)		20 (100.0)	
Weight (kg)		66.27		59.00
		(17.07)		(10.08)
40-49	3 (15.0)		2 (10.0)	
50-59	5 (25.0)		9 (45.0)	
60-69	4 (20.0)		4 (20.0)	
70-79	4 (20.0)		5 (25.0)	
80-89	1 (5.0)		0 (0.0)	
90-99	2 (10.0)		0 (0.0)	
100-109	1 (5.0)		0 (0.0)	
Height		172.95		168.30
		(5.94)		(7.98)
140-149	0 (0.0)		3(7.9)	
150-159	0 (0.0)		8(21.1)	
160-169	4 (20.0)		7(18.4)	
170-179	13 (65.0)		0(0.0)	
180-189	3 (15.0)		1(2.6)	

Table 4. 1: Demographic of Participants

4.3 Inferential analysis

Normality of the data is tested using Shapiro-Wilk Test so as to determine whether the data is normally distributed or not. Paired sample t-test and independent t-test are the inferential analysis to assess objectives and hypotheses of this research. IMB SPSS Statistic Version 26 was used to generate the result of the research.

4.3.1 Test for normality

Since the sample size of this research is less than 50, Shapiro-Wilk test is used to test for normality. Null hypothesis of the normality test indicates the result is normal whereas alternate hypothesis indicates the result is abnormal. Since all the p value of the results are greater than 0.05, it is failed to reject null hypothesis. Thus, all the results obtained are normal.

	Shapiro-Wilk Sig
Stable Modified Wall Squat	
SEBT Dominant Leg Pre-test	0.385
SEBT Dominant Leg Post-test	0.230
SEBT Non-dominant Leg Pre-test	0.361
SEBT Non-dominant Leg Post-test	0.409
Unstable Modified Wall Squat	
SEBT Dominant Leg Pre-test	0.857
SEBT Dominant Leg Post-test	0.349
SEBT Non-dominant Pre-test	0.826
SEBT Non-dominant Post-test	0.862

Table 4. 2: Test of Normality using Shapiro Wilk Test

4.3.2 Paired sample T test

Paired sample t test is used to compare the results of the pre-test and post-test of both control and intervention groups for the same sets of participants of this research.

Table 4.3 shows the results of the paired sample t test for SEBT composite score for dominant leg. For the stable modified wall squat group, the mean SEBT composite score for the dominant leg for the pre-test (M=91.38%, SD=9.90) has decreased in post-test (M=90.85%, SD=7.17) with the mean difference of -0.53, t value of -0.34 and p value of 0.741. The difference is

statistically significant with 95% confidence interval (CI) [-2.78, 3.83]. For the unstable modified wall squat group, the mean SEBT composite score of the unstable modified wall squat group increased from 87.33% (SD=7.10) to 93.16% (SD=4.54) with the mean difference of 5.83, t value of 3.48 and p value of 0.002. Thus, this difference is statistically significant with 95% CI [-9.33,-2.33].

	SEBT Composite Score (%)			
	Pre-test M (SD)	**Post-test M (SD)**	**Diff**	**Sig**
Stable Modified Wall Squat	91.38 (9.90)	90.85 (7.17)	-0.53	0.741
Unstable Modified Wall Squat	87.33 (7.10)	93.16 (4.54)	5.83	0.002

Table 4. 3: Results of Paired sample t-test for SEBT composite score for dominant leg

Table 4.4 shows the results of paired sample t-test for SEBT composite score for non-dominant leg of both of the groups. For the stable modified wall squat group, the mean SEBT composite score of the non-dominant leg is decreased from 91.90% (SD=9.66) to 91.22% (SD=6.01) with the mean difference of -0.68, t value of 0.44 and p value of 0.668. This difference is statistically difference with 95% CI [-2.57, 3.92]. For the unstable modified wall squat group, the mean of SEBT composite score of the pre-test is 86.52% (SD=9.21), which increased to 93.01% (SD=7.88) during the post-test. The

mean difference is 6.49, t value is -3.75 and the p value is 0.001. This difference is statistically difference with 95% CI [-10.11, -2.87].

	SEBT Composite Score (%)			
	Pre-test M (SD)	**Post-test M (SD)**	**Diff**	**Sig**
Stable Modified Wall Squat	91.90 (9.66)	91.22 (6.01)	-0.68	0.668
Unstable Modified Wall Squat	86.52 (9.21)	93.01 (7.88)	6.49	0.001

Table 4. 4: Results of Paired sample t-test for SEBT composite score for non-dominant leg

4.3.3 Independent T test

To compare the difference in both control and intervention groups, Independent T test is used.

Referring to table 4.5, the significant difference between the effect of stable modified wall squat and unstable modified wall squat on SEBT composite score of both dominant and non-dominant legs is tested by using Independent T test. The mean score of dominant leg composite score in stable modified wall squat group is reported -0.53% (SD=7.06) whereas in unstable modified wall squat group is reported 5.83% (SD=7.49). Next, non-dominant leg composite

score in stable modified wall squat group and unstable modified wall squat group have the mean score of -0.68 (SD=6.93) and 6.49 (SD=7.74) respectively.

The mean difference of dominant leg composite score between stable and unstable modified wall squat group is -2.97 with t value of -2.77 and p value of 0.009. The mean difference of non-dominant leg composite score between both groups is -0.85 with t value of -3.09 and p value of 0.004. Since the p values of both dominant and non-dominant leg composite score between both groups are less than 0.05, it indicates that there is significant difference between the effect of stable and unstable modified wall squat on dynamic balance.

	Stable Modified Wall Squat M (SD)	**Unstable Modified Wall Squat M (SD)**	**Diff**	**t**	**Sig**
Dominant leg (%)	-0.53 (7.06)	5.83 (7.49)	-2.97	-2.77	0.009
Non-dominant leg (%)	-0.68 (6.93)	6.49 (7.74)	-0.85	-3.09	0.004

Table 4. 5: Mean difference of SEBT composite score of both legs between both groups

4.3.4 Independent t-test on gender

The effect of gender on the SEBT of both control and intervention groups can be carried out by using Independent T test. Table 4.6 shows that the effect on SEBT of stable modified wall squat group. The mean difference of male in SEBT composite score of the dominant leg in stable modified wall squat group is 0.07% (SD=7.15) whereas for the female is -2.91 (SD=7.11). The mean difference between male and female is -2.97 with t value of -0.74 and p value of 0.466. For the SEBT composite score of the non-dominant leg in stable modified wall squat group, the mean difference of male is -0.51 (SD=6.79) whereas female is -1.36 (SD=8.53). The mean difference between female and male is -0.85 with t value of -0.21 and p value of 0.833.

	Stable Modified Wall Squat				
	Variable Mean (SD)		**Diff**	**t**	**Sig**
	Gender				
	Male	**Female**			
Dominant leg	0.07 (7.15)	-2.91 (7.11)	-2.97	-0.74	0.466
Non-dominant leg	-0.51 (6.79)	-1.36 (8.53)	-0.85	-0.21	0.833

Table 4. 6: Results of Independent t-test for gender in stable modified wall squat

According to table 4.7, the men difference of male in SEBT composite score of dominant leg in unstable modified wall squat group is 7.17 (SD=8.12) whereas for the female is 3.82 (SD=6.38). The mean difference of SEBT composite score of dominant leg between male and female is 3.35 with t value of 0.98 and p value of 0.340. For SEBT composite score of non-dominant leg, the male has the mean difference of 8.58 (SD=8.25) while the female is 3.35 (SD=6.07). The mean difference between the male and female is 5.23 with t value of 1.53 and p value of 0.143.

	Unstable Modified Wall Squat				
	Variable Mean (SD)		**Diff**	**t**	**Sig**
	Gender				
	Male	**Female**			
Dominant leg	7.17 (8.12)	3.82 (6.38)	3.35	0.98	0.340
Non-dominant leg	8.58 (8.25)	3.35 (6.07)	5.23	1.53	0.143

Table 4. 7: Results of Independent t-test for gender in unstable modified wall squat group

Since the p values of gender on SEBT composite score in both groups are greater than 0.05, it indicates that there is no significant difference on gender on SEBT composite score in both groups.

4.4 Hypothesis Testing

Null hypothesis (H_0): There is no effect on unstable modified wall squat on dynamic balance among recreational badminton players.

Alternate hypothesis (H_1): There is effect on unstable modified wall squat on dynamic balance among recreational badminton players.

The paired sample t-test was conducted to compare the significant difference on effect of unstable modified wall squat on dynamic balance. The confidence level is set as 0.05. According to the paired sample t-test which was done, the SEBT composite score for dominant and non-dominant legs have the p value of 0.002 and 0.001 respectively. Since p value <0.05, null hypothesis is rejected. In conclusion, unstable modified wall squat has significant effect in improving dynamic balance among recreational badminton players.

Chapter 5

Discussion

5.1 Chapter Overview

Discussion on significant findings from the results sections in accordance with the research objectives will be outlined in this chapter, which will then followed by the limitations of study, recommendations for future research as well as the conclusion of this research project.

5.2 Discussion

5.2.1 Effect of stable modified wall squat in improving dynamic balance

According to the table 4.3 and 4.4 above, the mean SEBT composite score of the dominant leg in stable modified wall squat group has decreased from 91.38% to 90.85% with the mean difference of -0.53%. For the mean SEBT composite score of the non-dominant leg in stable modified wall squat group also has decreased from 91.90% to 91.22% with the mean difference of -0.68%. Hence, it can be concluded that the difference is not statistically significant in both legs and there is no effect in improving dynamic balance in both legs after performed stable modified wall squat.

Several studies have shown that strengthening exercises including the squat exercises has significant difference in improving dynamic balance among athletes. According to the study done by Mohammaadi et al. (2012), it showed

that there is significant effect of strength training on dynamic balance by increasing the mean reaching distance in every directions of SEBT among 30 male athletes who aged between 15 and 17 years old. Besides that, according to the study done by Eylen et al. (2017), the result also showed that there is significant differences in dynamic balance among 10 male volleyball players in experimental group after 8 weeks of intervention.

The result is not accordance to the studies of Mohammadi et al. (2012) and Eylen et al. (2017) may because of the strengthening exercises used in the study. In both of these studies, not only squat exercise was used in strengthening training, but combined strengthening exercises such as leg extension, calf raise and lunge were used. There are a lot of muscles in the lower extremities and each of the muscles have its own role during movement. By doing only the squat exercise may only activating the gluteus maximus, gluteus minimus, gluteus medius, quadriceps and hamstrings without activating the other muscles such as the calves. Hence, it is recommended that to perform combined lower limb strengthening exercises instead of only doing the squats in future studies.

Furthermore, according to these two studies, only male participants were recruited (Mohammadi et al., 2012) (Eylen et al., 2017). Since this research recruited both male and female recreational badminton players, the result of the study might be difference from the previous studies as male has better strength, neuromuscular control, joint stability and landing biomechanics compared to female (Sell et al., 2018). Besides that, Mohammadi et al. (2012) introduced

Delorme's program into the training program. Delorme's program is a progressive resistance exercise (PRE) program (Todd et al., 2012). Progression is important in strengthening training as there might have muscle adaptation after same intensity exercise in a long period of time (Frontera & Ochala, 2015).

5.2.2 Effect of unstable modified wall squat in improving dynamic balance

The mean SEBT composite score of the dominant leg in unstable modified wall squat group has increased during the post-test compared to the pre-test. The mean difference of the composite score of the dominant leg is 5.83%. Besides dominant leg, the mean SEBT composite score of the non-dominant leg in unstable modified wall squat group has increased from 86.52% to 93.01% with the mean difference of 6.49%. From these findings, it indicates that there is significant mean difference on the dynamic balance of both legs in unstable modified wall squat. Hence, there is effect on dynamic balance after performed unstable modified wall squat.

The finding of this study was in accordance with several studies which have proven that exercising on unstable surface can improve dynamic balance. According to a systemic review which was done by Behm et al. (2015), it showed that unstable strength training has significant effect on power and balance performance among young adults compared to the control group. However, unstable strength training only showed little improvement in balance among young adults when compared to stable strength training (Behm et al., 2015).

Unstable surface such as bosu ball will make the exercises more challenging compared to stable surface as brain and muscles will be engaged a deeper level to keep the body balance while exercising (Mademli et al., 2021). Tendons, ligaments and joint receptors can be activated while performing exercises on unstable surface (Nam et al., 2016). Increasing in muscle strength in the lower limbs can improve dynamic balance. Thus, It can be assumed that performing lower limb strengthening exercise on unstable surfaces can improve dynamic balance.

5.2.3 Comparison between effect between stable and unstable modified wall squat in improving dynamic balance among recreational badminton players

In this study, it is concluded that there is significant difference between the effect of stable and unstable modified wall squat on dynamic balance among recreational badminton players. The hypothesis of the study is supported.

Dynamic balance not only can be improved by strengthening the lower limb muscle, a study showed that core training is considered as one of the factors to improve dynamic balance of the athletes. The study showed that the junior tennis players have significant improvement in dynamic balance after 5 weeks of core training (Bashir et al., 2019). Core muscles such as pelvic floor muscles, abdominal muscles, multifidus, erector spinae and diaphragm help in maintaining the stability of the spine in order to achieve dynamic balance

(Almutairi et al., 2022). Hence, it is recommended to combine core training with the lower limb strengthening training in order to improve the dynamic balance of an individual.

The result showed that there is no significant difference between gender and both control and intervention group in improving dynamic balance. According to a study, it has proven that males have better dynamic balance compared to females as the composite score of the Y-balance test is greater than female (Alnahdi et al., 2015). Another study also showed that males have better balance by using tandem stand (Wheaton & Crimmins, 2016). Therefore, this finding may be caused by unbalanced gender distribution in each groups as majority of the participants are males.

According to the two studies which have significant effect of strengthening exercises on dynamic balance, the exercises that given to the participants are combined lower limb strengthening exercises such as lunge, leg extension, leg curl up and so on (Eylen et al., 2017)(Mohammadi et al., 2012). Hence, other strengthening exercises for the lower extremities can be added in the future studies in order to strengthen other muscle groups of the lower limb.

Moreover, the result of the dynamic balance may be affected by other factors such as visual system. It is well known that vision plays an important role in maintaining balance. Vision take a role in sensory feedback system which can enhance bipedal upright stability during standing and locomotion (Collings et al.,

2015). If there is impairment in the vision, the dynamic balance will be affected (Daneshmandi et al., 2021). Besides the vision, vestibular system also takes part in controlling the dynamic balance (Talebi et al., 2016). Semi-circular canals are responsible to detect the rotation of the head in different directions in order to maintain dynamic balance by sending impulses to the brain according to the movement of the liquid in the canals (Khan & Chang, 2013). Lastly, proprioception helps in maintaining dynamic balance. Proprioception is known as "joint sense" which detect the movement of the joints, muscles, tendons and skin from the mechanoreceptors (Aman et al., 2015). Therefore, if the participants have problem in visual system, vestibular system as well as the proprioceptive system can affect the scoring of the dynamic balance. Thus, this can be included in the exclusion criteria of the study.

5.3 Limitations of study

It is important to discuss the limitations found in the present study which may influence the findings of the study. Some limitations of this study were detected and discussed below.

Firstly, the participants who were recruited in this study are aged between 18 and 23 years old. Between the age of 18 and 25 years old, it is considered as young adult age. Thus, the participants who were recruited in this study were categorized under this age group. Therefore, the result could not be generalised into other population in other age group.

Next, the result showed that there is no significant difference between gender and both control and intervention group in improving dynamic balance. This finding may be caused by unbalanced gender distribution in each groups as majority of the participants are males. Furthermore, all the participants recruited were Chinese instead of other races. Hence, the results could not be compared with people with other races.

Besides that, one of the limitations is that there might have bias when requesting the participants to fill in the IPAQ-SF. This is because the participants have to recall the frequency of participating in physical activity level in the past 7 days. Some participants might have the chance in forgetting the frequency of

participating in each physical activity levels. Hence, the physical status of the participants might have some inaccuracies.

Participants who participate in other exercises such as weight training, aerobics exercise as well as other sports may affect the result of the research. Different intensity, biomechanics of the sport which activate different group of muscles. The result on dynamic balance between both stable and unstable modified wall squat may be inaccurate.

5.4 Recommendations for future study

In future studies, more female participants should be recruited to allow equally gender distribution in each of the groups. Hence, the relationship between gender and dynamic balance can be studies and the effect of gender on dynamic balance improvement can be determined.

The strength of the lower limb muscles should be measured in future studies which allow to study the relationship between the lower limb muscle strength and dynamic balance among the recreational badminton players as well as athletes in other sports. It is suggested to combine with core muscle training as some of the studies proved that core muscles are important for dynamic balance. Intensity of the exercise can be progressed week by week so as to avoid the muscle adaptation if same intensity of the exercise is given for 6 weeks. The progression of exercise can also increase interest of the participants while participating in the research.

Since the result of this study has significant effect between the stable and unstable modified wall squat among recreational badminton athletes, it is suggested to apply in other sport population as a training program as well as for the elderly as a rehabilitation program.

Chapter 6

Conclusion

In general, the current study determines the effect of stable and unstable wall squat on dynamic balance among recreational players respectively and compares the effects between stable and unstable wall squat on dynamic balance among recreational badminton players.

The result of the study shows that there is significant improvement on dynamic balance in unstable wall squat group among recreational badminton players ($p<0.05$). However, the result shows that there is no significant effect of stable modified wall squat on dynamic balance among recreational badminton players ($p>0.05$). Besides that, the effect between both groups on dynamic balance among recreational badminton players shows significantly shows difference. The hypothesis of the study is accepted. Hence, strengthening exercises can be performed on unstable surfaces to improve dynamic balance of an athlete.

Since there were some limitations in this study, it is recommended to recruit more female participants in future study. The strength of the lower limb muscles could be measured to determine the effect of lower limb muscle strength on dynamic balance. To get a more accurate result, researchers of future studies can include core and back muscles exercises into training program as not only the lower limb muscles affect dynamic balance. Lastly, since the result of this

study shows that dynamic balance can be improved by doing unstable modified wall squat, this intervention can be applied to athletes in different sports as well as other populations such as elderly as a rehabilitation program. .

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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:

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
1.	Knowledge and Attitude Towards Overweight and Obesity Among Physiotherapy and Medical Students: A Cross-Sectional Study	Ching Yung Shan	Mr Muhammad Noh Zulfikri Bin Mohd Jamali	4 November 2022 – 3 November 2023
2.	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	Lee Kah Yi		
3.	Effects on Menstrual Cycle on Dynamic Balance and Muscle Strength Among Recreational Players	Ler Chai Hong		
4.	Knowledge and Awareness Towards Pneumonia Among UTAR Non-Health Sciences Undergraduate Students	Chooi Yan Yee	Pn Nurul Husna Binti Khairuddin	
5.	The Effect of Active Video Games on 6-Minute Walk Test in Overweight and Obese Children	Chin Jay Ven		
6.	Association of Functional Ability of Upper Extremity and Scoliosis Among College Students: A Correlational Study	Sammi Leong Sing Yee	Dr Deepak Thazhakkattu Vasu	
7.	A Correlation Study Between Achilles Tendon Contracture and Posterior Tibial Tendon Dysfunction on Ankle Instability Among Young Adults with Pes Planus	See Wan Ni		
	A Correlational Study of the Relationship Between			

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		

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

APPENDIX B-INFORMED CONSENT FORM

Research Participant Information Sheet

Universiti Tunku Abdul Rahman
Faculty of Medicine and Health Sciences
Department of Physiotherapy
Bachelor of Physiotherapy (Honours)

Information Sheet to Participate in the Study
The effect of unstable modified wall squat on dynamic balance among recreational players

Student Investigator: Chu Sin Jiet
Department: Faculty of Medicine and Health Science
Course Name and Course Code: UMFD3026 Research Porject
Year and Semester: Y3S2
Course Coordinator: Mr. Avanianban Chakkarapani

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 effect on modified wall squat on dynamic balance among recreational badminton athletes.

Approximately 38 UTAR students will participate in this study and will be divided into 2 groups where 19 participants in a group.

Procedures
If you agree to be in this study, you will be asked to perform stable modified wall squat or unstable modified wall squat depend on which group you are randomly assigned in. You will also need to perform a dynamic balance test before and after this study.

Length of Participation
This study will take you about 30 minutes each session and you need to visit for 3 days per week. This study will be lasted for 6 weeks.

Risks and Benefits
The risk of this study is you may have muscle pain or muscle soreness after this study. However, the pain and soreness will not last long. The benefit of this study is you can gain lower limb strength and improve dynamic balance after this study.

Confidentiality

No information that will make it possible to identify you, will be included in any reports to the University or in any publications.
Research records will be stored securely and only approved researchers will have access to the records.

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 or complaints, about the research, the researcher conducting this study can be contacted at 0138813540 or sinjiet2000@1utar.my.
The Course Coordinator can be contacted at Mr. Avanianban Chakkarapani, 0122672457, avanianban@utar.edu.my to express your concerns or complaints about the research and wish to talk to someone other than individuals on the research team or

Please keep this information sheet for your records.

Research Participant Consent Form

Universiti Tunku Abdul Rahman
Faculty of Medicine and Health Sciences
Department of Physiotherapy
Bachelor of Physiotherapy (Honours)

Consent Form to Participate in the Study
The effect of unstable modified wall squat on dynamic balance among recreational athletes

Student Investigator: Chu Sin Jiet
Department: Faculty of Medicine and Health Sciences
Course Name and Course Code:
Year and Semester:
Course Coordinator: Mr. Avanianban Chakkarapani

I have read the provided information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have, has been answered to my satisfaction. I understand that I will be given a copy of this form, and the researcher will keep another copy on file. I consent voluntarily to be a participant in this study.

Name of Participant: _____

IC No: _____ Date: _____

APPENDIX C-DEMOGRAPHIC DATA AND SCREENING FORM

DEMOGRAPHIC DATA AND SCREENING FORM

1. Name:

2. Age:

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

4. Contact number:

5. Are you a recreational badminton athlete?

☐ Yes ☐ No

6. Height:_____cm

7. Weight:_____kg

8. Do you have any of the conditions:

☐ Recent fracture of lower limbs of 6-24 weeks

☐ Cardiovascular disease

☐ Spine musculoskeletal condition in the past 6 month

APPENDIX D-INTERNATIONAL PHYSICAL ACTIVITY

QUESTIONNAIRE-SHORT FORM

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (August 2002)

SHORT LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ

The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ

Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation

Translation from English is supported to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information
More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective*. Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ **days per week**

☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

APPENDIX E-INSTRUMENTS

Figure 2: Stopwatch

Figure 3: BOSU ball

Figure 4: Position of modified wall squat

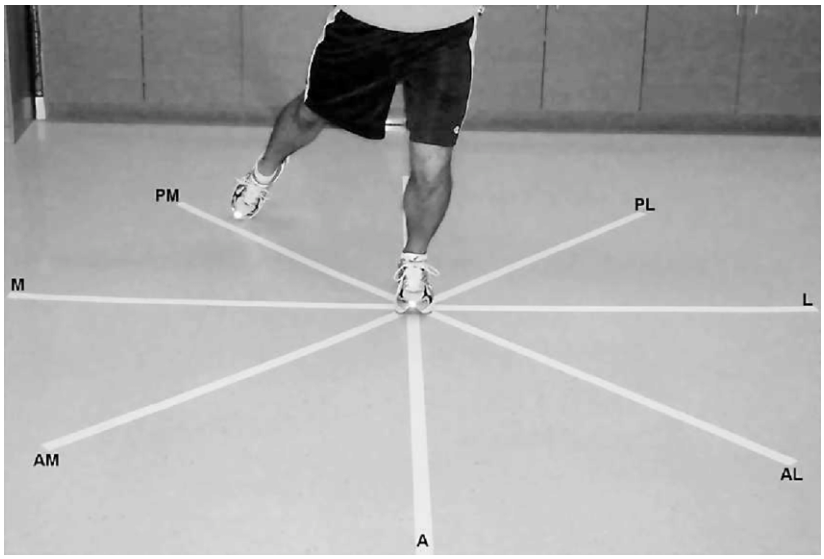
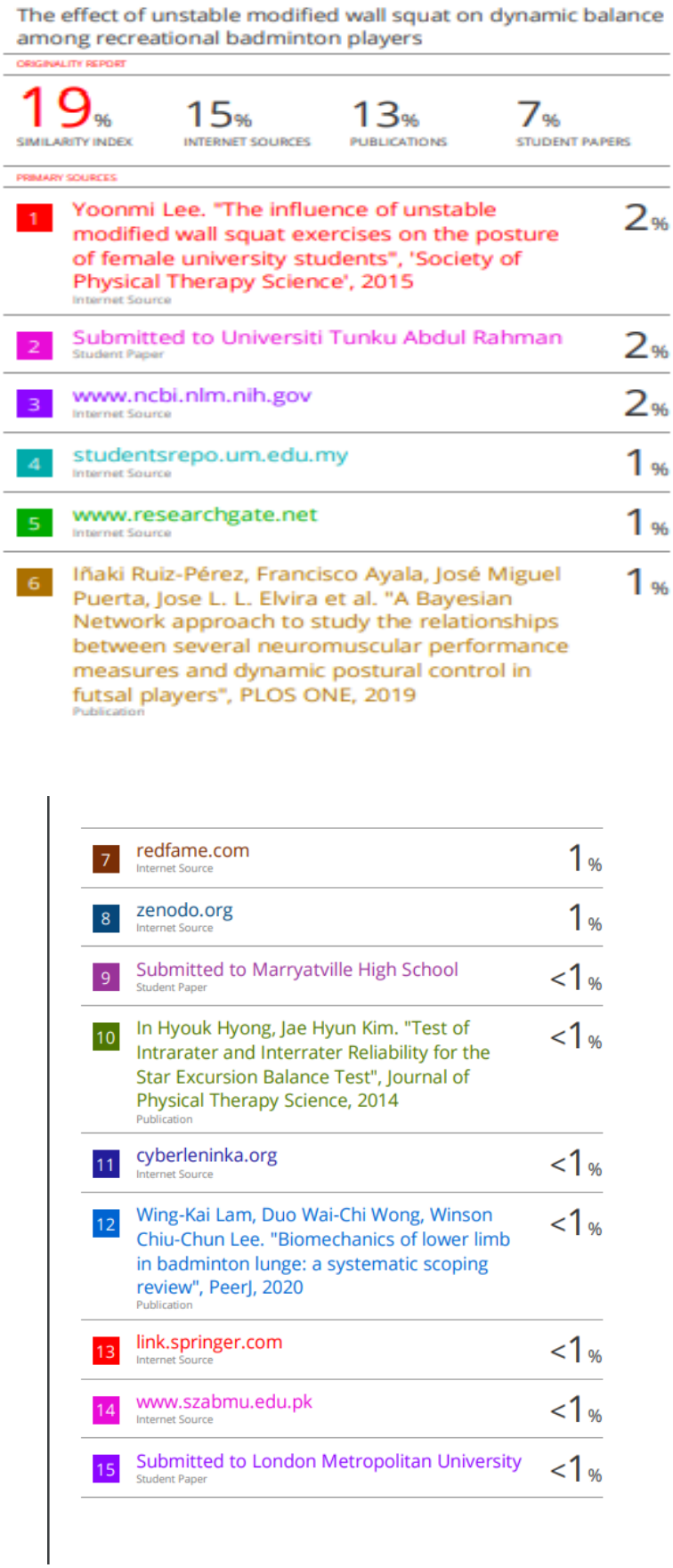


Figure 5: Star Excursion Balance Test (SEBT)

APPENDIX F – TURNITIN REPORT



The effect of unstable modified wall squat on dynamic balance among recreational badminton players

ORIGINALITY REPORT

19%	15%	13%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Yoonmi Lee. "The influence of unstable modified wall squat exercises on the posture of female university students", 'Society of Physical Therapy Science', 2015 Internet Source	2%
2	Submitted to Universiti Tunku Abdul Rahman Student Paper	2%
3	www.ncbi.nlm.nih.gov Internet Source	2%
4	studentsrepo.um.edu.my Internet Source	1%
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