THE RELATIONSHIP BETWEEN ISOKINETIC KNEE STRENGTH AND KNEE BIOMECHANICS DURING SINGLE LEG LANDING AMONG RECREATIONAL ATHLETES

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By

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TABLE OF CONTENTS

HUBUNGAN ANTARA KEKUATAN LUTUT ISOKINETIK DAN BIOMEKANIK LUTUT SEMASA PENDARATAN KAKI TUNGGAL DALAM KALANGAN ATLET REKREASI

ABSTRAK

Objektif: Kajian ini mengkaji hubungan antara kekuataan lutut isokinetic dan biomekanik lutut semasa pendaratan kaki tunggal dalam kalangan atlet rekreasi. Kaedah: Sepuluh atlet rekreasi lelaki dengan min umur 20 di Universiti Sains Malaysia direkrut untuk menyertai kajian ini. Peserta akan menjalani pemeriksaan fizikal seperti tinggi, berat, peratusan lemak badan, panjang segmen kaki dan kaki dominan. Seterusnya, kekuatan lutut isokinetik untuk kedua-dua belah lutut akan dinilai dengan menggunakan dynamometer. Seterusnya peserta perlu melakukan lompatan berpantul dengan menggunakan kedua-dua belah kaki semaksima yang boleh tanpa sebarang bantuan dan selepas itu perlu mendarat dengan menggunakan kaki yang dominan di atas platform sebanyak tiga kali. Korelasi digunakan untuk analisis statistik.

THE RELATIONSHIP BETWEEN ISOKINETIC KNEE STRENGTH AND KNEE BIOMECHANICS DURING SINGLE LEG LANDING AMONG RECREATIONAL ATHLETES

ABSTRACT

Objective: This study investigated the relationship between isokinetic knee strength and knee biomechanics during single leg landing among recreational athletes. Methods: 10 male recreational athlete from Universiti Sains Malaysia with mean age of 20 were recruited in this study. Participant go through a physical check up, which include measuring height, weight, body fat percentage, length of leg segment and their dominant leg. Next, participant's isokinetic knee strength for both legs will be evaluated by using dynamometer. Next, participant have to execute counter movement jump with both leg as high as possible without any assistance and after that you need to land with dominant leg on the platform. Correlation were used for statistical analysis.

CHAPTER 1

INTRODUCTION

1.1 Background of study

Jumping and landing is one of the important techniques that are common in sports and should be mastered by athletes. This statement supported by Chalitsios *et al.*, (2019) who said that players in sports such as basketball and soccer usually perform repetitive tasks such as jumps, rapid changes of direction, and intense accelerations or decelerations. The landing process required athletes to land as smoothly as possible, absorb force with the use of muscle while feet are in contact with the surface, land flat foot to ensure that weight is spread equally on the whole foot and finally move gluteus back and hold knees behind toes. When the athlete loses one of the jump-landing phases, it can cause injury. For instance, the most common injured region in volleyball is ankle followed by lower back and knee (Bahr and Bahr, 1997). These types of injury can be related to jumping and landing technique. Moreover, single leg landing is shown has causes higher number of lower limb injuries when compared to DLL (Wang, 2011). This is because, SLL recorded higher GRF ($p < .001$), larger flexion moment ($p < .001$) and lesser knee extensor ($p =.002$) compared to DLL, which indicate stiffer landing technique than DLL.

Athletes should have knowledge about proper landing to prevent injury. There are several prevention methods that can be done which is strengthening of the thigh muscles which are hamstring and quadriceps. This is because these muscle groups can act as a protection from injury because it absorbs the force during landing to prevent it to be absorbed by knee joint and later cause injury to the knee (Hoffman, 2017). Therefore, resistance training has been suggested to increase strength and further reduce the risk for musculoskeletal injuries, and the severity of such injury and muscle (Hoffman, 2017).

Several studies suggested that resistance training can reduce muscle injury. Heidt *et al.*, (2000) showed that prevalence of knee injuries and the severity of ligament involvement in ACL injuries, in the untrained group was higher than the trained group (3.1% versus 2.4%). Micheli, Glassman & Klein (2000), stated that fitness exercise should be one of the injury prevention strategy for children and adolescent. There are still lack of study about the relationship of isokinetic knee strength and knee biomechanics during single leg landing. The purpose of the current study is to determine the relationship between these two variables.

1.2 Objective of the Study

1.2.1 General Objective

To determine the relationship between isokinetic knee strength and knee biomechanics during single leg landing among recreational athletes.

1.2.2 Specific Objectives

1) To determine the relationship between isokinetic knee strength and knee kinematics in frontal plane during single leg landing among recreational athletes.

2) To determine the relationship between isokinetic knee strength and knee kinematics in sagittal plane during single leg landing among recreational athletes.

3) To determine the relationship between isokinetic knee strength and knee kinematics in transverse plane during single leg landing among recreational athletes.

4) To determine the relationship between isokinetic knee strength and ground reaction force during single leg landing among recreational athletes

1.3 Research Hypotheses

1)Null Hypotheses: There is no relationship between isokinetic knee strength and knee kinematics in frontal plane during single leg landing among recreational athletes.

Alternative Hypotheses: There is a relationship between isokinetic knee strength and knee kinematics in frontal plane during single leg landing among recreational athletes.

2)Null Hypotheses: There is no relationship between isokinetic knee strength and knee kinematics in sagittal plane during single leg landing among recreational athletes.

Alternative Hypotheses: There is a relationship between isokinetic knee strength and knee kinematics in sagittal plane during single leg landing among recreational athletes.

3)Null Hypotheses: There is no relationship between isokinetic knee strength and knee kinematics in transverse plane during single leg landing among recreational athletes.

Alternative Hypotheses: There is a relationship between isokinetic knee strength and knee kinematics in transverse plane during single leg landing among recreational athletes.

4)Null Hypotheses: There is no relationship between isokinetic knee strength and ground reaction force during single leg landing among recreational athletes.

Alternative Hypotheses: There is a relationship between isokinetic knee strength and ground reaction force during single leg landing among recreational athletes.

1.4 Problem Statement

The increases of force during jump-landing can cause muscle strain on lower extremities and further cause the leg to go into valgus position (Seymore et al., 2019). Muscle weakness is thought to be one of the underlying mechanism for excessive dynamic knee valgus (DKV) during dynamic movement (Powers, 2003). However, DKV is rarely studied during SLL which is common motion in sports. Unlike previous studies that fixed the landing height (i.e., drop landing from a box with 30cm height). Natural jump height that will be used in this study protocol is maximal counter movement jump (CMJ) which is similar to the real game situation. Moreover, the effect of muscle weakness on lower limb biomechanics during SLL among recreational athletes. By studying the relationship between knee strength and knee biomechanics, a greater understanding about how to prevent injury can be achieved.

1.5 Significance of the Study

In competitive sport such as basketball and Frisbee, jumping and landing motion is considered as one of the important skills because of the repetition execution of the movement in the game. These skills required athlete to have good muscle strength to bear with the force produce by the repetitive motion. By analysing the relationship between isotonic knee strength and knee biomechanics, coaches would get benefit from this study as they can build a strategy or program to improve the strength of knee muscles and further reduce risks of injuries associated with single leg landing (SLL). They can teach their athlete on how to land properly or prevent injury because of landing. Athletes also can get benefit from this study as they will become more aware about their jumping and landing technique. They also would more understand about their knee biomechanics.

1.6. Operational Definition

Term	**Operational definition**
Dynamic Knee Valgus (DKV)	The combination of hip adduction, hip internal rotation, knee flexion, knee external rotation, knee abduction, ankle inversion and ankle dorsiflexion during dynamic motions. In this study, DKV will be analysed during single leg landing (SLL).
Recreational Athletes	University students that play specific sport (volleyball, Frisbee, basketball) and plays at least 3 times per week for health-related purposes.
Maximal Effort Counter Movement Jump (CMJ)	Athletes stand on the ground and then flex their knees and hips and then extend their knee and hips again to jump upwards highest as they can from the ground.

CHAPTER 2

LITERATURE REVIEW

2.1 Single Leg Landing

Landing is an act that cause the body to land on the surface from certain height after jumping motion. Landing can be found in several sports such as volleyball, badminton, Frisbee and also sepak takraw. It is considered as one of the most frequent tasks that is common in sports. For examples, in volleyball, setter have to jump around 18-22 times per set and middle blockers jumps around 18-23 per set (Lima, Palao & Clemente, 2019).

Landing can be categorised as single leg landing (SLL) and double leg landing (DLL). Single leg landing is an act of land on one leg after jumping and double leg landing use two leg. When comparing SLL to DLL, participants demonstrate increased knee valgus (compared to varus) in SLL (Pappas *et al.*, 2007). This is due to excessive force that have to be absorbed by knee is increased in SLL compare to DLL. Force can be distributed fairly among both knee in DLL and reduce knee valgus. Athletes commonly performed SLL because of the high intensity of the game that required them to focus on how to score point rather than their landing technique. For example, in a badminton epidemiology study by Sasaki, Nagano & Ichikawa, (2018) it was found that during a badminton game, SLL after an overhead stroke consisted of 21.07% of the whole match duration. SLL is also can be found in volleyball games where player have to block the ball from the spiker many time to avoid losing point. They have less time to think about their landing technique because of the game progress faster and they need to act quickly.

Another landing method is soft landing and stiff landing. Soft landing positively altering landing mechanics by allowing the knee joint to be in a slightly flexed position, which increase the impact absorption at ground contact (Dai *et al.*, 2014). On the other hand, stiff landing is characterised with a more extended knee position at ground contact (Devita and Skelly, 1992). Stiff landing absorb impact poorly and is more common during SLL.

2.2 Influence of Leg Strength on Lower Limb Biomechanics during Landing

Muscle involved in knee movement is hamstring and quadriceps. Hamstring consist three separate muscle which is biceps femoris, semitendinosus, semimembranosus and help in flexion motion of the knee and extension of the hip joint. Quadriceps consist of four different muscle which is rectus femoris, vastus medialis, vastus lateralis and vastus intermedius. Quadriceps muscle work as extensor for knee and flexor for hip joint. These two muscle have to work together to maintain healthy knee and smooth movement. When one of the muscle become weaker or don't have enough endurance, it can cause muscle imbalance. Muscle imbalance is a condition when one set of the muscle are stronger, weaker or tighter than another muscle and will cause excessive force or stress to the knee joint and lead to injury. Study by Daneshjoo *et al.*, (2013) shown between-limb strength asymmetries greater than 10% have been associated with increased risk of knee injury in football players. Example of injury is anterior cruciate ligament (ACL) injury. Knee strength can be measured by using isokinetic dynamometer. These dynamometer express strength as torques at multiple constant angular velocities (Rezaei *et al*, 2014). Isokinetic dynamometers measure muscle strength by recording the resistive moment required to counter balance the joint moment applied by the participant and maintain a constant joint angular velocity.

2.3 Common Injuries Related to Landing

Dynamic knee valgus (DKV) is an abnormal movement pattern visually characterised by excessive medial movement of the lower extremity during weight bearing tasks such as during SLL. This excessive medial lower extremity movement is a multi-joint, multiplane pattern com-prised of varying degrees of increased 3-dimensional (3D) joint kinematics that include hip adduction and internal rotation and knee abduction and external rotation (Powers, 2010). Prospective studies have reported that increased knee valgus angle and knee abduction moment during landings were predictive of non-contact ACL injuries in athletes, particularly females (Hewett *et al.*, 2005). DKV can be evaluated through functional tasks such as single leg squat (SLS), drop landing and single leg landing (SLL). However, to the best of our knowledge, DKV during SLL is rarely studied despite it is a common motion in sports and one of the causes of non-contact injuries.

Lower limb injuries are common cases among athletes because of the skill and trick that they have to do mostly involve movement of their lower limb. For examples in football games, in order to dribble the ball against their opponent, it would involve fast movement of their leg, sudden turn and sudden stop. This movement actually will stress and overload their muscle and ligament and will lead to injuries such as ACL tear, groin and hamstring strain and ankle sprain. Fernandez, Yard & Comstock, (2007) showed that 52% from sport injury cases are related to lower limb. Recently, Mack *et al.*, (2020) stated that knee is the most common injured region for lower limb with 29.3% from all cases reported followed by ankle (22.4%), thigh (17.2%), and foot (9.1%).

CHAPTER 3

METHODOLOGY

3.1 Study Design

The study design used is cross-sectional. Thirty participants from various types of sport that involved intense jumping were involved in this study. The research purpose is to determine the relationship between isokinetic knee strength and knee biomechanics during single leg landing among the participant. The data collection procedures take place at Sport Science Lab 1 and 2, USM Health Campus and it took around one hour for each participant to complete the trials. Figure 3.1 shows the flow chart of the study procedures.

3.2 Sample Size Calculation

The sample size was calculated by utilizing the G*Power Software (v.3.1.9.2, Universität Düsseldorf, Northrhine-Westphalia, Germany) which is a program that is free to use. The margin α-error is fixed to 5% with certainty span at 95%. A priori sample size calculation showed that 15 participants per gender were sufficient to yield 0.8 power of the study with 0.5 effect size. By including 20% of estimated drop out, 18 participants per gender were recruited. Therefore, a total of 36 participants recruited for the study. The effect size was based on mean different between two different groups from Ghasemi & Zahediasl (2012).

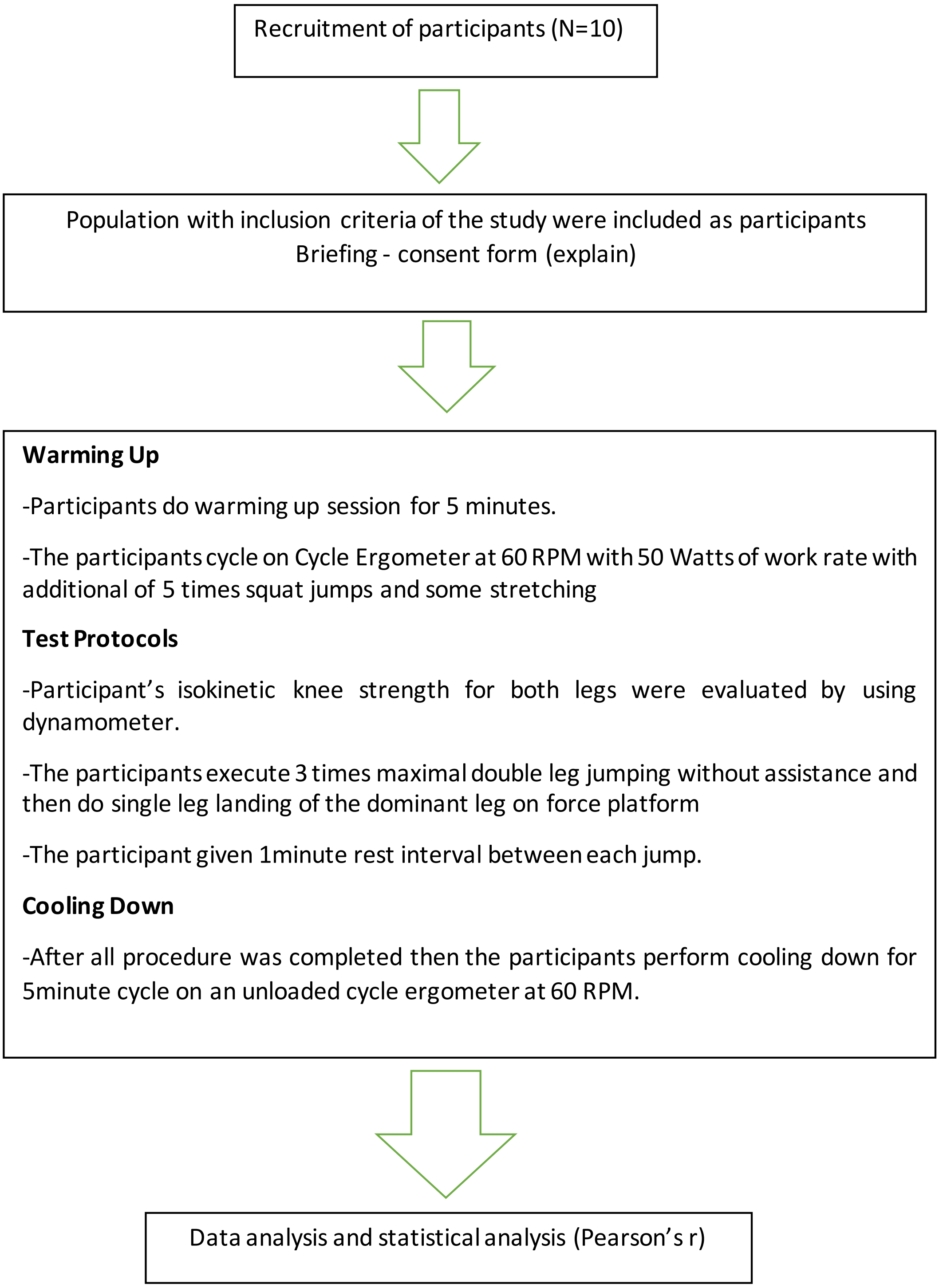

Figure 3.1: Flow chart of the study procedures

3.3 Study Participants

10 male athletes from volleyball, basketball and Frisbee team that play at recreational level and above were involve in this study. Purposive sampling method used to search for volunteers that suitable with the selection criteria set at the beginning of the study. Recruitment was conducted by advertising the research through poster (Appendix C). The participants were given information about the study procedures before joining it. Participants were asked to be honest about their medical status and signed the consent form given. Participants were requested to inform researcher if they get health problem during the study was conducted.

3.4 Selection Criteria

Inclusion and exclusion criteria for this study were as follows:

Inclusion criteria

- Aged 18 to 25 years old
- Recreational athletes (play either volleyball, basketball or Frisbee at least 3 times per week)
- Healthy

Exclusion criteria

- Have any lower limb or back injury that required surgery for the past six months
- Exclude by medical doctor from any type of physical activity

3.5 Data Collection Procedures

Before the day of the test, participants were advised to have enough sleep for at least 6 hours. They were asked to take their meal and avoid any caffeine product 2 hours before the test begin. Participants also reminded to wear tight fitting clothes so that the retroreflective markers that were placed on their body stay still and measurements were accurate.

3.5.1 Preliminary tests

Participants went through physical check-up; height and body weight measurements by using a digital medical scale (Seca 769, Hamburg, Germany) and body fat percentage, evaluated using Omron HBF-375 Body Fat Analyzer (Seca 796, Hamburg, Germany). Their dominant leg was also checked by using Ball Kicking test (BKT) (Brophy *et al.*, 2010) and leg length was measured by using measuring tape. Length leg measured from anterior superior iliac spine (ASIS) to ipsilateral medial malleolus.

3.5.2 Single leg landing test

Participants were asked to warm up for 5 minutes on the cycle ergometer (Cybex Inc., Ronkonkoma, NY, USA) prior to beginning the test. Throughout the warming up session, the cycle ergometer will be set at 50 Watts resistance and participants were instructed to cycle consistently at a speed of 60 RPM. The participants would then be asked to execute ballistic jumps five times. In order to minimize the risk of injury by strengthening the muscles, tendons, joints and bones for the exercise, warming up sessions are necessary and will possibly boost performance relative to not warming up. 35 retroreflective markers (25-mm diameter) placed by researcher on the participants' lower leg, as followed from the Plug-in-Gait Marker Set, particularly on the sacrum, on both Anterior

Superior Iliac Spine (ASIS), medial and lateral thigh, medial and lateral femoral epicondyle, lateral shin, calcaneus, medial and lateral malleolus and second metatarsal (Figure 3.2). The right way of SLL were demonstrated by the researcher so that participants have a clear idea of what they need to do. Then a testing session provided for the participants. The researcher would then continue with the SLL actual test.

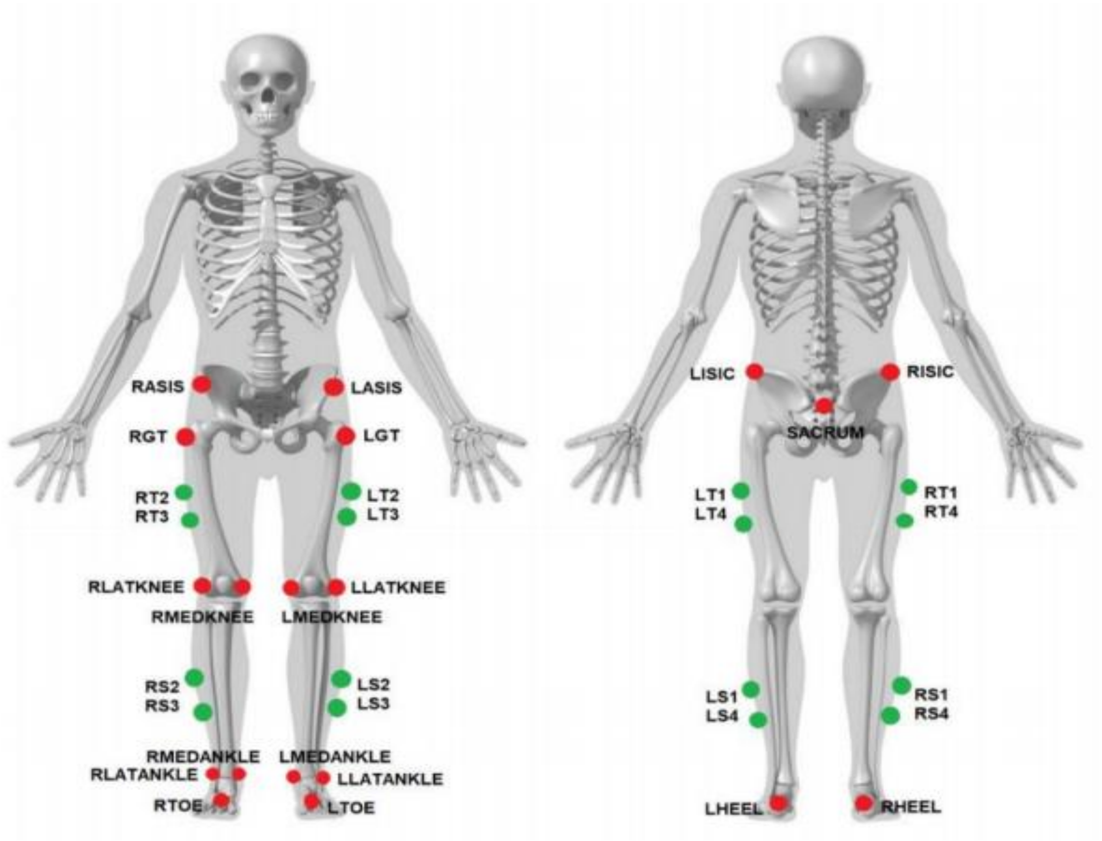

Figure 3.2: Retroreflective markers' placement on participant's lower leg

During the actual test, participants were asked to execute the Counter Movement Jump (CMJ) with both legs as high as possible. No external assistance, such as a drop jump box, were used. Participants stand on the force platform with both feet slightly apart while performing the maximal CMJ attempt, based on their comfort. They were asked to bend over slightly and jump as high as they can. Participants were expected to land on the force plate (Kistler, NY, USA) with their dominant leg. Participants were recommended to apply natural landing style, where the forefoot touches the ground first and bend the knees slightly to reduce risks of injuries. They were barefooted during the test. The same procedures were repeated for another leg (Figure 3.3).

Figure 3.3: Single leg landing (SLL)

Participants started their jump on the basis of the researcher's instructions and was given 1 minutes of rest between trials. Participants were required to complete 3 trials for the test. A task was considered successful when the participants can jump with a comfortable landing pose without any external assistance or supporting leg and land. The participants were requested to redo the experiments for any failed tests or any mistakes that happened during the data collection after the testing session.

They performed 5 minutes of cycling on the unloaded Cycle Ergometer at 60 RPM as a cooling down session after they finished the trials. Participants were asked to stretch the leg muscles used during the test.

3.5.3 Isokinetic knee strength test

Isokinetic strength test for both knees were conducted by using dynamometer (Biodex 3 Multijoint Testing and Rehabilitation System, Shirley, NY, USA). Isokinetic strength was determined by peak torque which was normalised to each participant's body mass (peak torque/body weight, PT/BW). Peak torque is a valid and reliable parameter to measure maximal strength according to Coratella & Bertinato, (2014).

Based on study by Mail *et al.*, (2019) the procedure were started with the participant seated with the hip flexed at 90°. The support lever were secured between the lower third and upper two-thirds of the tested leg while the dynamometer axis of rotation was aligned to the knee rotation axis. After the depth of seat, the height of dynamometer, and the length of support lever were adjusted, participants were strapped in the testing position. After a familiarisation session, the test started with knee extension from 90° flexion. Participants performed two sets of five repetitions of knee flexion-extension test at 60°/s of angular velocity with one minute rest interval between the sets (Claiborne *et al.*, 2006). Then, the same procedures were repeated for another leg.

3.6 Data analysis

Data included for anthropometry are weight, height, body mass index (BMI), body fat percentage and length of dominant leg segment. The BMI was classified based on standard from International Classification (WHO, 2004). Trajectory of retroreflective markers were recorded and processed by using Qualisys Track Manager Software (v 2,6,673, Gothenburg, Sweden). 3D kinetics and kinematics analysis of the single leg landing for the dominant leg were carried out using Visual 3D Software (version 5, Gothenburg, Sweden), whereby the participants' musculoskeletal model were built to