The association between static biomechanical parameters and musculoskeletal injury in lower extremities in male recreational weight trainers

By

Fahmeeda Makada

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Durban University of Technology

I, Fahmeeda Makada, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary).

7 November 2022

Fahmeeda Makada Date

Approved for final examination

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Dr G. Matkovich: M. Tech Chiropractic Date

Dedication

TO MY PARENTS.

FOR THEIR ENDLESS LOVE, SUPPORT AND ENCOURAGEMENT AND TO WHOM I WILL FOREVER BE INDEBTED.

Acknowledgements

To my parents, Mohammed and Fozia, none of this would have been possible without your support and love. Thank you for always believing in me.

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Abstract

Background: Anatomical alignment of the lower extremity has been proposed as a risk factor for acute and chronic lower extremity injuries such as ACL injuries, patellofemoral syndrome, and plantar fasciitis. Lower extremity malalignment influences the load distribution on the joints, mechanical efficiency of the muscles and proprioceptive orientation and feedback from the hip and knee, resulting in altered neuromuscular function and control of the lower extremities.

During recreational weight training, the weight trainer performs exercises with gradual load on machines or free weights, aimed to improve their muscular condition, fitness, power, or performance in other sports. The weight trainer uses his own bodyweight or specialised forms of equipment such as barbells, dumbbells and resistance training machines to target specific muscle groups and to perform specific joint actions.

Various intrinsic and extrinsic factors contribute to injury. Anatomical alignment – amongst others - is regarded as an intrinsic factor. Studies state that suggested risk factors for injuries include heavy loads in extreme joint positions, training frequency, intensity, volume, muscle strength, stability and foot morphology.

Several studies have examined musculoskeletal injuries in specific weight training populations such as powerlifters, weightlifters and bodybuilders. Very few studies have investigated the recreational weight training population. The purpose of this study is to identify whether associations exist between the relevant biomechanical parameters and injury, to prevent or correct these abnormalities.

Objectives: This study aimed to establish lower extremity static biomechanical parameters of the hip (flexion, extension and Craig's test), knee (quadriceps angle and tibial torsion test), ankle (dorsiflexion, Feiss line, hindfoot, and forefoot alignment) and leg length discrepancy, and to establish if an association exists between the above-mentioned parameters and musculoskeletal injuries in the lower extremities in male recreational weight trainers.

Method: 30 Male recreational weight trainers were recruited from fitness centres within the greater Durban area to the DUT Chiropractic clinic, where the assessment took place. Each participant was assessed for injury and static biomechanical measurements were taken. The statistical analysis was performed using Stata version 16. For normally distributed continuous variable the mean and 95% CI was done. Shapiro Wilk test was used to test for normality. For not normally distributed variables, median and interquartile range was performed. 15 participants were diagnosed as injured and 15 participants as uninjured. As the sample size of this study is small, Fisher's exact test was used to evaluate the association between two categorical variables.

Results: The statistical analysis was performed using Stata version 16. For normally distributed continuous variables the mean and 95% CI were done and Shapiro Wilk test was used to test for normality. For not normally distributed variables, median and interquartile range were performed. As the sample size of this study is small, Fisher's exact test was used to test the association between two categorical variables. Prevalence of injury was thus 50%. In the injured population, 46.67% were acute and chronic injuries. 16.67% of injuries were traumatic and 33.3% were non-traumatic.

Fisher's exact test was used to see the association between biomechanical measurement and existence of injury. Accordingly, Fisher's exact test with *p-value* 0.036 indicated that there was enough evidence of association between right quadriceps angle and injury. The injured participants were more likely to have a low right quadriceps angle. However, the rest of the biomechanical measurements have no association with injury

Conclusion: The injured participants were more likely to have a low right quadriceps angle. The rest of the biomechanical measurements have no association with injury.

Keywords: Biomechanics, weight training, musculoskeletal injuries

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List of Abbreviations and Acronyms

ACL: Anterior cruciate ligament

ASIS: Anterior superior iliac spine

DUT: Durban University of Technology

LLD: Leg length discrepancy

MSK: Musculoskeletal

PSIS: Posterior superior iliac spine

Q angle: Quadriceps angle

Reps: Repetitions

ROM: Range of motion

WT: Weight training

Definition of Terms

Acute injury

Injuries that occur suddenly and last a short period of time.

Barbell

A long bar with non-fixed weight at each end, used typically for strength training (Merriam-Webster 2022).

Biomechanical

The mechanics of biological and especially muscular activity (As in locomotion or exercise) (Merriam-Webster 2022).

Biomechanical parameters

Factors that affect joint movement, i.e., range of motion and alignment factors.

Bodybuilding

A type of weight training that is not judged on the weight lifted or time taken to complete an event, but rather on physical appearance of the athlete (Keogh and Winwood 2017).

Chronic injury

Injuries that occur over long periods of time and last a long time, usually longer than three months.

CrossFit

This type of weight training includes a variety of bodyweight and resistance exercises, gymnastics, weightlifting, powerlifting, and endurance activities which are generally combined into high-intensity workouts performed in rapid succession with limited or no recovery time (Keogh and Winwood 2017).

Deadlift

A conventional deadlift begins with the lifter in a hip hinged position, the hips and knees in flexion while the lifter grasps the bar, shoulder width apart, whilst maintaining a neutral spine. The bar is lifted off the ground, the hips and knees move into extension for a moment before the bar is set back down and returning to the original position.

Dumbbell

A short bar with a fixed weight at each end, used typically in pairs for strength training.

Kinematic chain

This chain describes how the human body can be considered in terms of a series of interrelated links or segments, where one segment affects both proximal and distal to the first segment (Ellenbecker and Aoki 2020).

Leg press

The leg press is a machine which involves an inclined seated area, which has a plate in front. The lifter seats himself and places both feet on the plate, shoulder width apart. In this position, the hip, knee and ankle joints are flexed. The lifter pushes the plate, thereby extending his knees and ankles and then returns to the flexed position.

Lower extremity

Lower part of the body, comprising the hips, knees and foot/ankles.

Lunges

The lunge begins with the lifter in an upright position, the lifter steps forward with one leg, lowering their hips until both knees are flexed at 90 degrees. The leg that is forward maintains a hip flexion and the opposite side in hip extension. The lifter returns to the starting position and repeats this movement on the opposite leg.

Musculoskeletal

System involving muscles, bone, tendons, ligaments and soft tissue structures.

Musculoskeletal injury

Harm caused to muscles, nerves, tendons, joints, cartilage and/or spinal discs, via external forces or stimulus, thereby causing discomfort to an individual.

Powerlifting

A type of weight training that is like weightlifting, with lifters attempting to lift the maximum loads for one repetition. However, in powerlifting competitions, the three lifts performed are the squat, bench press, and deadlift (Keogh and Winwood 2017).

Recreational weight training

Weight trainers who do not compete in any weight training divisions.

Repetitions

Term used to describe the number of times a specific exercise is performed.

Resistance training

A form of weight training with the aim to develop muscular strength and endurance.

Sets

Term used to describe the number of cycles of repetitions that is performed.

Squats

The squat begins with the lifter in an upright position and the knees and hips fully extended. The lifter then squats down by flexing at the hip, knee and ankle joints to the desired squat depth. Thereafter the lifter reverses direction and ascends back to the upright position (Schoenfeld 2010: 3497).

Strongman

A type of weight training that involves events that utilise a variety of heavy implements such as stones for lifts and carries, tyres for flipping, logs and stones for overhead pressing, and trucks or sleds for pulling (Keogh and Winwood 2017).

Resistance band

A closed loop elastic band of varying resistances, used for strength training.

Weight training/strength training

A form of resistance training with the aim of developing muscular strength and endurance.

Weightlifting

A type of weight training that requires the lifter to lift maximal loads for one repetition in two exercises: the clean and jerk and the snatch (Keogh and Winwood 2017).

1. Chapter One: Introduction

1.1 Introduction

Resistance training is synonymous with weight training, weightlifting, and strength training. This is physical exercise wherein there is recurrent concentric and eccentric muscle contractions, occurring against an external resistance such as dumbbells, barbells, weight plates or resistance machines (Nuzzo 2021: 1425). The purpose is to enhance overall health and fitness as well as improve muscle size and strength.

Weight training is a popular physical activity performed by individuals across age groups, it is typically performed to increase muscle hypertrophy, muscular strength, and aid with weight loss. Weight trainers use dumbbells, barbells, exercise machines and bodyweight to perform exercises that target specific muscle groups. These weight trainers can also be referred to as recreational weight trainers. There are several groups of athletes who compete in sports in which weight training is the primary form of training. These include Olympic weightlifters, powerlifters, bodybuilders, cross-trainers, and strongman. They are regarded as elite or competitive weight trainers.

Recreational weight trainers are individuals with no motivation to participate in weight training competitions. They train to improve and maintain fitness, body physique or strength.

The exercises typically performed by weight trainers - elite and recreational - with regards to the lower extremity include barbell squats, deadlifts, leg presses and lunges. These compound exercises target several muscle groups simultaneously, including quadriceps, hamstrings, gluteal and leg muscles. These exercises result in muscles, joints, ligaments, and tendons being under compressive loads in extreme joint positions. Muscles and joints need to function at optimum levels to withstand these forces and avoid injury. Joint alignment and muscle function are vital as abnormalities in joint alignment could present as a risk factor for various musculoskeletal injuries. According to Murphy, Connolly and Beynnon (2003: 22), alignment of the hip, knee and ankle are potential risk factors for lower extremity musculoskeletal injury.

Musculoskeletal injuries can be defined as harm caused to muscles, nerves, tendons, joints, cartilage and/or spinal discs, via external forces or stimulus, thereby causing discomfort to an individual. Amongst weight trainers it can be as a result of overuse, poor technique or poor exercise selection and are a significant source of pain. Their proper management not only reduces this pain but also reduces further injury to surrounding tissue and prevents long-term damage (Collopy, Kivlehan and Snyder 2012: 36). Heavy lifting is a well-known injury risk in the general population. Coupled with the complex demands on balance and coordination, one can assume that the risk of injury is high (Aasa *et al.* 2017: 214). Musculoskeletal injuries of the lower extremities include, but are not limited to, sacroiliac joint syndrome, piriformis syndrome, patellofemoral pain syndrome, anterior cruciate ligament injury and plantar fasciitis.

The joints of the lower extremity form a closed kinematic chain, consequently, changes in alignment in one joint will have subsequent changes in the rest of the chain. Joints have several biomechanical parameters that govern their movement and alignment. Within the hip joint, there has been research reported on the association between the position of anterior cruciate ligament (ACL) injuries and kinematics of the hip joint (Kaneko and Sakuraba 2013: 1216). According to Kaneko and Sakuraba (2013: 1216), excessive internal rotation of the hip joint can lead to knee valgus alignment due to the kinematic chain; therefore, an increase in femoral anteversion may cause an ACL injury.

Within the foot and ankle joint, literature has shown inter-segmental coordination between rear foot inversion/eversion and tibia internal/external rotation as well as tibia internal/external rotation and hip internal/external rotation (Pohl, Messenger and Buckley 2007: 296). It has also shown that joint biomechanics are closely inter-related, and that altered or disrupted coupling mechanisms may be one of the multiple aetiological factors of musculoskeletal injuries since it would result in pathological joint contact forces and soft tissue stress (Pohl, Messenger and Buckley 2007: 296).

Malalignments in structure and joint biomechanics in the hip, knee and/or ankle can result in compensatory motion and abnormalities in movement. These deviations could potentially cause injuries (Buchanan and Davis 2005: 559).

Leg length discrepancy (LLD) is related to the occurrence of injuries such as patellofemoral pain. It is possible that LLD affects gait kinematics and kinetics, such as rearfoot inversion angle and knee adduction moment, which are related to the development of lower limb injuries such as knee osteoarthritis (Resende *et al.* 2016: 147).

During weight training exercises the joints of the hip, knee and ankle are subjected to significant loads in stressed positions. These movements occur in a closed kinematic chain, where both ends of the chain are fixed, and any adjustment in the angle in one joint reciprocally results in altered angles in other joints (Svoboda *et al.* 2016: 38). Muscle activity in the lower limb with the foot fixed to the ground is different than when the foot is in free motion. This has implications in sports training (Svoboda *et al.* 2016: 38).

1.2 Aim

The aim of this study was to determine if alterations in static biomechanical parameters in the hip, knee and ankle are associated with musculoskeletal injury in the lower extremities in male recreational weight trainers.

1.3 Objectives

The objectives were two-fold:

1. To establish lower extremity static biomechanical parameters; of the hip (flexion, extension and Craig's test), knee (quadriceps angle and tibial torsion test), ankle (dorsiflexion, Feiss line, hindfoot, and forefoot alignment) and the leg length discrepancy of male recreational weight trainers.

2. To establish if an association exists between the above-mentioned parameters and musculoskeletal injuries in the lower extremities of male recreational weight trainers.

1.4 Rationale

Weight training has become one of the most popular forms of exercise for developing musculoskeletal and health related fitness and remains in the top ten for intended activities (Baker *et al.* 2013). Individuals aged 13-65 years participate in weight training with the aim of improving physique, improving cardiovascular fitness, weight loss and/or gaining strength. Fitness centres have become widely available and accessible by offering personal training and group training classes. Recreational weight trainers would be more prone to musculoskeletal injuries due to lack of knowledge and/or support during the training process. Weight training, if not performed correctly with correct body positions and posture, can result in injury.

Previous studies have investigated musculoskeletal injuries in competitive weight trainers, such as powerlifters and bodybuilders (Aasa *et al.* 2017), but none have looked at recreational weight trainers as they do not train at the same intensity and frequency as competitive weight trainers.

This study will help practitioners and sports therapists understand the risk factors for musculoskeletal injury in recreational weight trainers and allow them to treat these optimally.

1.5 Outline of chapters

This chapter introduced the research topic, as well as highlighted the aims, objectives, and the rationale of the study. Chapter Two will provide an in-depth understanding of weight training and its associated musculoskeletal injuries, as well as a review of the current literature related to anatomy and biomechanics involved. Chapter Three will discuss the methodology used to conduct this study. Chapter Four will present an analysis of the results. Chapter Five will discuss the results and conclusion and Chapter Six will discuss limitations and recommendations for future research.

2. Chapter Two: Literature Review

2.1 Introduction

This chapter aims to describe weight training and common weight training exercise techniques that are performed in relation to the lower extremities, understand the joint biomechanics, review literature related to musculoskeletal injuries during weight training and discuss the risk factors involved.

2.2 Weight Training

2.2.1 Definition of weight training

Weight training is a form of resistance training with the aim of developing muscular strength and endurance. Weight trainers use resistance machines, dumbbells, barbells, and weight plates in different joint motions to target specific muscle groups. Squats target the gluteal and quadricep muscles, while deadlifts target the posterior chain, including quadratus lumborum, gluteal and hamstring muscles. Weight training exercises vary from compound exercises, squats, deadlifts and lunges to isolated exercises like knee extension, knee flexion and hip thrusts.

2.2.2 Types of weight training

Weight training can be divided into competitive and recreational. Competitive weight trainers participate in competitions within their division of weight training. Recreational weight trainers have no competitive motive. Rather, their goal is to improve fitness, physique and/or performance in another sport.

There are various styles of weight training, ranging from physique goals like bodybuilding, to strength and fitness goals like powerlifting and CrossFit. The bodybuilding style of weight training is the most common style performed by recreational weight trainers, as opposed to powerlifting style and Olympic lifting styles (Weitz, 1997). This style includes high volumes of sets and exercises repeated multiple times per week (Weitz, 1997). The average number of reps per exercise, performed by a weight trainer is 6-15, whilst the average number of sets performed per exercise is 4-5 sets (Weitz, 1997).

2.3 Joint biomechanics

Weight training involves movements and exercises in extreme joint positions, combined with heavy weights. To achieve specific goals such as muscular hypertrophy or endurance, muscles need to be continuously challenged by increasing the weight and performing variations of the exercises. Extreme joint positions are known to cause excessive mechanical stress on joints and the surrounding tendons, muscles, and ligaments which may result in, or lead to, injury (Aasa *et al.* 2017).

It has been suggested that abnormal joint alignment, resulting from biomechanical changes can influence joint loads, mechanical efficiency of muscles and proprioceptive feedback from the hip and knee, thereby altering neuromuscular function and control (Nguyen and Shultz 2009: 511). These biomechanical changes affect all the joints in the kinematic chain. As the joints of the lower extremity transfer force from one joint to the adjacent joint, both ends of the chain are fixed. Consequently, any adjustment in angle in one joint results in altered angles in the other joint (Svoboda *et al.* 2016: 37-38).

The hip joint is a complex structure responsible for transferring the weight of the axial skeleton into the lower extremities, whilst allowing for dynamic loading during activities (Bowman, Fox and Sekiya 2010). Consequently, it plays a crucial role in athletic activities during which it is often exposed to many greater than normal axial and torsional forces (Byrne, Mulhall and Baker 2010). This joint receives forces from the upper body and transfers forces to the lower body, thereby playing an important role in the kinematic chain.

The tibiofemoral joint and patellofemoral joint make up the knee joint. One of the main roles of this joint is to transmit, absorb and redistribute forces caused during activities of life (Masouros, Bull and Amis 2010). The knee joint acts as a pivot between the two longest bones in the human body, whilst the strongest muscles in the body act across it (Masouros, Bull and Amis 2010). As a result, the knee joint is influenced and affected by the hip joint above and the ankle joint below.

The ankle joint complex is known to function with a high degree of stability compared to the joints of the hip and knee (Brockett and Chapman 2016).

Joints are governed by various parameters which form its alignment and consequently enable or inhibit motion. Joint motion can be measured in terms of its range of motion or alignment factors, allowing the ability to determine the efficiency of a joint and its surrounding structures.

2.3.1 Joint range of motion

The hip joint is controlled by the acetabulum of the pelvis and the head of the femur, allowing three degrees of freedom in flexion and extension, adduction and abduction and medial and lateral rotation. Weight training exercises require the hip to move primarily into flexion and extension which are controlled by the psoas major, iliacus, rectus femoris and sartorius in flexion, and gluteus maximus and hamstrings into extension. Normal values for hip flexion in males are 110-120 degrees and normal values for hip extension in males are 10-15 degrees (Magee 2014).

Knee joint motion is controlled by tibiofemoral and patellofemoral joints, allowing motion in flexion, extension and rotation. These movements are controlled by hamstrings and quadriceps muscle groups. During squatting the knee joint takes up to seven times the bodyweight (Masouros, Bull and Amis 2010).

The ankle joint complex is made up of the talocalcaneal, tibiotalar and transverse-tarsal joints, allowing movements in plantar and dorsiflexion, abduction and adduction and inversion and eversion. These movements are controlled by the tibialis anterior, triceps surae, gastrocnemius and soleus complex (Brockett and Chapman 2016). The normal value for ankle dorsiflexion in males is 20 degrees (Magee 2014).

2.3.2 Joint Alignment

The lower extremity is made up of a closed kinematic chain, leading to its interdependence between segments. Alignment characteristics may interact with, or cause, compensation at other segments. Biomechanical changes resulting from compensations may influence joint loads, mechanical efficiency of muscles and proprioceptive orientation from the hip and knee joints (Nguyen and Shultz 2009). Abnormal alignment has been proposed as a risk factor for musculoskeletal injuries (Nguyen and Shultz 2009).

2.3.2.1 Hip

Craig's test in the hip is used to measure femoral anteversion, which is the degree of forward projection of the femoral neck in the frontal plane (Choi and Kang 2015). An increase in femoral anteversion can potentially increase hip adduction and knee abduction, thereby influencing the Q angle in the knee (Choi and Kang 2015). ACL injury in the knee has been seen as the biggest risk factor for malalignment in the hip as increased anteversion results in decreased congruity of the hip joint, and consequently excessive internal hip rotation and knee valgus (Kaneko and Sakuraba 2013). The normal values for this test in a male are 8-15 degrees (Magee 2014).

2.3.2.2 Knee

The quadriceps angle (Q angle) is an angle formed between two lines. The first connects the ASIS to the centre of the patella and the second connects the centre of the patella to the tibial tuberosity (Nguyen and Shultz 2009). This angle is 13 degrees in males (Magee 2014). An increased Q angle, coupled with an increased femoral anteversion, is a risk factor for ACL injury. It is also a risk factor for patellofemoral syndrome and plantar fasciitis.

Tibial rotation is the axial or transverse plane alignment of the shank segment of the lower extremity (Davids and Davis 2007). Excessive tibial internal rotation can disrupt the shock absorption function of the foot (Davids and Davis 2007) and cause increased femoral anteversion (Kaneko and Sakuraba 2013).

2.3.2.3 Ankle

Hindfoot alignment - The leg to heel alignment assesses the subtalar joint to identify a varus or valgus. Hindfoot malalignment has been identified as risk factors for ankle sprains, stress fractures and tendinitis (Ohnishi *et al.* 2018).

Forefoot alignment - Forefoot to heel alignment is tested to identify varus or valgus.

Feiss line - Also known as the navicular drop test, is used to identify the position of the navicular and the medial longitudinal arch. Different arch structures have been associated with a greater incidence of ankle injuries, stress fractures, and iliotibial band friction syndrome (Sporndly-Nees *et al.* 2011).

2.4 Techniques of weight training

Weight training involves the upper and lower extremities. Depending on the muscles being targeted, different exercises are performed. This study looks at the lower extremities, hence only the important exercises pertaining to the lower extremities will be discussed.

2.4.1 Exercise Techniques

2.4.1.1 The Squat

The squat begins with the lifter in an upright position and the knees and hips fully extended. The lifter then squats down by flexing at the hip, knee and ankle joints to the desired squat depth, thereafter the lifter reverses direction and ascends back to the upright position (Schoenfeld 2010: 3497). This exercise is usually performed weighted, with a barbell balanced on the lifter's back or holding a dumbbell in front of the lifter's chest. The hips, knees and ankles are loaded in a flexed position. Decreased range of motion in the hip, knee or ankle joint would not allow the lifter to adequately squat to a depth that allows the femur to be parallel to the ground, which consequently places stress on the surrounding musculature (Schoenfeld 2010).

2.4.1.2 The Leg Press

The leg press is a machine which involves an inclined seated area, which has a plate in front. The lifter seats himself and places both feet on the plate, shoulder width apart. In this position, the hip, knee and ankle joints are flexed. The lifter pushes the plate, thereby extending his knees and ankles and then returning to the flexed position. A lifter with a flatfoot, abnormal forefoot or hindfoot is at risk of plantar fasciitis, tendinitis and joint dysfunctions.

2.4.1.3 The Lunge

The lunge begins with the lifter in an upright position, the lifter steps forward with one leg, lowering their hips until both knees are flexed at 90 degrees. The leg that is forward maintains a hip flexion and the opposite side, hip extension. The lifter returns to the starting position and repeats this movement on the opposite leg in a dynamic sequence. Hip range of motion is important in maintaining stability during this exercise (Noh *et al.* 2019).

2.4.1.4 The Deadlift

A conventional deadlift begins with the lifter in a hip hinged position, the hips and knees in flexion. The lifter grasps the bar, shoulder width apart, whilst maintaining a neutral spine. The bar is lifted off the ground, the hips and knees move into extension for a moment before the bar is set back down and returning to the original position.

2.5 Musculoskeletal injuries

2.5.1 Definition of an injury

A musculoskeletal injury can be defined as harm caused to muscles, nerves, tendons, joints, cartilage and/or spinal discs, via external forces or stimulus, thereby causing discomfort to an individual. Common injuries associated with weight training include joint dysfunction, myofascial syndromes, sacroiliac joint syndrome, piriformis syndrome, patellofemoral syndrome, plantar fasciitis, Achilles tendinitis, ligament and tendon injuries.

2.5.2 Epidemiology of injuries in weight training

Across the weight training sports the five most injured sites are shoulder, lower back, knee, elbow, and wrist/hand; with strain, sprains and tendinitis being the most common injury types (Keogh and Winwood 2017). Injury rates of 1-2 injuries per athlete per year and 2-4 injuries per 1000 h of training (Keogh and Winwood 2017).

2.5.3 Types of musculoskeletal injuries

2.5.3.1 Hip joint

The hip joint is involved in flexion movements in the majority of the exercises performed, such as the squat, deadlift, leg press and lunge, therefore adequate hip flexion range of motion is important. Poor motion can be because of, or result in, joint dysfunction or restriction, sacroiliac joint syndrome, piriformis syndrome and/or myofascitis of surrounding musculature.

2.5.3.2 Knee joint

Injuries to the knee joint include patellofemoral joint syndrome, ligament strains and myofascitis of surrounding musculature. Knee flexion and tibial rotation during exercises like squats and deadlifts increase the tension on the joint itself, and hamstrings and quadricep muscle groups. The knee joint is one of the most commonly injured joints amongst the weight training population (Aasa *et al.* 2017).

2.5.3.3 Foot/ankle joint

The foot/ankle joint is prone to injuries like plantar fasciitis, Achilles tendinitis, joint dysfunction and myofascial syndromes. During weight training the foot/ankle joint is involved in dorsiflexion ROM. Poor foot alignment and posture can inhibit ROM or negatively influence it, leading to risk of injury.

2.5.4 Risk factors for MSK injury

Heavy lifting is a well-known risk factor for injury in the general population. This, coupled with the demands of balance and co-ordination, leads to the assumption that the risk of injury is high (Aasa *et al.* 2017: 214). Factors that may contribute to injury include joint alignment – including factors such as asymmetries, biomechanical factors, and anatomical discrepancies - and range of motion abnormalities. Other factors such as poor technique, faulty training, and overuse may contribute to injury. External contributors to injury include environmental, dietary and emotional factors.

2.5.4.1 Range of motion

Range of motion in a joint refers to the ability of the joint to move to its maximum capacity without experiencing pain in or around the joint. When ROM is inhibited, exercises will not be performed at optimal levels.

2.5.4.2 Alignment

Joint malalignment influences all segments in the kinematic chain. The hip joint is influenced by knee internal or external rotation and the foot/ankle joint influences the knee joint by the movements of pronation and supination. The closed kinematic chain of the lower limbs allows it to influence and affect each other, its alignment, and interaction between muscle and fascia.

2.6 Conclusion

Recreational weight training, whilst different from competitive weight training, still holds a risk for MSK injuries. Changes in range of motion and anatomical alignment of the lower extremity has been proposed as a risk factor for acute and chronic lower extremity musculoskeletal injuries such as ACL injuries, patellofemoral syndrome, and plantar fasciitis (Nguyen *et al.* 2009: 202; Kaneko and Sakuraba 2013: 1215). Lower extremity malalignment influences the load distribution on the joints, mechanical efficiency of the muscles and proprioceptive orientation and feedback from the hip and knee, resulting in altered neuromuscular function and control of the lower extremities (Choi and Kang 2015: 1141). Malalignment can be the result of changes in biomechanical measurements, specifically the degree of hip flexion and extension, femoral torsion, quadriceps angle, tibial rotation, leg length discrepancy and ankle alignment.

There are various intrinsic and extrinsic factors which contribute to MSK injury. Anatomical alignment, amongst others, is regarded as an intrinsic factor (Murphy, Connolly and Beynnon 2003: 22). Aasa *et al.* (2017: 211) stated that heavy loads in extreme joint positions had been suggested as a risk factor for injuries. Other factors include training frequency, intensity, volume, muscle strength, stability, and foot morphology.

3. Chapter Three: Methodology

3.1 Introduction

This chapter includes detailed information about the procedures used while conducting the study. This includes study design, participant recruitment, data collection and data analysis.

3.2 Methodological flow

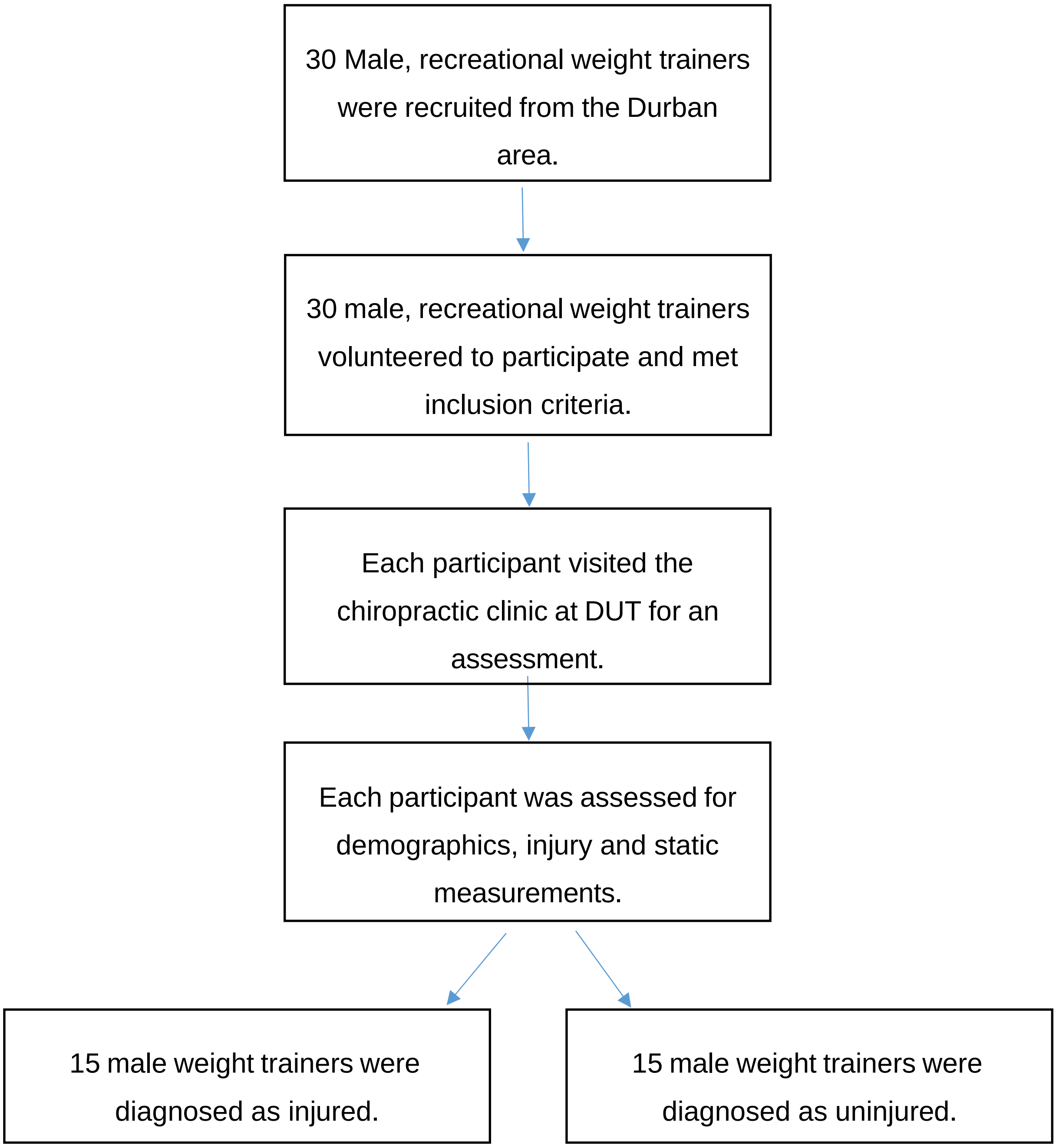

Figure 1: Methodological flow diagram

3.3 Study Design

This study was a quantitative, non-experimental, observational study, determining biomechanical parameters of the joints of the lower extremity i.e., hip, knee and ankle joints. Data collection was carried out at the Durban University of Technology, Chiropractic Day clinic.

3.4 Study population

This study investigated 30 male recreational weight trainers, between the ages of 18-35, from various fitness centres within the greater Durban area. All the participants were recreational weight trainers who fulfilled the inclusion criteria. Participants were chosen irrespective of injury to the lower extremity.

3.5 Permission to conduct study

Permission to conduct this study was obtained from the following sources:

- Permission to utilise the DUT clinic from the Clinic Director (Appendix J).
- Permission from research director at DUT (Appendix K).

3.6 Sample size

In an email communication on 3 June 2021, statistician Tonya Esterhuizen suggested using a sample size of 30 male recreational weight trainers in the study.

3.7 Sampling and recruitment

Non-probability purposive sampling was used to select weight training participants. Advertisement posters (Appendix A) were placed in various gyms and fitness centres to recruit participants. Participants were recruited through the following means: a) placing of adverts at the centre (Appendix A) and b) the researcher verbally communicating with the weight trainers in the study. Participants who wished to participate, contacted the researcher who then interviewed the participant to determine eligibility for the study (Appendix D).

3.8 Criteria for participation in the study

Upon completion of the telephonic interview (Appendix D), it was determined whether the weight trainers met the criteria to be included in the study and were therefore eligible to participate. The criteria were as follows:

3.8.1 Inclusion criteria

- Participants must sign the letter of informed consent, to ensure they understand what the study entails (Appendix B).
- Participants must be male, to ensure homogeneity in the sample, due to gender differences found in the pelvis which alter the kinematic chain (Choi and Kang 2015: 1141).
- Participants must be between the ages of 18-35, to ensure no age-related changes affect the results.
- Participants must be weight training for a minimum 6-month duration, in order to term them recreational weight trainers.
- Participants must be weight training at minimum 3 times per week and lower extremity weight training at least once per week, to ensure that the results are true for a weight trainer.

3.8.2 Exclusion criteria

- Participants who have taken part competitively in any weight training division will be termed competitive weight trainers.
- Participants with any congenital musculoskeletal anomaly affecting their lower extremity will be excluded.
- Participants with a history of surgery to their lower extremities will be excluded from participating in the study. This is due to the possible effects of surgery on the accuracy of measurements to be taken.
- Participants with fractures, dislocations, or direct trauma to the lower extremity will be excluded because these injuries can impact the measurements to be taken.

3.9 Allocation

Once adverts were placed, participants contacted the researcher to participate in the study. Eligibility of participants was determined via a telephonic interview (Appendix D). Once the participant met the requirements for the study, an appointment was made at the Durban University of Technology Chiropractic Day Clinic. Upon arrival at the clinic, each participant went through the following procedure: an informed consent was read and signed (Appendix B), a case history was taken (Appendix E), a physical exam (Appendix F) was performed, a hip regional exam (Appendix G), a knee regional exam (Appendix H) and an ankle regional exam (Appendix I) were completed, and the relevant measurements recorded (Appendix C2).

Data was collected regarding the participants' demographics (age, height, weight) during the physical exam and recorded (Appendix C1). All the participants formed one group, with subgroup analysis related to the presence or absence of injury. Participants did not receive any treatment, however, they received a treatment voucher upon completion, as gratuity.

3.10 Measurement tools

3.10.1 Biomechanical measurements

3.10.1.1 Universal goniometer

The universal goniometer is a protractor (180° or 360°) that has one axis that joins two arms. One of these arms is stationary, while the other is movable around the axis of the protractor (Clarkson 2005).

The universal goniometer is an affordable and easily accessible tool for measuring joint range of motion and biomechanical measurements. It is more reliable than a visual estimation of joint range of motion and intra-tester reliability is superior to inter-tester reliability (Clarkson 2005).

3.10.1.2 Tape measure

The use of a tape measure is an easy, safe, and non-invasive means of assessing LLD. Although it is less reliable compared to radiographic techniques, it appears to have acceptable validity and reliability when used as a screening tool for assessing LLD (Sabharwal and Kumar 2008: 2918).

3.10.2 Measurements

3.10.2.1 Hip measurements

3.10.2.1.1 Hip flexion (passive)

This parameter measures flexion range of motion at the hip joint. Using a goniometer to measure, the normal value for passive hip flexion is 120 degrees (Clarkson 2005: 148). Reduced hip flexion values can lead to joint restriction or dysfunction and when hip flexion values are increased it can lead to joint instability and ligament laxity.

3.10.2.1.2 Hip extension (passive)

This parameter measures extension range of motion at the hip joint. Using a goniometer, the normal value for passive hip extension is 30 degrees (Clarkson 2005: 149). Decreased hip extension range of motion may cause joint restriction or dysfunction, whilst increased hip extension may lead to joint instability.

3.10.2.1.3 Craig's test (Femoral torsion angle)

Craig's test measures femoral anteversion or forward torsion of the femoral neck. Anteversion of the hip is measured, using a goniometer, by the angle made by the femoral neck with the femoral condyles. It measures the degree of forward projection of the femoral neck from the coronal plane of the shaft. The normal range is 8-15 degrees (Magee 2014: 710). Abnormal femoral anteversion values can affect knee joint kinematics, causing patellofemoral syndrome, sacroiliac joint syndrome and piriformis syndrome.

3.10.2.2 Knee measurements

3.10.2.2.1 Quadriceps Angle

The Q angle is the angle between the quadriceps muscle and the patella tendon (Magee 2014: 729). The Q angle is measured using a goniometer. The normal angle for males is 13 degrees (Magee 2014: 848). Abnormal Q angle measurements may lead to patellofemoral syndrome, hip dysfunction and foot pronation.

3.10.2.2.2 Tibial torsion test

Tibial torsion refers to the degree of rotation of the tibia. Tibial torsion of 13-18 degrees is usually present in adults (Magee 2014: 930). Abnormal tibial torsion values can lead to hip and knee joint dysfunction.

3.10.2.3 Foot/ankle measurements

3.10.2.3.1 Ankle dorsiflexion (non-weight-bearing)

This test measures the dorsiflexion range of motion at the talocrural joint. It is measured using a goniometer, with the normal value for ankle dorsiflexion being 20 degrees (Clarkson 2005: 202). Increased dorsiflexion range of motion may lead to joint instability, and decreased dorsiflexion range of motion may lead to joint dysfunction.

3.10.2.3.2 Feiss line (Navicular drop test)

This test is used to assess the height of the medial arch, using the navicular position (Nielsen *et al*. 2009). Based on the height of the navicular, it represents first, second or third-degree flatfoot (Magee 2014: 929). Flat-footedness is linked to ankle/foot pronation which may cause plantar fasciitis and joint dysfunction.

3.10.2.4 Alignment tests

These are used to determine the relation of the leg to the hindfoot and the relation of the hindfoot to the forefoot. They determine varus and valgus of the forefoot and hindfoot (Magee 2014: 929). Varus and valgus abnormalities may cause conditions like Achilles tendinitis, plantar fasciitis and flatfoot.

3.10.2.4.1 Hindfoot heel alignment

Hindfoot heel alignment is assessed by the vertical bisector of the calcaneus in relation to the inferior surface of the heel. This test assesses if the hindfoot is in a normal, valgus or varus position.

3.10.2.4.2 Forefoot heel alignment

Forefoot heel alignment assesses the relationship of the line of the metatarsal heads to the inferior surface of the heel. This test assesses if the forefoot is in a normal, valgus or varus position.

3.10.2.5 Functional leg length discrepancy

Leg length discrepancy is the result of compensation for a change that may have occurred due to positioning rather than structure. It is the measurement from the umbilicus to the medial malleolus, using a tape measure (Magee 2014: 719). LLD may be caused by sacroiliac joint syndrome and hip joint dysfunction.

3.11 Study procedure

Each participant was required to answer a set of questions, telephonically (Appendix D), to determine eligibility for the study. Once accepted, the participant was booked a date and time at the chiropractic clinic. This appointment was conducted in a private room. The participant was required to sign a letter of informed consent (Appendix B) and the procedure was then explained by the researcher.

A case history (Appendix E) was taken, a physical examination (Appendix F) was performed and three regional examinations (hip, knee and ankle), (Appendices G, H, I) were completed.

The researcher then recorded measurements in the hip (range of motion, in flexion and extension, Craig's test), in the knee (quadriceps angle and tibial torsion test) and in the ankle (range of motion, Feiss line, hindfoot and forefoot heel alignment) and leg length discrepancy.

The researcher used a goniometer, which is a tool used to measure joint movements and a tape measure. The participant was directed into specific positions and movements to get an accurate measurement.

The biomechanical measurements were measured bilaterally. Each measurement was repeated and recorded three times and the average measurement calculated. All measurements were recorded on the measurement data sheet (Appendix C2).

Each participant was given a treatment voucher at the end of the study as gratitude for their time. Participants were not aware of this voucher prior to entering the study.

3.11.1.1 Hip measurement procedures

3.11.1.1.1 Hip flexion (passive)

The participant was positioned supine on the examination table, the researcher passively flexed the participant's hip as far as possible with the opposite leg extended. The goniometer was centred at the greater trochanter, aligning one arm along the centre of the thigh and the other arm aligned horizontally (Cheatham, Hanney & Kolber 2017: 766). The degree of hip flexion was read and recorded.

3.11.1.1.2 Hip extension (passive)

The participant was positioned in a side lying position on the examination table with the test extremity facing upward. The lowermost extremity was flexed at the hip to 45 degrees and at knee to 90 degrees. The researcher passively extended the hip with knee straight as far as possible. The goniometer was centred at the greater trochanter aligning one arm of the goniometer over the centre of the thigh and the other arm along a zero-degree position (Cheatham, Hanney & Kolber 2017: 767). The degree of hip extension was read and recorded.

3.11.1.1.3 Craig's test (Femoral torsion test)

The participant was positioned in a prone position on the examination table with the knee in 90-degree flexion. The researcher was standing on the contralateral side, and internally and externally rotated the participant's hip on the side being tested, while simultaneously palpating the greater trochanter on the same side. When the greater trochanter was parallel to the table at its most lateral position, the researcher used a goniometer to measure the angle between the true vertical and the long axis of the tibia (Magee 2014: 710).

3.11.1.2 Knee measurement procedures

3.11.1.2.1 Quadriceps angle (Q angle)

The participant was positioned in the supine position, with the hips and knees in extension, and the quadriceps muscle in a relaxed position. A line was drawn from the ASIS to the midpoint of the patella on the same side and from the tibial tubercle to the midpoint of the patella. The angle formed was measured and recorded (Magee 2014: 848).

3.11.1.2.2 Tibial torsion

The participant was positioned prone on the examination table with the knee flexed to 90 degrees. The researcher viewed from above the angle formed by the foot and thigh after the subtalar joint had been placed in the normal position, noting the angle the foot made with the tibia (Magee 2014: 930).

3.11.1.3 Foot/ankle measurement procedures

3.11.1.3.1 Ankle dorsiflexion (non-weight-bearing)

The participant was positioned supine on the examination table, with a towel placed under the knee to relax the gastrocnemius and the ankle in the anatomical position of 0 degrees. The axis of the goniometer was placed inferior to the lateral malleolus. The stationary arm of the goniometer was positioned parallel to the longitudinal axis of the fibula, pointing towards the fibula head. The moveable arm was positioned parallel to the fifth metatarsal. The participant was then asked to flex the ankle into maximal dorsiflexion and the researcher adjusted the moveable arm so that it was parallel to the fifth metatarsal again. The reading was taken and recorded as the degree of non-weight-bearing ankle dorsiflexion (Clarkson 2005: 202).

3.11.1.3.2 Feiss line (Navicular drop test)

With the participant non-weight-bearing on the foot being tested, the researcher marked the apex of the medial malleolus, the plantar aspect of the first MTP joint and the navicular. A line was drawn between these three points. The navicular was palpated on the medial aspect of the foot, and an assessment was made as to the position of the navicular relative to the line. The participant was asked to weight-bear on the foot being tested and the navicular height was assessed again and recorded (Nielsen, *et al.* 2009).

3.11.1.3.3 Hindfoot heel alignment (Non-weight-bearing)

The participant was positioned prone on the examination table with the foot extending over the end of the table. The researcher located the widest portion of the gastrocnemius and marked it, then the widest portion of the Achilles tendon was located and marked. The researcher joined these two points. A third mark was made at the calcaneal ridge. A line was joined from the Achilles to the calcaneal ridge. The angle between these two lines was measured and recorded (Magee 2014: 929).

3.11.1.3.4 Forefoot-heel alignment (Non-weight-bearing)

The participant was positioned prone on the examination table with the foot extending over the end of the examination table. The researcher maintained the foot in subtalar neutral, using two rulers. One ruler followed the under surface of the heel while the other followed the first to fifth metatarsal heads. The angle between the rulers was measured and recorded (Magee 2014: 929).

3.11.1.3.5 Functional leg length discrepancy

The participant was positioned supine on the examination table. The researcher measured the distance from the umbilicus to the medial malleolus, using a tape measure, which was recorded (Magee 2014: 721).

3.12 Data analysis

The statistical analysis was performed using Stata version 16. For normally distributed continuous variables the mean and 95% CI were done. The Shapiro Wilk test was used to test for normality. For not normally distributed variables, median and interquartile range were performed. As the sample size of this study is small, statistician Tonya Esterhuizen suggested using Fisher's exact test to assess the association between two categorical variables.

3.13 Ethical issues

3.13.1 Informed consent

Each participant was given a simple but thorough document stating the details and procedure of the study so they would be able to make an informed decision about taking part in the research (Berg and Latin 2004: 16-17).

3.13.2 Confidentiality

Only the researcher and those involved in gathering the research information have access to knowledge, or knowledge of the identity of the subjects and their related information. This is to ensure anonymity (Berg and Latin 2004: 19).

3.13.3 Gym consent

Verbal consent was given by relevant gyms to advertise.

3.13.4 Autonomy

The procedure of the study was explained to each participant and participants could choose to withdraw from the study at any point in time.

3.13.5 Justice

Non-probability convenience sampling was used in participant selection.

3.13.6 Non-maleficence

There was no health or physical risks placed on the participant and they were not harmed in any way.

3.13.7 Benevolence

Participants received a treatment voucher at the end of the study, as a form of gratuity.

4. Chapter Four: Results

4.1 Introduction

This chapter includes a review of the objectives of the study and presents the results of the study. The discussions related to each finding will be presented in Chapter 5.

The statistical analysis was performed using Stata version 16. For normally distributed continuous variables the mean and 95% CI were done. The Shapiro Wilk test was used to test for normality. For not normally distributed variables, median and interquartile range were performed. As the sample size of this study is small, Fisher's exact test was used to test the association between two categorical variables. BMI of the participants was evaluated with the cut-off points: <18.5 kg/m2 underweight, 18.5-24.9 kg/m2 healthy weight, 25.0-29.9 kg/m2 overweight, and ≥30 kg/m2 obese.

4.2 Descriptive data

The total sample of weight trainers that participated in the study was 30 (n =30). The ages ranged from 18-39 years old, and the average age of participants was 25 with 95% CI (23, 27). The average height was 1.77 meter with 95% CI (175.2, 179.8) (Table 2). The BMI result indicated that there was no participant who fell in the category of underweight. Only 16.7% (5) of them were obese (Table 3). Based on the Shapiro Wilk test (SWilk), age and height were found to be normally distributed with *p-value* 0.053 and 0.99 respectively (Table 1).

Table 1: Normality test using Shapiro Wilk test

Variables	**Obs**	***p-value***
Age	30	0.05329
Height	30	0.99842
Weight	30	0.00248

Table 2: Mean, median and confidence interval of physical measurement

Variables	**Mean**	**Std. Err.**	**95% CI**	
Age	24.86667	0.807627	(23.2, 26.5)	
Height	177.5333	1.115959	(175.2, 179.8)	
Variable	**Median**	**Min**	**Max**	**IQR**
Weight	79.5	64	135	17

Table 3: BMI of participants

BMI	Freq.	Percent
Healthy	13	43.33
Overweight	12	40
Obese	5	16.67

4.3 Biomechanical parameters

The first objective was to establish lower extremity static biomechanical parameters of the hip (flexion, extension and Craig's test), knee (quadriceps angle and tibial torsion test), ankle (dorsiflexion, Feiss line, hindfoot and forefoot alignment), and the leg length discrepancy of male recreational weight trainers. The measurements for each of the joints were categorised into high, low or normal measurements for the hip, knee and ankle joints. The ankle/foot measurements were also categorised into varus, valgus or normal, as well as the degree of flatfoot.

Tables 4, 5 and 6 below show the frequency and percentage of participants in each category for each measurement. For the foot/ankle, the measurements are divided into range of motion, alignment and foot posture. Figures 2 - 6 show a visual representation of the data obtained as well as reporting for each joint.

4.3.1 Biomechanical parameters of the hip joint

Table 4: Frequency of biomechanical measurements in the hip joint

Variable		**Freq.**	**Percent**
Hip			
Right hip flexion	High	3	10
	Low	13	43.33
	Normal	14	46.67
Left hip flexion	High	2	6.67
	Low	11	36.67
	Normal	17	56.67
Right hip extension	High	0	0
	Low	4	13.3
	Normal	26	86.7
Left hip extension	High	1	3.33
	Low	6	20
	Normal	23	76.7
Right Craig's test	High	0	0
	Low	10	33.3
	Normal	20	66.7
Left Craig's test	High	0	0
	Low	12	40
	Normal	18	60

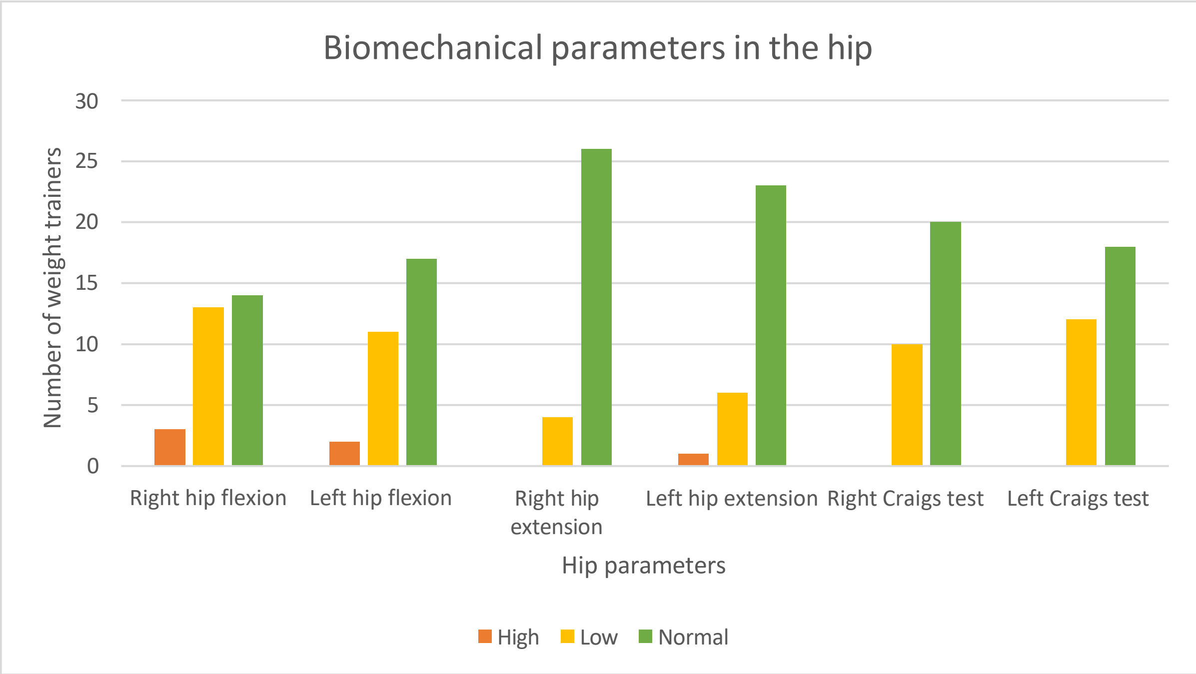

Figure 2: Biomechanical parameters in the hip

Table 4 and figure 2 above, describe the biomechanical measurements taken in the hip which were flexion and extension range of motion as well as Craig's test. The graph provides a visual depiction of the measurements comparing high, low and normal values recorded for each parameter. 36,67% of participants showed low values for right hip flexion whilst the rest of the hip parameters showed normal values.

4.3.2 Biomechanical parameters of the knee joint

Table 5: Frequency of biomechanical measurements in the knee joint

Variable		**Freq.**	**Percent**
Knee			
	High	3	10
Right tibial rotation	Low	7	23.3
	Normal	20	66.7
	High	3	10
Left tibial rotation	Low	5	16.7
	Normal	22	73.3
	High	0	0
Left quadriceps angle	Low	24	80
	Normal	6	20
	High	2	6.7
Right quadriceps angle	Low	16	53.3

	Normal	12	40

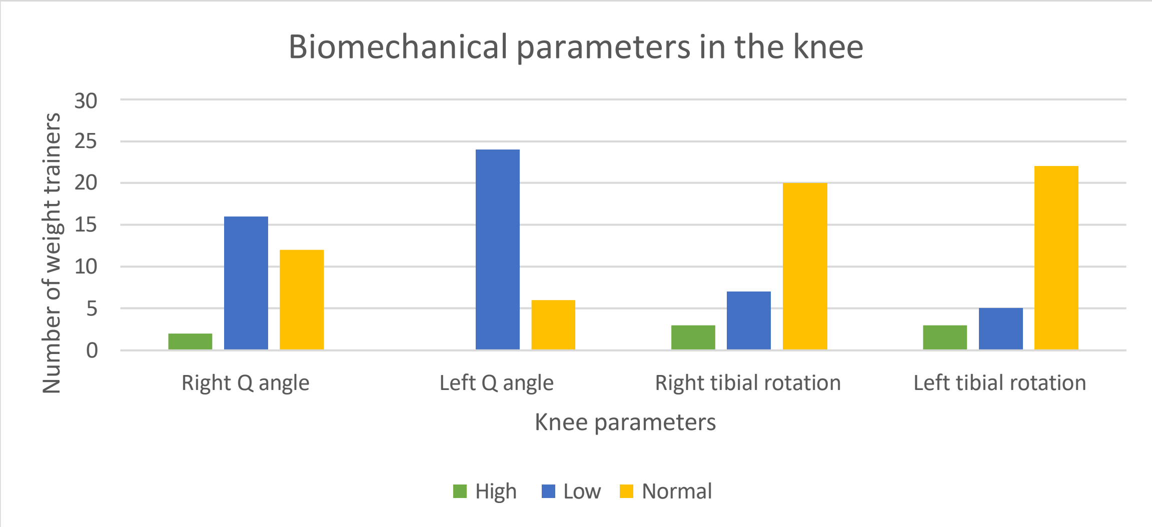

Figure 3: Biomechanical parameters in the knee

Table 5 and Figure 3 above describe the biomechanical measurements recorded for the knee joint, including quadriceps angle and tibial rotation. 53,3% of participants had low right quadriceps angle and 80% had low left quadriceps angle. Right and left tibial rotation shows the majority of participants with normative values.

4.3.3 Biomechanical parameters of the foot/ankle joint

Table 6: Frequency of biomechanical measurements in the foot/ankle joint

Variable		**Freq.**	**Percent**
Foot/Ankle			
Range of motion			
Right ankle Dorsiflexion	High	2	6.67
	Low	11	36.7
	Normal	17	56.7
Left ankle Dorsiflexion	High	1	3.3
	Low	10	33.3
	Normal	19	63.3
Alignment			
Right hindfoot	Varus	15	50
	Normal	11	36.7
	Valgus	4	13.3
Left hindfoot	Varus	14	46.7
	Normal	13	43.3
	Valgus	3	10

Right forefoot	Varus	12	40
	Normal	16	53.3
	Valgus	2	6.7
Left forefoot	Varus	9	30
	Normal	19	63.3
	Valgus	2	6.7
Posture			
Right Feiss Line	Normal	23	76.7
	1/3 flatfoot	5	16.7
	2/3 flatfoot	2	6.7
Left Feiss Line	Normal	23	76.7
	1/3 flatfoot	5	16.7
	2/3 flatfoot	2	6.7

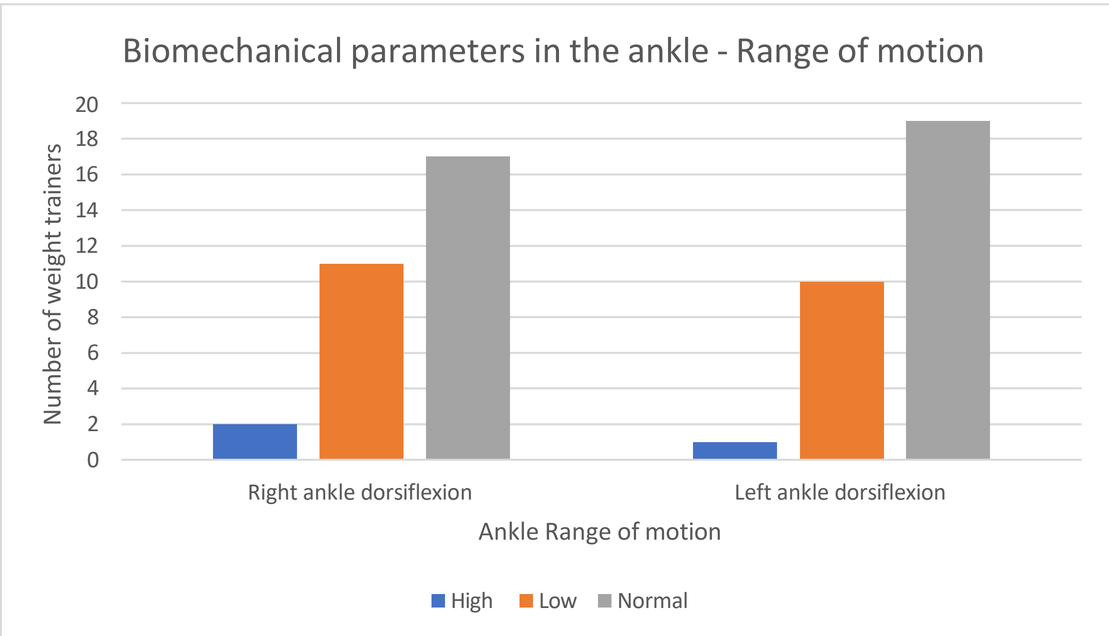

Figure 4: ROM: Biomechanical parameters in the ankle

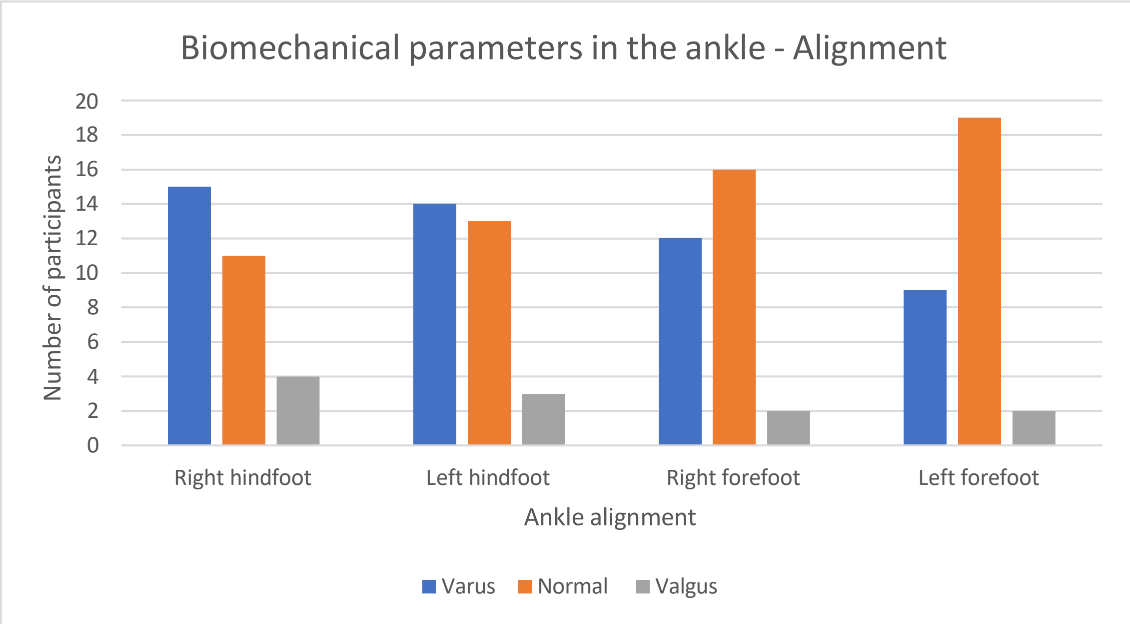

Figure 5: Alignment: Biomechanical parameters in the ankle

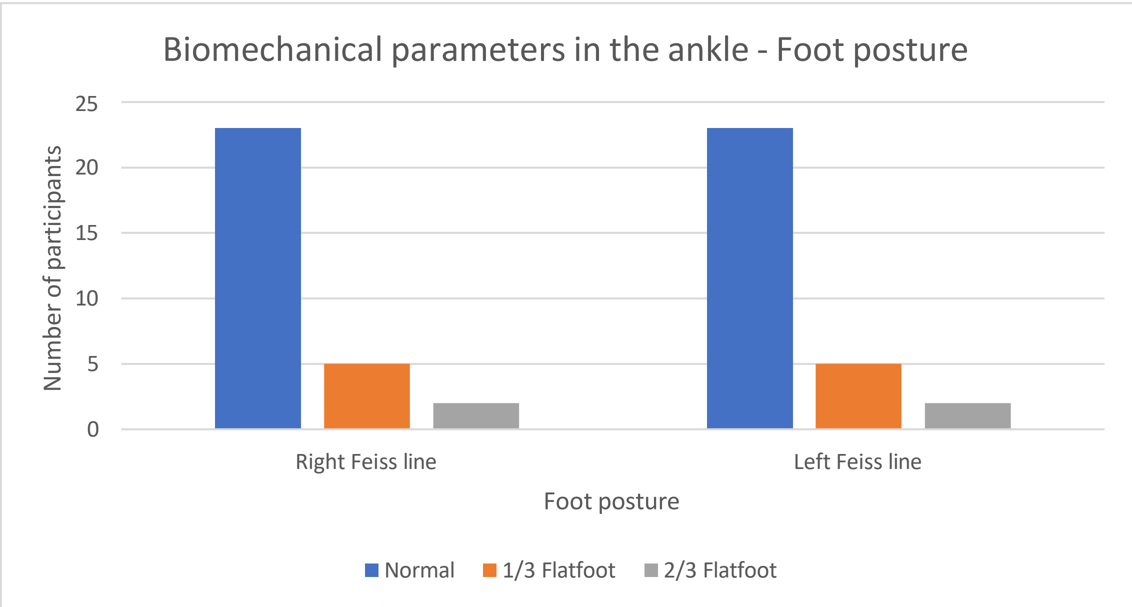

Figure 6: Foot posture: Biomechanical parameters in the ankle

Table 6 and figures 4, 5 and 6 above, present the measurements recorded for the foot/ankle. Three types of measurements were recorded: range of motion (ankle dorsiflexion), alignment (hindfoot and forefoot) and foot posture (Feiss line which indicates the degree of flat-footedness). Figure 5 shows that 50% of participants had a varus right hindfoot and 46,7% had a varus left hindfoot alignment, whilst forefoot alignment, range of motion and foot posture showed majority normal values.

4.3.4 Leg length discrepancy

The biggest leg length discrepancy was found to be 3 cm which occurred in two people. Half of the participants (15) had 1 cm leg length discrepancy and 40% of participants had legs of the same length (Table 7).

Table 7: Leg length discrepancy in cm

Discrepancy in cm	Freq.	Percent
3	2	6.67
2	1	3.33
1	15	50
0	12	40
Total	30	100

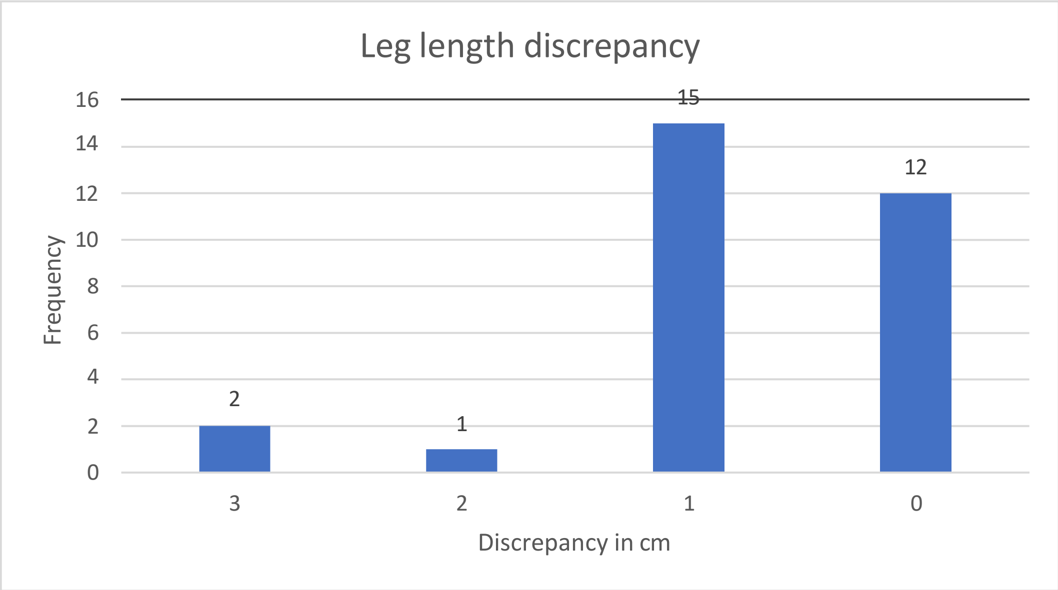

Figure 7: Leg length discrepancy

4.4 Prevalence of injuries

In half of the study participants, the severity of injury was found to be mild and moderate. There was no injury in 15 study participants (50%) (Table 8). The prevalence of injury was thus 50%. Amongst the injured participants, 46.67% had acute and chronic injuries. 16,67% were traumatic injuries and 33.3% were non-traumatic injuries.

Table 8: Prevalence of severity and cause of injury

Variable		**Freq.**	**Percent**
Severity of injury	None	15	50
	Mild	8	26.67
	Moderate	7	23.33
	None	15	50

Duration of injury	Acute	8	26.67
	Sub-acute	1	3.33
	Chronic	6	20
Cause	None	15	50
	Traumatic	5	16.67
	Non-Traumatic	10	33.33

4.5 Associations

The second objective was to establish whether an association exists between the above-mentioned parameters and musculoskeletal injuries in the lower extremities of male recreational weight trainers. Fisher's exact test was used to see the association between biomechanical measurement and the existence of injury. Accordingly, Fisher's exact test with *p-value* 0.036 indicated that there was enough evidence of association between right quadriceps angle and injury. The injured participants were more likely to have a low right quadriceps angle. However, the rest of the biomechanical measurements had no association with injury as the *p-value* was more than 0.05. (Table 9).

Table 9: Fisher's exact test showing association between biomechanical measurements and MSK injuries

Variable	Category	Non-injured Freq (%)	Injured Freq (%)	Total Freq (%)	*p-value*
Right hip flexion	High	0 (0)	3 (100)	3 (100)	0.324
	Low	7 (53.8)	6 (46.2)	13(100)	
	Normal	8 (57.1)	6 (42.9)	14(100)	
Left hip Flexion	High	0(0)	2(100)	2 (100)	0.284
	Low	7 (63.6)	4(36.4)	11(100)	
	Normal	8 (47.1)	9(52.9)	17(100)	
Right hip extension	Low	2 (50)	2(50)	4(100)	1.00
	Normal	13 (50)	13(50)	26 (100)	
Left hip extension	High	0 (0)	1(100)	1 (1.00)	1.00
	Low	3(50)	3(50)	6(100)	
	Normal	12(52.2)	11(47.8)	23(100)	
Right Craig's test	Low	6(60)	4(40)	10 (100)	0.700
	Normal	9(45)	11(55)	20(100)	
Left Craig's test	Low	5(41.7)	7(58.3)	12 (100)	0.710
	Normal	10 (55.6)	8(44.4)	18(100)	
Right tibial rotation	High	0 (0)	3(100)	3 (100)	0.284
	Low	4 (57.1)	3(42.)	7(100)	
	Normal	11(55)	9(45)	20(100)	
Left tibial rotation	High	1(33.3)	2(66.7)	3 (100)	0.727
	Low	2(40)	3(60)	5(100)	
	Normal	12(54.5)	10(45.5)	22(100)	
Right ankle dorsiflexion	High	0(0)	2(100)	2 (100)	0.400
	Low	5(45.5)	6(54.5)	11(100)	
	Normal	10 (58.8)	7(41.2)	17(100)	
Left ankle	High	0(0)	1(100)	1 (100)	1.00
	Low	5(50)	5(50)	10(100)	

dorsiflexion	Normal	10(52.6)	9(47.4)	19(100)	
Right hindfoot	Varus	7 (46.7)	8(53.3)	15 (100)	0.370
	Normal	7(63.6)	4(36.4)	11(100)	
	Valgus	1(25)	3(75)	4(100)	
Left hindfoot	Varus	8(57.1)	6(42.9)	14 (100)	0.324
	Normal	7(53.9)	6(46.1)	13(100)	
	Valgus	0(0)	3(100)	3(100)	
Right forefoot	Varus	8(66.7)	4(33.3)	12(100)	0.161
	Normal	7(43.8)	9(56.2)	16(100)	
	Valgus	0(0)	2(100)	2(100)	
Left forefoot	Varus	5(55.6)	4(44.4)	9 (100)	0.536
	Normal	10(52.6)	9(47.4)	19(100)	
	Valgus	0(0)	2(100)	2(100)	
Right Feiss line	Normal	13 (56.5)	10(43.5)	23(100)	0.477
	1/3 Flatfoot	2(40)	3(60)	5(100)	
	2/3 Flatfoot	0(0)	2(100)	2(100)	
Left Feiss line	Normal	13(56.5)	10(43.5)	23(100)	0.477
	1/3 Flatfoot	2(40)	3(60)	5(100)	
	2/3 Flatfoot	0(0)	2(100)	2(100)	
Leg length discrepancy	0	7(58.3)	5(41.7)	12 (100)	0.536
	1	8(53.3)	7(46.7)	15(100)	
	2	0(0)	1(100)	1(100)	
	3	0(0)	2(100)	2(100)	
Right quadriceps angle	High	0(0)	2(100)	2(100)	0.036
	Low	6(37.5)	10(62.5)	16(100)	
	Normal	9(75)	3(25)	12(100)	
Left quadriceps angle	Low	12(50)	12(50)	24(100)	1.000
	Normal	3(50)	3(50)	6(100)	

5. Chapter Five: Discussion

5.1 Introduction

This study was undertaken to determine the normative values for static biomechanical parameters in male recreational weight trainers and to determine whether there is an association between the static biomechanical parameters and musculoskeletal injury. To draw such conclusions, the following objectives were set:

1. To establish lower extremity static biomechanical parameters of the hip (flexion, extension and Craig's test), knee (quadriceps angle and tibial torsion test), ankle (dorsiflexion, Feiss line, hindfoot, and forefoot alignment), and leg length discrepancy of male recreational weight trainers.

2. To establish whether an association exists between the above-mentioned parameters and musculoskeletal injuries in the lower extremities of male recreational weight trainers.

In this chapter, the results of the previous chapter are discussed with regards to current literature.

5.2 Biomechanical parameters

5.2.1 Hip joint

In the hip joint, flexion and extension range of motion measurements were taken as well as Craig's test which measures the degree of femoral anteversion. The results in figure 2 show that 46,67% of participants had normal right hip flexion range of motion in the hip joint and 56,67% had normal left hip flexion range of motion in the hip joint. Hip extension range of motion was also normal with 86,7% of participants having normal right hip extension ROM and 76,7% of participants having normal left hip extension ROM. For alignment, Craig's test showed 66,7% of participants had normal alignment in the right hip joint and 60% of participants had normal alignment in the left hip joint. Hip range of motion and alignment are crucial in exercises like squats and deadlifts as it allows the lifter to perform movements like a hip hinge and squatting to depth in the exercises. These normative values correspond with other studies showing normal hip ROM in male recreational weight trainers (Cheatham, Hanney and Colber 2017).

Whilst the majority of the sample showed normal values in the hip joint, a large percentage of the sample showed low values for hip ROM. Right hip flexion ROM showed 43,33% of participants with low ROM values and 36,67% had low left hip flexion ROM values.

5.2.2 Knee Joint

In the knee joint, quadriceps angle and tibial rotation measurements were taken. In figure 3 we see that right Q angle and left Q angle showed measurements below normal values. 53.3% of participants had a low right quadriceps angle and 80% had a low left quadriceps angle. The Q angle represents the direction of the quadriceps muscle force vector in the frontal plane. A decreased Q angle can be because of femoral external rotation as the extensor mechanism would be more in line with the ASIS and the tibial tuberosity (Daneshmandi *et al.* 2011). A decreased Q angle is a risk factor for patellofemoral joint syndrome and patellofemoral osteoarthritis. The quadriceps muscle group plays an important role in squats and lunges.

5.2.3 Foot/ankle Joint

In the foot/ankle, measurements were taken in dorsiflexion range of motion, hindfoot, forefoot alignment and degree of flatfoot. Figure 4 shows range of motion with the majority of participants having normal range motion in the ankle joint. Figure 5 shows ankle alignment; 50% of participants presented with a varus right hindfoot alignment and 46.7% with left hindfoot alignment. Forefoot alignment was normal. Figure 6 shows flatfoot, 76.7% of participants did not have a flatfoot, 16.7% had 1st degree flatfoot and 6.7% had 2nd degree flatfoot.

5.2.4 Leg length discrepancy

A leg length discrepancy of 3 cm was found in two participants (6,67%), according to table 6. Leg length discrepancy, found in 40-70% of the population, is defined as a condition in which paired limbs are noticeably unequal (Gurney 2002). The presence of LLD may indicate musculoskeletal dysfunction and has been implicated as an aetiological factor in hip, knee, ankle and foot pain (Gibbons, Dumper and Gosling

2002). The majority of people have differences in leg length, averaging 5.4 mm. A difference of more than 20 mm is clinically significant in contributing to musculoskeletal pathologies (Woodfield *et al.* 2011).

5.3 Association with injury

The second objective examined the association between the abovementioned biomechanical parameters and musculoskeletal injury. Musculoskeletal injuries were divided into acute (26,67%) and chronic (20%). Acute injuries are defined as being present for less than three days and chronic injuries, present for more than three months. Musculoskeletal injuries were found in 50% of the participants (Table 8). This is less than the injuries found in competitive weightlifters, which was found to be 64,2% (Calhoon and Fry 1999), and more than injuries sustained during CrossFit, which was found to be 36.1%. The increased injuries found in weightlifters could be due to the nature of weightlifting which involves intense movements like lifts which are significantly different to recreational weight training movements. CrossFit involves high intensity training with similar types of exercises to recreational weight training. In the bodybuilding division, 44.8% of elite bodybuilders reported having experienced an injury in the last 12 months.

Previous studies have shown that factors that may contribute to injury due to training are muscle fatigue, technical errors, excessive overload of muscles and joints, poor warm-up techniques and poor recovery after training (Keogh and Winwood 2017). Recreational weight trainers, unlike weightlifters and powerlifters, do not necessarily learn technique and form and lack the directive of a coach or trainer. This can make them more susceptible to injuries due to fatigue and training errors.

A decreased right quadriceps angle was associated with injury as seen in Table 9 ($p < 0.05$). Quadriceps angle is the line connecting the ASIS to the centre of the patella and the extension of a line from the tibial tubercle to the same reference point on the patella (Park and Stefanyshyn 2011: 392). This angle is 13 degrees in males (Magee 2014: 848). The Q angle plays an important role in determining the biomechanical function of the lower extremity and the alignment of the hip, leg and foot (Charrette 2017). A decreased Q angle could be attributed to height. Whilst demographics and measurements were not correlated in this study, previous studies (Khasawneh, Allouh and Abu-El-Rub 2019) have shown that Q angle is significantly smaller in taller persons. The average height was 1.77 meters with 95% CI (175.2, 179.8) (Table 2). The quadriceps muscle also plays an important role in the evaluation of the Q angle. Previous studies have shown that quadriceps contraction had a corollary on the Q angle values by affecting the position of the patella (Khasawneh, Allouh and Abu-El-Rub 2019). Males generally have stronger quadriceps muscles, leading to lower Q angles.

5.4 Conclusion

Static biomechanical parameters of the hips, knees and ankles were studied to determine the association with musculoskeletal injuries in male recreational weight trainers in the Durban area. Thirty participants were recruited to participate in the study (n=30). The average age of participants was 25 (95% CI) and the average height was 1,77m (95% CI). Of the thirty (n=30) participants, 15 participants (50%) were diagnosed as having a musculoskeletal injury.

The first objective recorded the biomechanical parameters in the hip, knee and ankle joints. The biomechanical parameters that showed significant differences in measurements in the weight training population was in the knee, with quadriceps angle showing low measurements and in foot/ankle hindfoot alignment, showing varus alignment.

The second objective established an association between the biomechanical parameters and MSK injuries. The only association found was between right quadriceps angle and musculoskeletal injury. The rest of the biomechanical parameters showed no significant association with musculoskeletal injury.

In conclusion, the findings of this study may help provide empirical information to support anecdotal suggestions of associations between biomechanical parameters and musculoskeletal injury in male recreational weight trainers. The results of this study suggest right quadriceps angle as a risk factor for musculoskeletal injury in weight trainers. This can potentially help practitioners, sports therapists and clinicians in diagnosing and treating musculoskeletal pain in recreational weight trainers.

6. Chapter Six: Limitations and recommendations

6.1 Conclusion

It can be concluded that alterations in right quadriceps angle of the knee can be associated with lower extremity musculoskeletal injuries in male recreational weight trainers.

6.2 Limitations

- This study was limited in that the objectives only looked at the associations between biomechanical measurements and injury, and not causation of injuries.
- The study is limited to data for the lower extremities in males only, which is not representative of the entire weight training population, which includes females.
- The use of a tape measure and goniometer for the joint measurements were subjective, which may have caused inaccuracy in the measurements and associations with injury.
- Due to the COVID-19 pandemic the sample size was reduced.

6.3 Recommendations

6.3.1 Methodological recommendations

- Future studies should make use of more reliable and accurate measurement tools to ensure more accurate measurements.
- Females should be included in future studies to compare the differences as there are different injury risk factors affecting them.
- A larger sample size should be used to achieve a more accurate representation of the population.

6.3.2 Recommendations for future studies

- This study can be investigated further by looking at injury causes and prevention.
- Further research can be done into the epidemiology of recreational weight training injuries.

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APPENDIX A

Are you a

Male weight trainer

Between the ages of

18-35?

Research is being conducted at the Durban University of Technology Chiropractic Day clinic

For more information and to participate, please contact Fahmeeda on 083 256 5347

DUT DURBAN UNIVERSITY OF TECHNOLOGY INSTITUTIONAL RESEARCH ETHICS COMMITTEE

LETTER OF INFORMATION

Title of the Research Study: The association between static biomechanical parameters and musculoskeletal injury in the lower extremities in male recreational weight trainers.

Principal Investigator/s/researcher: Fahmeeda Makada, B. Tech Chiropractic.

Co-Investigator/s/supervisor/s: Dr. G. Matkovich, M.Tech Chiropractic.

Brief Introduction and Purpose of the Study: Musculoskeletal injury is common in weight trainers. Injury to the joints of the lower extremity can be associated with abnormal biomechanical factors. These factors can cause injury at that joint or other joints in the lower extremity. The aim of this study is to determine if biomechanical parameters can be associated with musculoskeletal injuries.

Outline of the Procedures: You as the participant will be required to answer several questions, telephonically, in order to determine eligibility for the study. Once accepted, you will be booked a date and time at the Chiropractic clinic. This appointment will be conducted in a private room. You will be required to sign an informed consent and the procedure will then be explained to you by the researcher. A case history, physical examination and 3 regional examinations (hip, knee and ankle) will be completed. The researcher will then collect data regarding the demographics and injury characteristics, thereafter the relevant measurements will be taken. The researcher will use a goniometer, which is a tool used to measure joint movements and a tape measure. You, the participant will be directed in to specific positions and movements in order to get an accurate measurement. This is a once off session and you are not required to come back for a follow up. Approximate time for the whole session: 2-3 hours. No treatment or interventions will be administered.

Risks or Discomforts to the Participant: There will be no health risks. The taking of the measurements may be mildly uncomfortable, due to the different positions required, but you may report any discomfort to the researcher at any time.

Reason/s why the Participant May Be Withdrawn from the Study: You may withdraw from the study at any point in time.

Costs of the Study: You will incur travelling costs for the trip to the Chiropractic day clinic.

Confidentiality: Confidentiality will be maintained, as data collection will be anonymous and no names will be recorded on the data collection sheets.

Persons to Contact in the Event of Any Problems or Queries:
Please contact the researcher (0832565347), my supervisor (0312018204) or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the DVC: Research, Innovation and Engagement Prof S Moyo on 031 373 2577 or moyos@dut.ac.za.

APPENDIX B

CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, ____________(Fahmeeda Makada), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

________________________ ____________ _______ __________________

Full Name of Participant **Date** **Time** **Signature / Right Thumbprint**

I, ________________ (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

____________________ ____________ ______________________

Full Name of Researcher **Date** **Signature**

____________________ ____________ ______________________

Full Name of Witness (If applicable) **Date** **Signature**

__________________ __________ ____________________

Full Name of Legal Guardian (If applicable) **Date** **Signature**

APPENDIX B

APPENDIX C1

Demographic and injury Data Collection sheet
Participant number:____________

1. Age			
2. Height			
3. Weight	kg		
4. Dominant side	Right/ Left		
5. Duration of weight training	months		
6. Weight training frequency	/week		
7. Duration per session	minutes		
8. Pain in the last 6 months	Hip	Knee	Ankle/ Foot
	Right/ Left	Right/ Left	Right/ Left
9. Pain at present	Hip	Knee	Ankle/ Foot
	Right/ Left	Right/ Left	Right/ Left
10. Injuries at present	Hip	Knee	Ankle/ Foot
	Right/ Left	Right/ Left	Right/ Left

11. Diagnosis

Hip	Knee	Ankle/ Foot
Osteoarthritis	Osteoarthritis	Plantar fascitis
Sacro-illiac joint syndrome	Patellofemoral pain syndrome	Ankle sprain
Illiotibial band syndrome	Patella tendinitis	Pes planus
Illiopsoas syndrome	Ligament injuries	Pes cavus
Tendonitis	Posterior tibial tendon dysfuntion	Anterior ankle impingement
Myofascitis	Bursitis	Ligament injuries
Joint fixation	Meniscal injuries	Archilles tendinitis
Other	Myofascitis	Myofascitis
	Joint fixation	Joint fixations
	Other	Other:

Measurement Data Collection sheet
Participant number:______________

	Normal	Measurement 1	Measurement 2	Measurement 3	Average	High	Normal	Low
Right hip flexion	110-120 degrees							
Left hip flexion	110-120 degrees							
Right hip extension	10-15 degrees							
Left hip extension	10-15 degrees							
Right Craigs test	8-15 degrees							
Left Craigs test	8-15 degrees							
Right quadriceps angle	13 degrees							
Left quadriceps angle	13 degrees							
Right tibial rotation	13-18 degrees							
Left tibial rotation	13-18 degrees							
Right ankle dorsiflexion	20 degrees							
Left ankle dorsiflexion	20 degrees							

						Varus	Normal	Valgus
Right hindfoot								
Left hindfoot								
Right forefoot								
Left forefoot								

					Normal	1/3 flatfoot	2/3 flatfoot	3/3 flatfoot
Right feiss line								
Left feiss line								

APPENDIX C2

						Right	Left	Normal
Leg length discrepancy								

APPENDIX D

Telephonic screening

Questions:	Answer required for inclusion into the study:
Are you willing to participate in a research study?	Yes
Are you willing to answer a few questions that would determine whether you are eligible for the study or not?	Yes
Are you male?	Yes
Are you between the ages of 18-35?	Yes
Do you weight train at least 3 times a week?	Yes
Have you been weight training for at least 6 months?	Yes
Have you ever participated competitively in any division of weight training?	No
Have you undergone any surgeries to your lower extremities or lower back?	No
Have you sustained any fractures, dislocations or trauma to the lower extremities?	No
Do you suffer from any congenital musculoskeletal conditions that you are aware of?	No

OUT DURBAN UNIVERSITY Of TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC

CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient:________________________ Date:_____ _

File#: ____________ Age:----

Gender: ______ _ Occupation·

Student:__________________________ _ Signature ____________________ _

FOR CLINICIANS USE ONLY:

fnitiat visit

Clinician: Si ature:

Case History:

Exammat,on:

Previous: Current

X-Ray Studies:

Previous: Current

Clinical Path. lab:

Previous: Current:

CASE STATUS:

PTT: Signature: Date:

CONDITIONAL:

Reason for Conditional:

Signature: Date:

Conditions met in Visit No: Signed into PTT: Date:

Case Summary ned off: Date:

Student's Case History:

ff

I. **Source of History:**

2. **Chief Complaint: (patient's own words):**

3. **Present Illness:**

	Complaint l(principle complaint)	**Complaint 2 (additional or secondary complaint)**
Location		
Onset: Initial:		
Recent:		
Cause:		
Duration		
Frequency		
Pain (Character)		
Progression		
Aggravating Factors		
Relieving Factors		
Associated S & S		
Previous Occurrences		
Past Treatment		
Outcome:		

4. **Other Complaints:**

S. **Past Medical History:**

General Health Status

Childhood Illnesses

Adult Htnesses

Psychiatric Illnesses

Accidents/Injuries

Surgery

Hospitalizations

6. Current health status and life-style:

AHergies

Immunizations

Screening Tests ind. x-rays

Environmental Hazards (Home, School, Work)

Exercise and leisure

Sleep Patterns

Diet

Current Medication
Analgesics/week:
Other (please list):

Tobacco
Alcohol
Social Drugs

7. Immediate Family Medical History:

Age of all family members
Health of aH family members
Cause of Death of any family members

	Noted	Family member		Noted	Family member
Alcoholism			Headaches		
Anaemia			Heart Disease		
Arthritis			Kidney Disease		
CA			Mental Illness		
DM			Stroke		
Dru Addiction			Thyroid Disease		
Epilepsy			**TB**		
Other (list)					

8. Psychosocial history:

Home Situation and daily life
Important experiences
Religious Beliefs

9. Review of Systems (please highlight with an asterisk those areas that are a problem for the patient and require further investigation)

General

Skin

Head

Eyes

Ears

Nose/Sinuses

Mouth/Throat

Neck

Breasts

Respiratory

Cardiac

Gastro-intestinal

Urinary

Genital

Vascular

Musculoskeletal

Neurologic

Haematological

Endocrine

Psychiatric

OUT DURBAN UMVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC

APPENDIXF
PHYSICAL EXAMINATION: SENIOR

Patient Name: ______________________ File no: __________ **Date:** __________

Student: **Signature:**

VITALS:

Pulse rate:		Respiratory rate:	
Blood pressure:	R L	Medication if hypertensive:	
Temperature:		Height:	
Weight:	Any recent change? Y / N	If Yes: How much gain/loss	Over what period

GENERAL EXAMINATION:

General Impression		
Skin		
jaundice		
Pallor		
Clubbing		
Cyanosis (Central/Peripheral)		
Oedema		
lymph nodes	Head and neck	
	Axillary	
	Epitrochlear	
	Inguinal	
Pulses		
Urinalysis		

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

NEUROLOGICAL EXAMINATION

COMMENTS

Clinician: Signature:

APPENDIXG

OUT
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DEPARTMENT OF CHIROPRACTIC

HIP REGIONAL EXAMINATION

Patient ____________________ File no: ______ __ Date: ____________ __

Student: ____________________ Signature: ____________________ __

Clinician: -- 'Signature: ____________________ __

Hip with complaint: Right ☐ Left:

OBSERVATION

- Gait: ____________________
- Posture: ____________________
- Weight-bearing symmetry: ____________________ __
- Balance and proprioception (Stork-standing test): ____________________ __
- Bony / soft tissue contours: Buttock contour ____________________ __
  - Hip flexion contracture ____________________ __
  - Lumbar lordosis ____________________ __
  - Scoliosis ____________________ __
- Skin: ____________________ __
- Swelling: --

PALPATION

• Anterior aspect			Right	Left
I.	Iliac crests			
2.	Greater trochanter			
3.	Pubic symphysis and tubercle			
4.	Femoral head			
5.	Femoral triangle	Femoral artery		
		Lymph nodes		
6.	ASIS's			
7.	Inguinal ligament			
8.	lnguinaJ hernia			
9.	Muscles -	Quadriceps		
		Adductors		
		Abductors		
		Psoas		

· Posterior aspect			Right	Left
I.	Iliac crests posteriorly			
2.	lschial tuberosity			
3.	Muscles	Piriformis		
		Gluteals		
		Hamstrings		
4.	PSIS's			
S.	Sciatic notch			
6.	SI joints			
7.	Lumbar Spine			
8.	Sacrum + coccyx			

ACTIVE MOVEMENTS (note rom *and pain)*	Right	Left

I.	Flexion (110- t20°)		
2.	Extension {10-15°)		
3.	Adduction (30°}		
4.	Abduction (30-50°)		
S.	Medial rotation (30-40°)		
6.	Lateral rotation (40-60°)		
PASSIVE MOVEMENTS {note *end-feel, rom and* pain)		**Right**	**Left**
I.	Flexion (tissue stretch or approximation)		
2.	Extension (tissue stretch)		
3.	Adduction (tissue stretch or approximation)		
4.	Abduction (tissue stretch)		
5.	Medial rotation (tissue stretch)		
6.	Lateral rotation (tissue stretch)		
RESISTED ISOMETRIC MOVEMENTS {note *strength and pain)*		**Right**	**Left**
I.	Hip Flexion		
2.	Hip Extension		
3.	Adduction		
4.	Abduction		
5.	Medial rotation		
6.	lateral rotation		
7.	Knee flexion		
8.	Knee extension		
REFLEXES		**Right**	**Left**
I.	Patella		
2.	Achilles		
DERMATOMES {indicate *de'fj_cits bi level and location}*			
I.	Level		
2.	Location		
JOINT PLAY MOVEMENTS		**Right**	**Left**
I.	Caudal glide (long axis traction superior - inferior)		
2.	Compression @ 90°(inferior - superior)		
3.	Medial lateral @ 180°/@90°		
4.	Lateral medial @ 180° / @ 90°		
5.	Internal rotation		
6.	External rotation		
7.	Anterior ▶ posterior		
8.	Posterior anterior		
9.	Quadrant (scouring) test		
SPECIAL TESTS		**Right**	**Left**
I.	Patrick FABER Test		
2.	Trendelenberg's Test		
3.	Craig's Test		
4.	Leg Length – Actual		
	Leg Length – Apparent		
5.	Sign of the Buttock		
6.	Thomas Test (hip flexion contracture)		
7.	Rectus Femoris Contracture Test		
8.	lliopsoas contracture Test		
9.	Ely's Test (rectus femoris hypertonicity)		
10.	Ober's Test (1TB contracture)		
II.	Noble Compression Test (1TB Friction Syndrome)		
12.	Piriformis Test		
13.	Hamstrings – Hamstring Contracture Test		
	Hamstrings – Tripod Test		

ft

OUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

DEPARTMENT OF
CHIROPRACTIC

KNEE REGIONAL EXAMINATION

Patient.______________________________ File:____________ Date:____________

Student.______________________________ .Signature:.______________________________

Clinician: ______________________________ Signature:______________________________

OBSERVATION {STANDING, SEATED ANDDURING GAIT CVCLEI.

A. **Anterior view**
GenuVarum:____________________
GenuValgum:.____________________
Patellar position:____________________
Tibial Torsion:.____________________
Skin:____________________
Swellin ------------------

B. **Lateral view**
Genu Recurvatum:'--------------
Patella Alta:.____________________
Patella Baja:.____________________
S n:____________________

C. **Posterior view**
Swelling:____________________
Skin:____________________

D. **General**
Movement symmetry:____________________
Structures symmetry:____________________

E. ACTIVE MOVEMENTS
Flexion (0- 135°}____________________
Extension (0- JS°} ____________________
Medial Rotation (20 - 30°)____________________
Lateral rotation (30 - 40°)____________________

F. PASSIVE MOVEMENTS
Tissue approx.____________________
Bone-bone____________________
Tissue stretch.____________________
Tissue stretch____________________
Patellar movement'--------------

RESISTED ISOMETRIC MOVEMENTS
Knee: Flexion:____________________
Extension:____________________
Internal rotation:.____________________
External rotation:.____________________

Ankle- Plantarflexion____________________
Dorsiflexion____________________

LIGAMENTOUS ASSESSMENT

One-Plane Medial lnstabiUty
Valgus stress (abduction)
Extended ____________________
Resting Position____________________

One-Plane Anterior Instability
Lachman Test (0-30°}____________________
Anterior Drawer Sigrt ____________________

Anterolateral Rotatory Instability
Slocum Test.____________________
Macintosh Test,____________________

Posterolateral Rotatory Instability
Jacob ____________________
Hughston's Drawer Sign____________________
Reverse pivot shift test,____________________

One-Plane Lateral Instability
Varus stress (adduction)
Extended____________________
Resting Position____________________

One-Plane Posterior Instability
Posterior "sag" Sign._ ____________________
Posterior Drawer Test.____________________

Anteromedial Rotatory Instability
Slocum Test.____________________

Posteromedial Rotatory Instability
Hughston's Drawer Sign____________________

TESTSFORMENISCUS INJURY

McMurray____________________________

"Bounce Home" _ _ _ _ _ _ _ _ _ _

Anderson med-lat grind.______________________________

Appley's,__________________________________ __

PUCATESTS

Mediopatetlar Plica _______________ __

Ptica "Stutter"__________________

Hughston's PHca.______________________________ __

TESTS FOR SWEWNG

Brush/Stroke Test ______________________

Patcllar Tap Test.______________________________ __

TESTS FOR PAffiLAFEMORAL PAINSYNDROME

Clarke's Sign __________________________

Waldron test, ...

Passi,ve patella tilt test:______________________________

OTHER TESTS

Wilson's.__________________________ __

Fairbank's.________________________ __

Nobfe Compression.________________________

Quadriceps Contusion Test.____________________ __

Leg Length Discrepancy_______________________ __

JOINT PLAY

Movement o-f the tibia on the femur P to A:_________________ A to P:.____________

Translation of the tibia on the femur M to L:____________ __ L to M:________________

Long axis distraction of the tibiofemoral joint ____

Inf, sup, lat. + med glide of the patella ____

Movement of the inf. tibiofibular joint A to P:,____________________ P to A:.________________________

Movement of the sup. tibiofibular joint A to P: P to A:.____________________ __

Movement of the sup. tibiofibu!ar }omt S to I : I to $:.________________________

PALPATION

Tenderness.____________________________ __

Joint line.________________________________ __

Ligaments______________________________ __

PateUa / Patella tendon:_________________________

Popliteai artery:,___________________________ __

SweHin.o--------------

Nodules/exostoses.____________________ __

Muscles:'Thigh:,______________________________

Leg:._______________________________

Bursae:'--------------

REFLEXES AND CUTANEOUS DISTRIBUTION

	R	L
Patellar Reflex (L3,L4)		
Medial Hamstring Reflex (LS,S I)		

DERMATOMES

	R	L		R	L
L2			SI		
l3			, S2		
l4			S3		
LS					

APPENDIX t

FOOT AND ANKLE REGIONAL EXAMINATION

DUI DURBAN UNIVERSIIYOF TECHNOtOGY — DEPARTMENT OF CHIROPRACTIC

Patient:_ .... File no:_ _________ Date:_ _______

Student:________________________________Signature:,____________________________

Clinician:.______________________________ Signature:.____________________________

Observation

Gait anaJysis (antalgic limp, toe off, arch, foot alignment. tibial alignment).

____

____

Swellin.O --

Heloma dura Imolle. --

SWn.____

Nails____

Shoes____

Contours (Achilles tendon, bony prominences)__________________________________

Active movements

Weight bearing:	R	L	*Non weigh:t bearing:*	R	L
Plantar flexion			50°		
Dorsiflexion			20°		
Supination					
Pronation					
Toe dorsiflexion			40°(mtp)		
Toe plantar flexion			40° (mtp)		
		Big toe dorsiflexion (mtp) (65-70°)			
		Big toe plantar flexion (mtp) 45°			
		Toe abduction + adduction			
		5° first ray dorsiflexion			
		5° first ray plantar flexion			

Passive movement motion palpation (Passive ROM quality, ROM overpressure, joint play)	R	L		R	L
Ankle joint *Plantarf1exion*			Subtalar joint *Varus*		
Dorsiflexion			*Valgus*		
Talocrural: *Long axis distraction*			Midtarsal:A-P *glide*		
First ray: Dorsiflexion			*P-A glide*		
Pfantarf1exion			*rotation*		
Circumduction of forefoot on fixed rearfoot			lntermetatarsal glide		
			Tarso metatarsal joints: *A-P*		
lnterphalangeal joints: *L-A dist*			Metatarsophalangeal dorsiflexion (with associated plantar flexion of each toe		
A-P glide					
lat and med glide					
rotation					

Resisted Isometric movements

	R	L		R	L
Knee flexion			Pronation (eversion)		
Plantar flexion			Toe extension (dorsiflexion)		
Dorsiflexion			Toe flexion (plantar flexion)		
Supination (inversion)					

Neurological

	R	L
Dermatomes		
Myotomes		
Reflexes		
Balance/proprioception		

Special tests

	R	L
Anterior drawer test		
Talar tilt		
Thompson test		
Homan sign		
Tinel's sign		
Test for rigid/flexible flatfoot		
Kleiger test (med. deltoid)		

Alignment

	R	L
Heel to ground		
Feiss line		
Tibial torsion		
Heel to leg (subtalar neutral)		
Subtalar neutral position:		
Forefoot to heel (subtalar & Midtarsal neutral)		
First ray alignment		
Digital deformities		
Digital deformity flexible		

Palpation

	R	L
Anteriorly		
Medial malleoli		
Med tarsal bones, tibial (post) artery		
Lat. malleolus, calcaneus, sinus tarsi, and cuboid bones		
Inferior tib/fib joint, tibia, mm of leg		
Anterior tibia, neck of talus, dorsalis pedis artery		
Posteriorly		
Calcaneus, Achilles tendon, Musculotendinous junction		
Plantarily		
Plantar muscles and fascia		
Sesamoids		

MEMORANDUM

To Prof Adam
Chair: IREC

From Dr Laura O'Connor
Head of Department: Chiropractic

Dr Desiree Varatharajullu
Clinic Director: Chiropractic Day Clinic: Chiropractic

Date 21.05.2020

Re : Request for permission to use the Chiropractic Day Clinic for research purposes

Permission is hereby granted to:

Ms Fahmeeda Makada (Student Number: 21347986)

Research title: "The association between static biomechanical parameters and musculoskeletal injury in the lower extremities in male recreational weight trainers•.

Ms Makada, is requested to submit a copy of her FRC/IREC approved proposal along with proof of her M.Tech: Chiropractic registration to the Clinic Administrator/s before she starts with her research in order that any special procedures with regards to her research can be implemented prior to the commencement of her seeing patients;

Thank you for your time.
Kind regards

Dr L O'Connor
Head of Department: Chiropractic

Dr D Varatharajullu
Clinic Director: Chiropractic Day Clinic: Chiropractic

Cc: Mrs Linda Twiggs: Chiropractic Day Clinic
Dr G. Matkovich: Supervisor

APPENDIXK

OUT
DURBAN
UNII/ERSfTY Of
TECHNOLOOV

DIRECTORATE FOR
RESEARCH AND
SUPPORT

Directorate for Research and Postgraduate Support
Durban University of Technology
Tromso Annexe, Steve Biko Campus
P.O. Box 1334, Durban 4-000
Tel.: 031-3732576n
Fax: 031-3732946

22nd June 2020
Ms Fahmeeda Makada
c/o Department of Chiropractic and Somatology
Faculty of Health Sciences
Durban University of Techno!ogy

Dear Ms Makada

PERMISSION TO CONDUCT RESEARCH AT THE OUT

Your email correspondence in respect of the above refers. I am pleased to inform you that the Institutional Research and Innovation Committee (IRIC} h-as granted **Full Permission** for you to conduct your research "The association between static biomechanical parameters and musculoskeletal injury in the lower extremities in male recreationa1 weight trainers" at the Durban University of Technology.

The DUT may impose any other condition it deems appropriate in the circumstances having regard to nature and extent of access to and use of information requested.

We wou1d be grateful if a summary of your key research findings can be submitted to the IRIC on completion of your studies.

Kindest regards.
Yours sincerely

DR LINDA ZIKHONA LINGANISO
DfRECTOR: RESEARCH AND POSTGRADUATE SUPPORT DtRECTORATE

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

24 June 2020

Ms F Makada
Shop 6, 23 Hill Street
Pinetown
Durban
3610

Dear Ms Makada

The association between static biomechanical parameters and musculoskeletal injury in the lower extremities in male recreational weight trainers
Ethical Clearance number IREC 027/20

The Institutional Research Ethics Committee acknowledges receipt of your gatekeeper permission letters.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

Professor J K Adam
Chairperson: IREC

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

6 August 2021

Ms F Makada
Shop 6, 23 Hill Street
Pinetown
Durban
3610

Dear Ms Makada

The association between static biomechanical parameters and musculoskeletal injury in the lower extremities in male recreational weight trainers
Ethical Clearance number IREC 027/20

The Institutional Research Ethics Committee acknowledges receipt of your Safety Monitoring and Annual Recertification report.

I am pleased to inform you that the study has been approved to continue.

Please note that ethical approval has been extended till **30 April 2022** if the research is not complete within this time, you will be required to apply for recertification three months before the expiry date.

Yours Sincerely

Prof J K Adam
Chairperson: IREC

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
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6 June 2022

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