T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF SPORTS PHYSIOTHERAPY

EFFECT OF THORACIC MOBILITY VERSUS LUMBOPELVIC STABILIZATION EXERCISES ON LOWER EXTREMITY FLEXIBILITY, DYNAMIC BALANCE AND PROPRIOCEPTION IN PATIENTS WITH CHRONIC ANKLE INSTABILITY

MASTER THESIS

ECEM NUR TAKINDI, PT

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THESIS APPROVAL FORM

Institute : Yeditepe University Institute of Health Sciences

Programme : Sports Physiotherapy

Title of the Thesis : Effect Of Thoracic Mobility Versus Lumbopelvic Stabilization Exercises On Lower Extremity Flexibility, Dynamic Balance And Proprioception In Patients With Chronic Ankle Instability

Owner of the Thesis : Ecem Nur TAKINDI

Examination Date : 31.01.2023

This study have approved as a Master Thesis in regard to content and quality by the Jury.

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APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated .... and numbered ....

Prof. Dr. Bayram YILMAZ

Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

04.01.2023

Ecem Nur TAKINDI

DEDICATION

This thesis is dedicated to my parents who have given me the opportunity of an education from the best institutions of Yeditepe. Thank you for always supporting me.

ACKNOWLEDGEMENT

I would like to express my thesis advisor, Dr. Öğr. Üyesi Elif Tuğçe ÇİL who is with me patiently and with interest at every stage of my thesis and guides me in the light of science.

I would like to thank the Noi Physio Pilates Studio family for not sparing their during my Graduate studies.

Also, I would like to thank to Pt. Cumhur Görgün who always be supportive and believed in me at every stages of this thesis and life.

I would like to express my endless and sincere thanks to my beloved family who have always supported me throughout my life.

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LIST OF SYMBOLS AND ABBREVIATIONS

CAI	Chronic Ankle Instability
ROM	Range of Motion
PRICE	Protect, Rest, Ice, Compression, Elevation
NMES	Neuromuscular Electrical Stimulation
TENS	Transcutaneus Electrical Stimulation
TM	Thoracic Mobility
LPS	Lumbopelvic Stability
LPST	Lumbopelvic Stability Training
TrA	Transversus Abdominus
ATFL	Anterior Talofibular Ligament
PTFL	Posterior Talofibular Ligament
CFL	Calcaneofibular Ligament
TMT	Tarsometatarsal Joint
MT	Metatarsal Joint
MTP	Metatarsophalangeal Joint
MCP	Metacarpophalangeal Joint
LCL	Lateral Collateral Ligament
MCL	Medial Collateral Ligament
DLC	Deltoid Ligament Complex
MAS	Medial Ankle Sprain
LAS	Lateral Ankle Sprain
MI	Mechanical Instability
FI	Functional Instability

US	Ultrasound
BMI	Body Mass Index
SEBT	Star Excursion Balance Test
COM	Center of Mass
CNS	Central Nervous System
CAIT	Cumberland Ankle Instability Tool
LEFS	Lower Extremity Functional Scale
FADI	Functional Ankle Disability Index
SIJ	Sacroiliac Joint
LPST	Lumbopelvic Stability Training
DM	Diabetes Mellutis
FAAM	Foot and Ankle Ability Measure
VAS	Visual Analog Scale
PHSB	Progressive Hop-to-Stabilization Balance
SLB	Single Leg Balance
ADL	Activity of Daily Life
PKE	Passive Knee Extention
BESS	Balance Error Scoring System
DIF	Demographic Information Form
ASLR	Active Straight Leg Raise
JPS	Joint Position Sense
A	Anterior
PL	Posterolateral
PM	Posteromedial

ABSTRACT

TAKINDI, E. N. (2023), Effect Of Thoracic Mobility vs. Lumbopelvic Stabilization Exercises On Lower Extremity Flexibility, Dynamic Balance And Proprioception In People With Chronic Ankle Instability, Yeditepe University, Institute of Health Sciences, Department of Sport Physiotherapy, Master Thesis. Istanbul.

The aim of the study is to compare the effects of thoracic mobility exercises and lumbopelvic stabilization exercises in patients with Chronic Ankle Instability (CAI) on dynamic balance, lower extremity flexibility and proprioception. This study was conducted in Noi Physio & Pilates Studio in November 2022 and January 2023. Total of 30 participants aged 20-45 were included in the study on a voluntary basis. Demographic information and informed consent forms were filled into all subjects who volunteered to participate in the study and in accordance with the research criteria and CAIT questionnaire and who get 27 points or less from this questionnaire were included. Participant were divided into 2 groups randomly and in addition to the rehabilitation protocols, each participants was given home exercise program including ankle strengthening exercises. Home exercise program was prescribed as 3 times a week. First group was received thoracic mobility rehabilitation exercises and second group was received lumbopelvic stabilization exercises in supervision of physiotherapist twice a week for 8 weeks (16 sessions total). Each exercise sessions taken with physiotherapist last approximately 50 minutes. Dynamic balance of the participants were assessed with Y Balance Test before and after the exercise program. Proprioception of lower extremity evaluated by measuring joint position sense with goniometer, and flexibility was assessed with Active Straight Leg Raise Test. As a result, Y Balance tests there was a significant difference in thoracic mobility group in every direction ($p<.05$). Active Straight Leg Raise Test has significant difference in both groups ($p<.05$). Joint Position Sense tests has shown a statistically significant difference between groups only in the hip and dorsiflexion ($p<.05$). In CAIT scores earned by the participants, a significant difference has been found between the groups for both feet. ($p<.05$).

Key Words: chronic ankle instability, dynamic balance, proprioception, flexibility, thoracic mobility, lumbopelvic stability.

ÖZET

TAKINDI, E. N. (2023). Torasik Mobilite ve Lumbopelvik Stabilizasyon Egzersizlerinin, Kronik Ayak Bileği İnstabilitesi Olan Kişilerde Alt Ekstremite Fleksibilite, Dinamik Denge ve Propriyosepsiyon Üzerine Etkisi, Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Spor Fizyoterapisi Yüksek Lisans Tezi, İstanbul.

Bu çalışmanın amacı, Kronik Ayak Bileği İnstabilitesi (KAİ) olan hastalarda torasik mobilite egzersizleri ile lumbopelvik stabilizasyon egzersizlerinin dinamik denge, alt ekstremite esnekliği ve propriyosepsiyon üzerindeki etkilerini karşılaştırmaktır. Bu çalışma Kasım 2022 ve Ocak 2023 tarihlerinde Noi Physio & Pilates Studio'da yapılmıştır. 20-45 yaş arası toplam 30 katılımcı gönüllülük esasına göre çalışmaya dahil edilmiştir. Araştırma kriterlerine ve CAIT anketine uygun olarak çalışmaya katılmaya gönüllü olan ve bu anketten 27 ve altında puan alan tüm katılımcılar demografik bilgi formu ve bilgilendirilmiş onam formu doldurdu. Katılımcılar randomizasyon yöntemiyle 2 gruba ayrıldı ve rehabilitasyon protokollerine ek olarak her katılımcıya ayak bileği kuvvetlendirme egzersizlerini içeren ev egzersiz programı verildi. Ev egzersiz programı haftada 3 gün olarak reçete edildi. Birinci gruba torasik mobilite rehabilitasyon egzersizleri, ikinci gruba ise lumbopelvik stabilizasyon egzersizleri verildi. Tüm seanslar fizyoterapist gözetiminde 8 hafta boyunca haftada iki kez toplam 16 seans olacak şekilde planlandı ve her egzersiz seansı yaklaşık 50 dakikadır. Katılımcıların dinamik dengeleri egzersiz programı öncesi ve sonrasında Y Denge Testi ile değerlendirildi. Alt ekstremite propriyosepsiyonu eklem pozisyon hissi testi kullanılarak gonyometre yardımıyla, esneklik ise Düz Bacak Kaldırma Testi ile değerlendirildi. Sonuç olarak, Y Balance testlerinde torasik mobilite grubunda her yönde anlamlı fark bulundu, lumbopelvik stabilizasyon grubunda sadece arasında PM yönünde anlamlı fark bulundu ($p<.05$), Aktif Düz Bacak Kaldırma Testinde her iki grupta da anlamlı fark elde edildi ($p<.05$). Eklem Pozisyon Algısı testleri, sadece kalça ve dorsifleksiyonda gruplar arasında istatistiksel olarak anlamlı bir fark göstermiştir ($p<.05$). Katılımcıların aldıkları CAIT puanlarında her iki bacak için gruplar arasında anlamlı fark bulunmuştur ($p<.05$).

Anahtar Kelimeler: Kronik ayak bileği instabilitesi, dinamik denge, propriyosepsiyon, esneklik, torasik mobilite, lumbopelvik stabilizasyon.

1. INTRODUCTION

Chronic ankle instability, condition associated with laxity and mechanical instability after repeated lateral ankle sprains. Average of 70% of people who experience an acute ankle sprain develop chronic ankle instability after a short time from initial injury [1].

It occurs frequently in professional athletes as well as in normal individuals. People who has CAI suffer from loss of balance, problems in weight bearing, gait problems and doing strenuous activities and walking on uneven surfaces [2] and experience repetitive injuries. Furthermore, decreased ROM, loss of strength, proprioceptive and neuromuscular deficits, and altered gait pattern can be seen in people with chronic ankle problems. Although the recovery process takes between 6 and 8 weeks, the individuals may not fully regain their functionality. In addition, chronic injuries in elite athletes can cause another secondary injury either. The effectiveness of the rehabilitation protocols of these people affects their return to their previous functionality and improve their quality of life.

Patients with chronic ankle instability are strongly advised to follow the most popular conservative therapy methos at least for the first two months. In the acute stage, PRICE (Protection, Rest, Ice, Compression, Elevation) protocol, NMES [54] (Transcutaneous Electrical Nerve Stimulation (TENS) application and brace use have been applied to reduce pain and edema. Bracing and taping methods fail to provide support for chronically unstable ankles. Neuromuscular, balance, proprioceptive exercises, strengthening exercises and functional exercises were provided as exercise therapy [3, 4]. Donavan et al. [4] studied joint mobilization techniques, stretching, concentric and eccentric exercises, gait training, plyometric and agility exercises in people with CAI. It is an undeniable fact that balance is affected in ankle injuries, and balance is a concept that encompasses the whole body. So it is important a holistic perspective to consider other parts of the body such as thoracic and lumbopelvic region as well. In this study, 30 individuals with CAI were divided into two groups by randomization method. While one group was given thoracic mobility (TM) exercises, the other group was given lumbopelvic stabilization (LPS) exercises.

The ability of the spine to preserve its anatomical structure under physiological loading is known as lumbopelvic stability (LPS). The interplay of the bone structure with ligaments, muscles, and the nervous system provides stability [5]. The concept of lumbopelvic stability muscles are: transversus abdominis (TrA), multifidus, internal and external obliques, rectus abdominis, erector spina, pelvic floor muscle and diaphragm [6].

In one research (Edmondston S. J. & Singer, K. P., 1997), an improvement in dynamic balance was observed due to the improvement of the thoracic mobility [8]. Because thoraric spine is capable of different movement in several planes and the main movement is accepted as rotation.

Therefore, mobility can be affected by several factors such as rib mobility, breathing mechanics and muscular stiffness. In this study, participants performed selected exercises for increasing their thoracic mobility [9]. To the best of our knowledge, the effect of thoracic region mobility on dynamic balance, proprioceptive and flexibility in people with CAI has not been investigated. In this study, we investigated both the effectiveness of lumbopelvic exercises and the effectiveness of thoracic mobility exercises in people with CAI. For these reasons, this study will be the first to investigate the effectiveness of both the thoracic and lumbopelvic exercises in patients with CAI.

The aim of this study is to investigate the effectiveness of thoracic mobility versus lumbar stabilization exercises on lower extremity flexibility, dynamic balance and proprioception in patients who have chronic ankle instability.

H0: There is not any difference between thoracic mobility exercises and lumbopelvic stabilization exercises on lower extremity flexibiliy, dynamic balance and proprioceptıon in patients who have chronic ankle instability.

H1: There is a difference between thoracic mobility exercises and lumbopelvic stabilization exercises on lower extremity flexibiliy, dynamic balance and proprioceptıon in patients who have chronic ankle instability.

2. GENERAL INFORMATION

2.1. Ankle and Foot Anatomy

The ankle joint complex is form between lower extremity and the foot and create the movement connection allowing the lower extremity to connection with the ground. This system is essential for gait and other activities of daily living. Regardless of carrying heavy loads and shear forces that ankle can carry, and it has a high degree of stability as compared to other joints such as the hip or knee [9]. Anatomical features such as bone, ligament and muscle structure contributes to the mobility and stability functions [10].

Ankle is divided into three parts for understanding the joint and movement mechanism which is hindfoot, midfoot and forefoot [1]. Hindfoot is consist of talus and calcaneus. The midfoot has five bones which are the navicular, cuboid, and the three cuneiforms. The forefoot consist of 5 metatarsal bones and 14 phalanges. Except for first toe there are 3 phalanges in each toe [12].

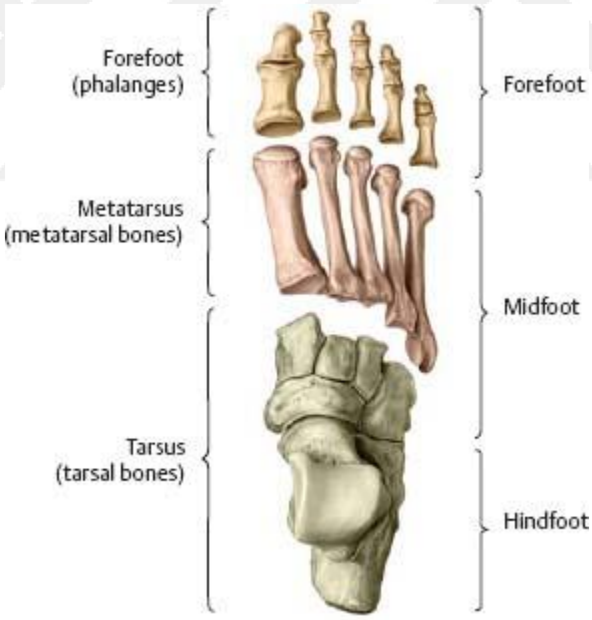

Figure 1: Foot Parts [11]

The ankle is formed by the distal tibia fibula and the anterior aspect of the talus. Lateral, medial and syndesmotic ligaments also contribute to the formation of this joint [12].

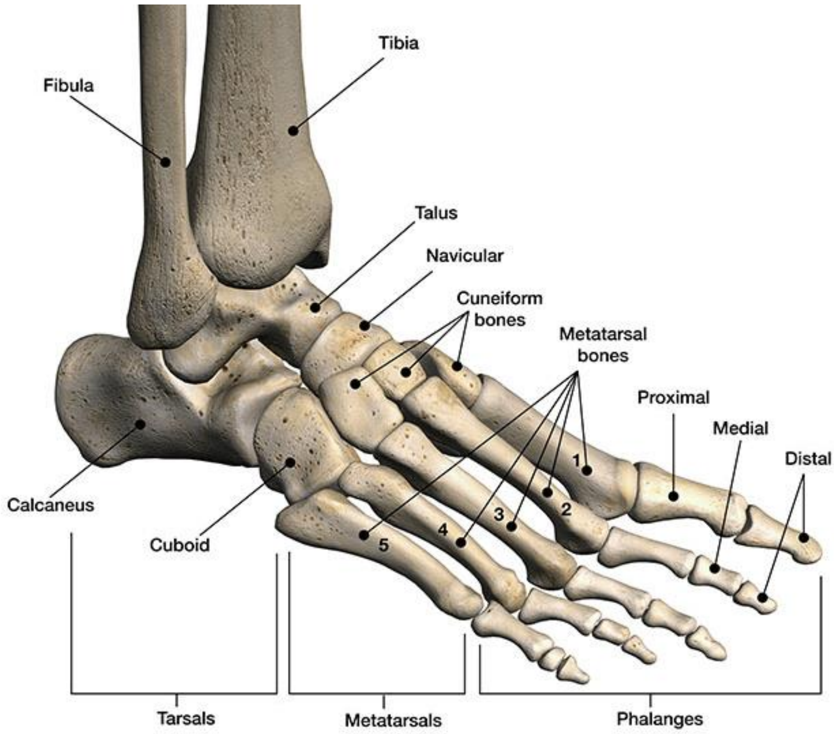

Figure 2: Foot Bones [13]

2.1.1. Tibiotalar (Talocrural) Joint

The talocrural (tibiotalar) or ankle joint consists of the articular surfaces of the tibial and fibular distal epiphyses. It can also be called the load-bearing joint of the body in 3 directions (superior, lateral and medial). The talus has head, neck and body, but not muscle connection [9].

The wide structure of the anterior surface of the talus makes it more stable in dorsiflexion movement. Lateral and medial malleolus tightly grips the talus from both directions. The talus [12] sometimes called the ‘‘mortise’’ joint [14]. The morphology of these surfaces provide dorsiflexion and plantarflexion in sagital plane and creates a gingival or hinge-type synovial joint with a single axis of motion that provides dorsiflexion and plantar flexion of the ankle and foot in the sagittal plane.

The accepted normal ROM angle for dorsiflexion is between 23-56° and this degree is 13-33° degrees for plantarflexion [12]. The isolated movement of the tibiotalar joint is mainly in the sagittal plane, but oblique axis of rotation also occurs in the transverse and frontal planes [14]. The talocrural joint is also supported by ligamentous structures such as ATFL, PTFL, CFL laterally, DLC medially [14].

2.1.2. Subtalar Joint

The calcaneus is the largest and strongest bone in the foot, located posteriorly and connected to the achilles tendon. It lies below the talus and forms a triplane, uniaxial joint with itself. The subtalar joint is divided into 2 parts as anterior and posterior [15].

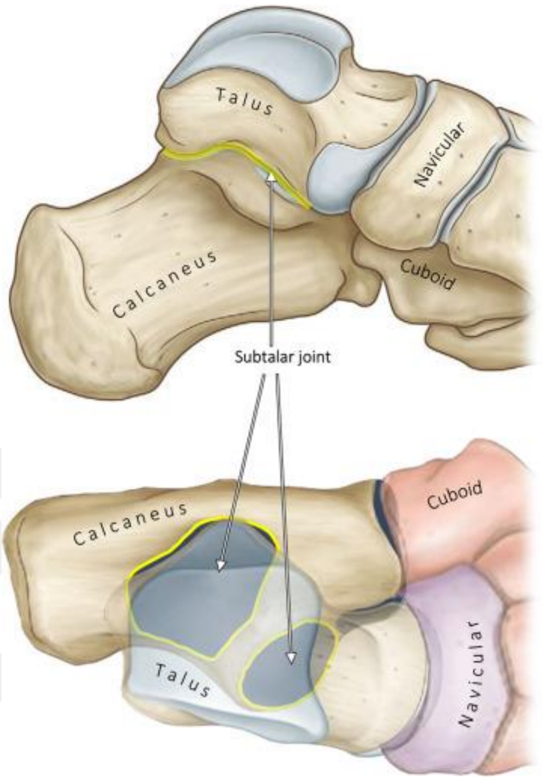

Figure 3: Subtalar Joint [16]

The two similarly articulating surfaces of the anterior subtalar joint on the inferior side of the talus are convex and concave on the superior surface of the calcaneus, and the surfaces that articulate the posterior talar joint are concave on the inferior and superior surfaces of the talus. Lateral surface of the calcaneus convexity. This joint allows inversion and valgus eversion of the ankle [9].

The talar head is also supported by the ‘spring’ ligament which help stabilising the talar head insufficiency can cause to acquired pes planus or flat foot deformity [15].

Many ligaments connect these two bone structures. One of the strong connections between the two bones is the interosseous talocalcaneal ligament. It starts from the inferior articular surface of the talus and extends superiorly to the calcaneus. Although the anterior and lateral talar ligaments are slightly weaker than the others, they contribute to this connection. Together, the CFL and the tibiocalcanel ligament support the subtalar joint. Among the peroneal muscles, the long tendons of the peroneus longus and brevis, tibialis posterior, flexor digitorum longus and flexor hallucis longus serve as support [9].

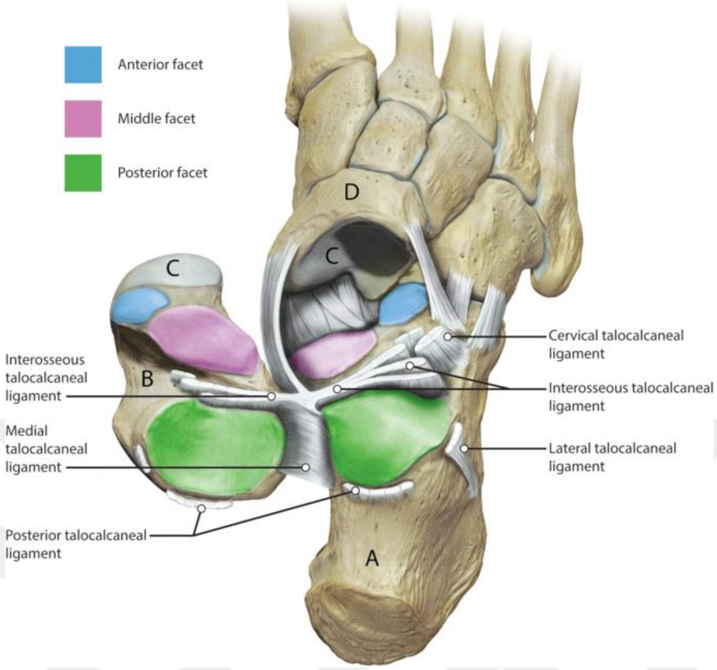

Figure 4: Ligaments of the Foot [17]

2.1.3. Distal Tibiofibular Joint

It is a type of syndesmosis joint located distal to the tibia and fibula. Moreover the gliding between the joint movement is one of the milestones for this joint. The structures that stabilize this joint are the thick interosseous membrane and anterior and posterior inferior tibiofibular ligaments. The structure of this syndesmosis serves as the roof for the talocrural joint [14].

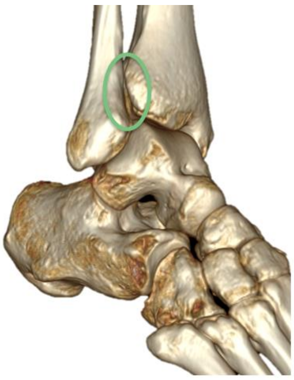

Figure 5: Distal Tibiofibular Joint [18]

2.1.4. Transverse Tarsal Joint

This joint is also known as the “Chopart joint”. The talonavicular and calcaneocuboid joints form this joint. Composed of the talonavicular and calcaneocuboid joint, this joint is also called the Chopart joint. There is a balance between muscle control and static support structures of talonavicular joint. If any deterioration occurs in the muscle control and supporting structures, it causes loss of function in the whole joint structure followed by fatigue of the remaining support. Because of the combined movements of the subtalar and transverse tarsal joints, the talonavicular joint problem causes longitudinal arch collapse and forefoot abduction movement. This can results in progressive valgus deformity [19].

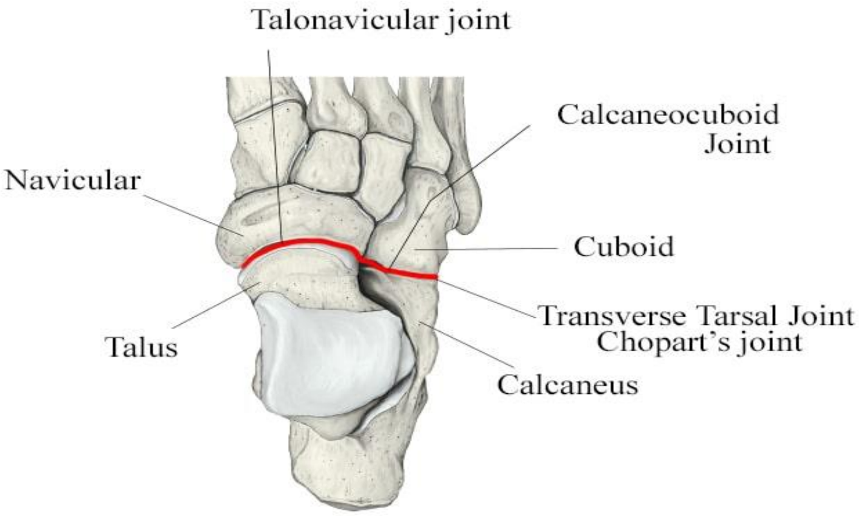

Figure 6: Transverse Tarsal Joint [20]

2.1.5. The Talonavicular Joint

The convex ellipsoid surface of the talus head and the concavity of the proximal segment of the navicula come together to form the talonavicular joint, which is supported by numerous ligamentous structures. At the proximal "acetabulum pedis" of the talonavicular joint, the subtalar joints' anterior and intermediate aspects form the socket in which the talar head articulates [19].

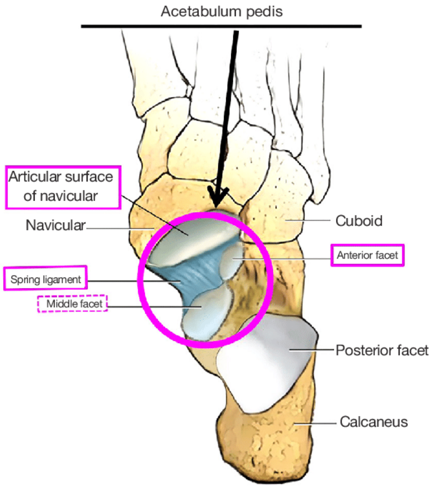

Figure 7: Acetabulum Pedis [21]

2.1.6. The Calcaneocuboid Joint

This joint, which is between the anterior surface of the calcaneus and the proximal surface of the cuboid, is a saddle-shaped joint. It is vertically convex and transversely concave. When the foot is inverted, a bony protrusion at the inferomedial corner of the cuboid articulates in the calcaneus' coronoid fossa and helps to stabilize the joint. A bony corner that hangs from the cuboid bone's upper edge is formed by the medial corner of the calcaneal articular surface [23].

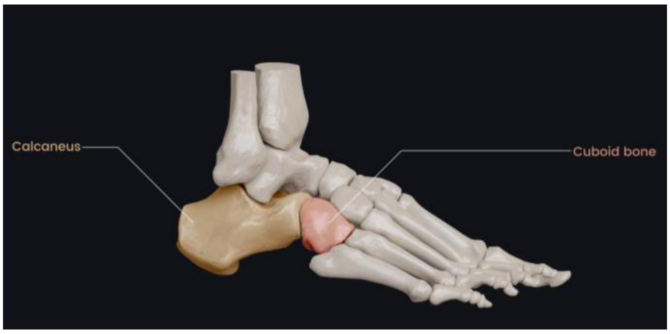

Figure 8: Calcaneocuboid Joint [22]

2.1.7. Midfoot Joint

Midfoot joints articulate between three cuneiform with navicula, cuboid with the 3rd cuneiform, 2nd and 3rd metatarsal bones with the third cuneiform, 1st metatarsal with the medial cuneiform, 4th and 5th metatarsal bones with the cuboid [23].

2.1.8. Tarsometatarsal Joint

Tarsometatarsal joint is divided midfoot from forefoot and also called Lisfranc’s joint. The distal tarsal, three cuneiform bones and cuboid articulate with the base of each metatarsal and create TMT joint line. It is seen in the shape of an S and is divided into 3 parts as medial (1st MT and cuneiform), middle (2nd and 3rd metatarsals and intermadiate and lateral cuneiform) and lateral (4th and 5th MT and cubiod bone) [24].

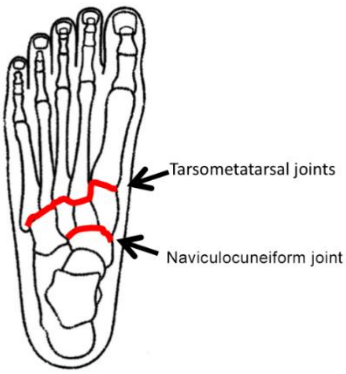

Figure 9: Tarsometatarsal Joint [25]

2.1.9. Metatarsophalangeal Joints (MTP)

The third metatarsal's distal joint surface, its sagittal prominence, and the medial and lateral condyles, as well as the medial and lateral proximal sesamoid bones, make up the MTP joint, which is almost like MCP joint. The proximal articular surface of the proximal phalanx also has a prominent sagittal groove that is located axially [26].

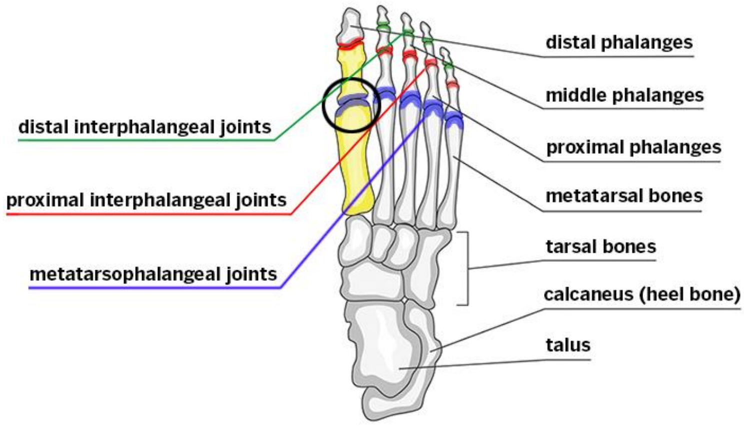

Figure 10: Foot Joints [27]

2.1.10. Interphalangeal Joints

The articulations between the phalanges of the foot are known as interphalangeal joints and are categorized as uniaxial hinge joints. Nine interphalengeal joints are present: two on the big toe and one on each of the four lateral toes. As proximal and distal interphalengeal joints, respectively. Middle and proximal phalanxes are separated by proximal interphalengeal joints. Middle phalange heads and distal phalange bases articulate at distal interphalengeal joints. The proximal and distal phalanges of the big toe only share one interphalengeal joint. The middle and distal phalanges' flexion (plantarflexion) and extension (dorsiflexion) movements are made possible by the synovial type interphalangeal joints [28].

2.1.11. Ankle Ligaments

Ankle ligaments can be classified according to their location on the joint. The ligaments on the medial part of the foot are called the deltoid ligament, those on the lateral part are called the lateral collateral ligaments, and the ligaments connecting the distal tibia and fibula are called the syndesmotic ligament [29].

2.1.11.1. The Lateral and Medial Collateral Ligaments

The lateral collateral complex consists of the anterior and posterior talofibular ligament and the calcaneofibular ligament. The deltiod ligament located in the medial area of the ankle has 2 layers, superficial and deep [29].

2.1.11.1.A. Lateral Collateral Ligaments

2.1.11.1.A.A. Anterior Talofibular Ligament (ATFL)

Described as the weakest ligament of the ankle, it is the most damaged ligament in ankle sprains plays a crucial role in preventing the talus from moving anteriorly and the ankle joint from flexing inward. This ligament starts from the anterior talofibular region and extends to the lateral malleolus. The anterior malleolus of the lateral malleolus is where the anterior talofibular begins [29].

2.1.11.1.A.B. Calcaneofibular ligament (CFL)

The lower parts of the ATFL are surrounded by the CFL originating from the lateral malleolus. In the neutral ankle position, the ligament descends obliquely downward and backwards to attach to the posterior region of the lateral calcaneal surface, where fibers linking the ligaments are frequently visible. In the neutral ankle position, the ligaments extend posteriorly and downward in an oblique direction where fibers linking the ligaments are frequently visible [29].

2.1.11.1.A.C. Posterior Talofibular Ligament

PTFL begins medial side of the lateral malleous. It extends almost horizontally until it is located posterolaterally to the talus. this ligament is taut in dorsiflexion and relaxed in plantar flexion [29].

2.1.11.1.B. Medial Collateral Ligament

In the literature, the medial collateral ligament is primarily divided into two layers: the superficial layer and the deep layer. The medial collateral ligament, which starts at the medial malleolus like the posterior talofibular ligament, is a multifascicular ligament that links to the talus, calcaneus, and navicula. As the peroneal tendon sheath connects to the calcaneofibular ligament on the lateral aspect, the posterior tibial muscle's tendon sheath covers the middle and posterior portions of the deltoid ligament [29].

2.1.11.1.C. Syndesmotic Articulation

It permits a movement during extreme dorsiflexion and plantarflexion, slight upward and medial rotations of the fibula and the tibiafibula as a whole to adapt to the varying width of the upper articular surface of the talus. The syndesmotic ligament is a ligament complex that prevents the separation of the distal tibia and fibula, restricting axial, rotational and translational movements [29].

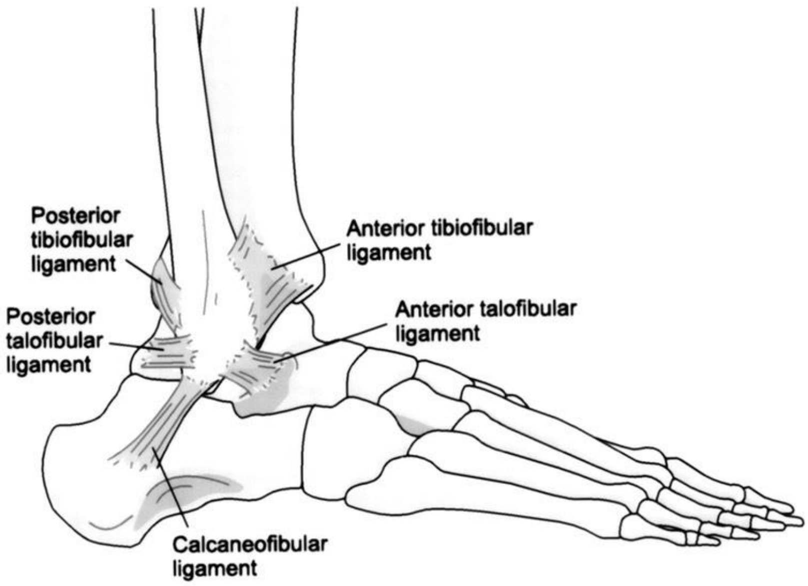

Figure 11: Ankle Ligaments Lateral Side

2.1.12. Ankle Muscles

The ankle joint has three distinct muscle components: lateral, posterior, and anterior. Interosseous membrane is bounded by tibia and fibula. These two bones divides the anterior and posterior compartments. Intermuscular septa is a solid fascial sheath, which extends from fibula to the facile area of the muscle, separates lateral compartment from the other two compartments [30].

The twelve extrinsic muscles, which have their origins in the leg and insert in the foot, are responsible for most of the motion in the feet and ankles. There are four categories that contain these muscles. The tibialis anterior, the extensor digitorum longus, the extensor hallucis longus, and the peroneus tertius are the four muscles that make up the anterior compartment. The extensor hallucis longus and tibialis anterior support dorsiflexion and inversion of the feet. Dorsiflexion and eversion of the feet are produced by the peroneus tertius. Only dorsiflexion of the feet is provided by the extensor digitorum longus [9].

The peroneus longus and brevis, which cause plantarflexion and eversion of the foot, are the two muscles that make up the lateral aspect. The gastrocnemius, soleus, and plantaris are the three muscles that make up the posterior compartment and are responsible for the foot's plantarflexion. The tibialis posterior, flexor digitorum longus, and flexor hallucis longus are the three muscles that constructs the deep posterior compartment and help the foot invert and plantarflex [9].

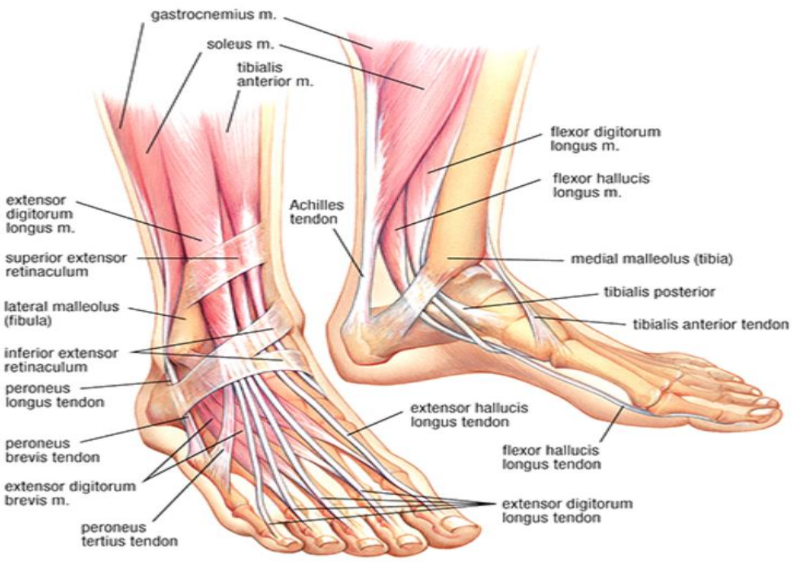

Figure 12: Ankle Muscles [31]

2.1.13. Nerve Supply

The ankle joint is stimulated by tibial, saral, deep peroneal, saphenous and accessory deep peroneal nerve. The tarsal joints stimulated by medial or lateral plantar nerves from the plantar plane and mainly by the peroneus profundus nerve from the dorsal plane. Branches from the intermediate dorsal cutaneous nerve also stimulates the joint between the lateral and intermediate cuneiform. Deep peroneal nerve is also called “nervus hesitans”. When present the lateral dorsal cutaneous nerve and the accessory nervus hesitans stimulates supplemental branches to the subtalar and calcaneocuboid joints. The tarsometatarsal joints were stimulated by the medial or lateral plantar nerve. Most of these were stimulated by nervus hasitans in their dorsal aspect, however the cuboid-metatarsal joints were stimulated by the middle dorsal cutaneous nerve. The intermetatarsal joints had a similar but less frequent origin. The joint between the fourth and fifth metatarsals are supplied by the intermediate dorsal cutaneous nerve provided. The metatarsophalangeal joints are mainly supplied of the plantar digital nerves [32].

The posterior aspect of the first metatarsophalangeal joint is innervated by the deep peroneal and medial dorsal cutaneous nerves. In addition, while the deep peroneal nerve innervates the second mtp joint, it is innervated by the 4th and 5th dorsal cutaneous nerves. In addition, these two nerve branches are also effective in the innervation of the big toe [32].

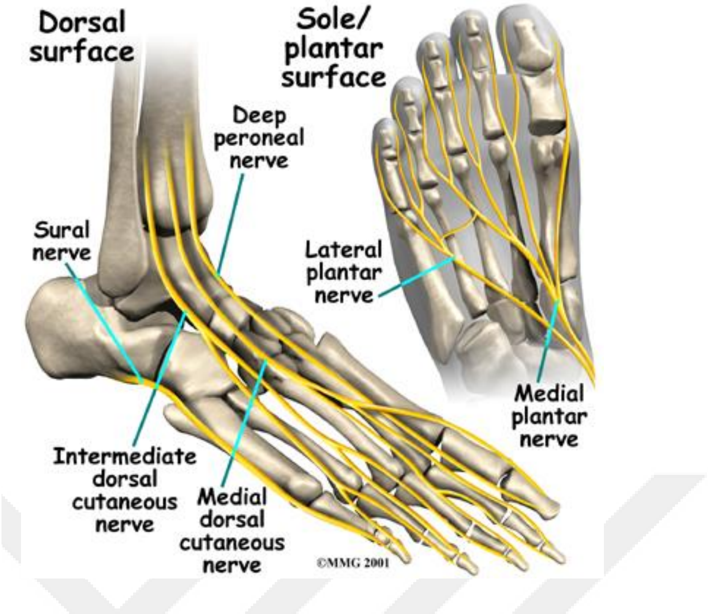

Figure 13: Nerve Supply of the Foot [33]

2.1.14. Blood Supply and Lymphatics

The dorsalis pedalis and posterior tibial arteries are primarily responsible for the blood flow to the foot. The anterior tibial artery continues as the dorsal pedis artery, which anastomoses with the lateral plantar artery to create the deep plantar arch. The dorsal pedis artery supplies blood to the tarsal bones and the dorsal part of the metatarsal, and the deep plantar arch helps to deliver blood to the toes. The posterior tibial artery enters the sole of the foot through the tarsal tunnel. The medial and lateral plantar arteries are formed next. By producing a deep plantar arch, these branches contribute to the blood supply to the toes by providing blood flow to the plantar surface of the foot. These arteries anastomose around the foot joints, resulting in blood flow to the joints. The avascular joint capsule diffuses nutrients from the surrounding blood supply to absorb them. The deep and superficial inguinal lymph nodes get lymphatic outflow from the foot through the popliteal lymph nodes [34].

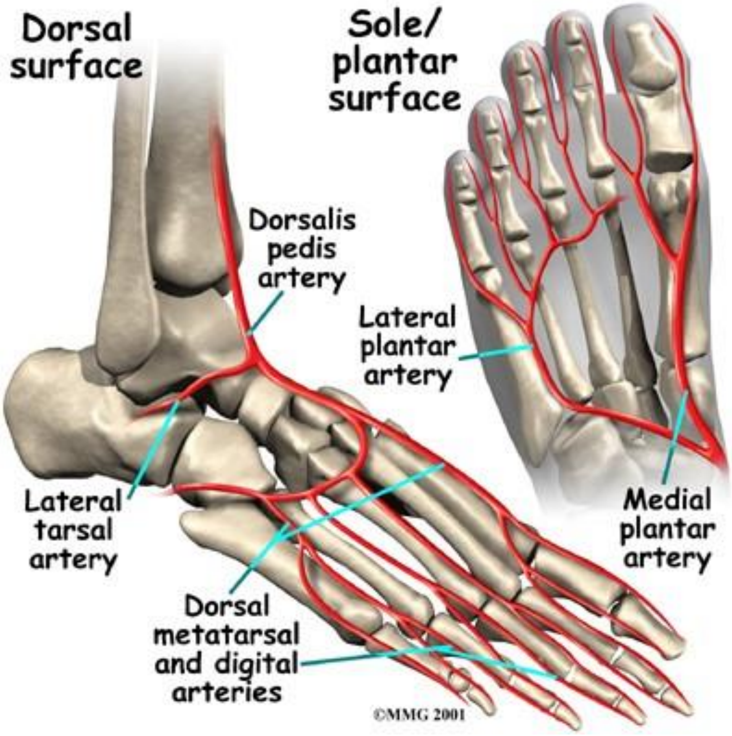

Figure 14: Blood suppy of the Foot [35]

2.2. Ankle Sprains

Ankle sprains are an extremely prevalent condition that affects both athletes and the general public. Furthermore, both primary care physicians and emergency rooms report that these are the most frequent injuries. Ankle sprains occur in a high percentage of patients (partial or complete rupture, stretched ligament). An ankle sprain happens once per 10,000 person-days globally. The annual cost of treating acute ankle sprains is around 2 billion dollars. Ankle sprain injuries can result in long-term impairment for up to 60% of patients. Ankle sprains can make as up to 30% of all injuries in younger, more active patients [36].

An ankle sprain is characterized as an injury to at least one ligament surrounding the ankle joint. Ligaments give the joint mechanical support, proprioceptive information, and directed motion, just like all other ligaments in the human body. Problems in functional instability of the foot and ankle, deterioration of foot kinematics, problems in proprioception can all be effects of recurrent ankle sprains. Repeated ligament injuries can lead to degenerative changes in the bones as well as persistent discomfort, instability, and pain [36].

Many types of classification are used in the literature for grading ankle injuries. The most popular of these is the classification used between grades 1 and 3 used by Kaikkonen et al.

- Grade I: Mild sprain; a minor sprain, strained ligaments without macroscopic tears, minimal discomfort or swelling, no mechanical instability, and no loss of function or movement.
- Grade II: Mild to moderate instability; moderate loss of motion, pain associated with compressive loading, medium sprain, a partial macroscopic tear of the ligaments, and a moderate amount of tenderness, discomfort, edema, and ecchymosis.
- Grade III: Considerable mechanical instability, total ligament rupture, extreme swelling, ecchymosis, soreness, and discomfort, major loss of function and motion, and inability to bear loads severe sprain [36,37].

2.2.1. Medial Ankle Sprain (MAS)

Medial ankle sprains occur when external rotation and forceful ankle eversion combine to cause the DLC disruption. The ligament that acts as the main stabilizer of the medial compartment is the deltoid ligament complex. The DLC's superficial and deep layers, which stabilize the ankle against valgus strain, they also prevent lateral translation and external rotation of the talus. Generally this injury typically occurs in contact with another athletes during competiton. Soccer and gymnastics have highest incidence of MAS [38].

2.2.2. Lateral Ankle Sprain (LAS)

Talocrural plantarflexion and subtalar inversion are two of the LAS mechanism. The ankle mortise and the thinner posterior dimension of the talus contact in the injured posture, reducing the talocrural joint's bone stability. The joint capsule from the lateral malleolus to the lateral talar neck is likewise closely related. Plantarflexion places the ATFL under the most strain, and inversion of the foot makes it more prone to damage. 70% of all LAS patients develop isolated ATFL sprains [39].

The only lateral ankle ligament that is present in both the talocrural and subtalar joints is the calcaneofibular ligament (CFL). The posterior talofibular ligament (PTFL) is stretched in dorsiflexion and relaxed in plantarflexion. This ligament, which starts from the talus and extends to the lateral malleol, is the least damaged ligament in the lateral compartment [38].

Beginning with a thorough and methodical history, a clinical evaluation of the lateral ankle sprains is conducted. A foot inversion and plantarflexion injury mechanism are indicators of lateral ankle injury. It is important to identify the precise location of the pain, whether there is localized or diffuse swelling, mechanical symptoms, and paresthesia [38].

Although the first ankle sprain symptoms disappear rapidly, people continue to experience pain and instability. The chronic ankle instability is caused by these numerous episodes of lateral ankle sprains (CAI) [37].

2.3. Chronic Ankle Instability (CAI)

Chronic ankle instability is a situation last more than 1 year characterized by rebouted episodes or perceptions of the ankle "giving way"; continuing symptoms. These symptoms can be pain, loss of strength, or reduced ankle range of motion (ROM); lacking self-reported function [40].

The earliest investigators of CAI, divided into 2 subgroups: mechanical instability (MI) and functional instability (FI). Although no universally accepted definition of functional ankle instability. Freeman subsequently defined as the tendency for the foot to give way. Evans et al. [43] define functional instability as a subjective complaint of weakness. This definition was extended by Lentell (Lentell G et al., 1990) [44] et al. including pain, feeling the involved ankle less functional than the other ankle, and less functional than before the injury.

Functional ankle instability is carried on by postural control deficiencies, neuromuscular deficits, muscle weakness, and proprioceptive deficits. Mechanical ankle instability is described as pathologic ligamentous laxity about the ankle-joint complex [37].

Tropp et al. [45] differentiated functional instability from mechanical instability by defining it as joint movement that does not need to exceed normal physiological limits but is beyond voluntary control.

Numerous reasons and mechanisms are thought to be responsible for this rise in ankle sprain incidence. Instability, muscle weakness, restricted ankle joint mobility, issues with footwear, and harmed proprioceptors in the ankle ligaments are a few of these contributing variables. According to, although the unconscious proprioception aspect is engaged in joint stabilization during unanticipated perturbations, the conscious proprioception aspect is important in general control during sports and activities of daily living [41].

Hertel et al. also mentioned issues with joint position sensing, muscular strength and balance deficiencies, changed common peroneal nerve function, delayed peroneal muscle reaction time, and decreased range of motion in the dorsiflexion joint [14,42].

2.3.1. Epidemiology

In sports injuries, which make up 10–30% of all injuries, the ankle is the joint that is most frequently harmed. About 2 to 7 people out of every 1000 people in the general population are affected each year [2].

Australian football players experienced ankle sprains 3.1 times out of every 1000 athlete-exposures in the 2016 season. Additionally, Gribble et al. estimated that the average yearly financial burden due to ankle sprains was €208 million in the Netherlands and $6.2 billion for high school athletes in the US. Each ankle sprain costs $1,029 in the US emergency department.

Athletes are also more prone to recurring ankle sprains after suffering one. A repeat ankle sprain occurred in 61, 60, and 46% of volleyball, basketball, and soccer cases, respectively. Nearly 2 year after the initial ankle sprain, 74% of patients with an acute ankle sprain experienced persistent symptoms like pain, weakness, felt instability, and edema [46].

2.3.2. Pathomechanism

Lateral ankle sprains often occur when external rotation of the tibia is accompanied by an inversion motion of the hindfoot. Although this injury is sometimes referred to as an inversion injury in the literature, this definition ignores the oblique movement of the tibia, which is external rotation [40].

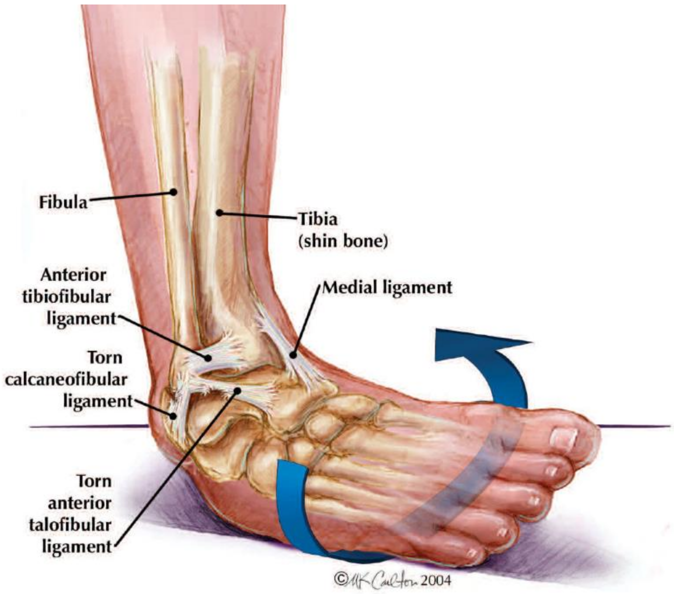

Figure 15: Lateral Ankle Sprain [47]

Although problems accompany many years after injury, up to 72% of these people have difficulty returning to their daily activities. Also, some patients reported that fear of ankle giving way can continiue to worsen over time rather than recovery [37].

Generally, lateral ankle injuries are mostly caused by fall on the lateral aspect of the foot. The CFL ligament is less likely to be involved in the injury, and this injury includes both varus and dorsiflexion. Torsion in the forefoot can cause damage to the lateral calcaneal ligament and talofibular ligament, as well as serious injuries to the bifurcate ligament. Involvement of the calcaneofibular ligament is much less common than other ligaments, due to the dorsiflexion and varus component.

During injury, overstrain of the sural and superficial fibular nerves, which provide capsular innervation, may occur. The lateral or medial rotation of the foot while stationary on the ground forms the rotation component. Rotation is associated with medial or lateral compartments depending on the direction of rotation when the foot is blocked on the ground. This mechanism of injury is the cause of fibrous entrapment and some osteochondral lesions and may include tibiofibular syndesmosis. Forced plantar flexion may cause a lesion in the anterior capsule as well as affect the anterior fibers of the lateral and medial collateral ligament [48].

According to Freeman et al.'s theory, functional deficits occur in afferent receptors located in the joint and ligament after trauma. This concept can be referred ‘‘articular deafferentation’’. Any ankle sprain can cause disruption not only in collagenous connective tissues but also in sensory mechanoreceptors. The impairments of the sensory receptors was believed to create proprioceptive deficits and restrain the central nervous system's accurate perception of where the ankle joint was in space. It is thought that problems in sensory receptors may cause proprioception deficits. As a result, a "giving way" feeling occurs due to hypersupination and peroneal muscle weakness [42].

2.3.3. Risk Factors

Risk factors can be categorized as intrinsic and extrinsic risk factors.

2.3.3.1. Intrinsic Risk Factors

Intrinsic risk factors for CAI are: age, gender, prior injuries, aerobic condition, limb dominance, flexibility, reaction time, postural stability, decreased balance, anatomic alignment, foot and ankle morphologic characteristics, coordination and cardiorespiratory endurance, and inadequate rehabilitation are intrinsic risk factors for CAI. In addition to this, the following intrinsic risk factors and how they affect CAI can be mentioned: [49]

- Restricted ankle dorsiflexion range of motion: Influence a variety of dynamic activities, including squat and step biomechanics in healthy adults, running and landing mechanics, and balance in elderly people [50].

- Decreased postural control: Frequently utilized to measure sensorimotor function to govern the muscles in the trunk and extremities and maintain balance, postural control requires the integration of somatosensory, visual, and vestibular afferent information as well as appropriate efferent responses [51]

When assessed using dynamic assessment procedures, which look at the ability to maintain stability within the bounds of the base of support during functional activities, postural control impairments have been particularly noticeable in people with CAI [52].

- Reduced ankle proprioception: Freeman et al. suggested that after injury to the nerve and musculotendinous tissue, joint afferents in the supporting ligaments may be impaired, proprioceptive deficits may occur, and in addition to these, decreased joint position sense may occur. The ability of proprioception in the foot and ankle to make postural adjustments in response to appropriate movements is crucial in preventing ankle injury. An individual's ability to sense their position before foot contact is important. Incorrect positioning and contact time are important in preventing ankle sprains. This incorrect positioning may be due to proprioception losses in inputs from mechanoreceptors [42].

- Body mass index (BMI): In both gender, a greater BMI is linked to a higher risk of CAI, and those who are underweight have a different relationship than those who are at a healthy weight [49].
- Reduced strength: It's commonly believed that peroneal muscle weakening causes lateral ankle instability, and that evertor muscles are crucial for preventing ligamentous injuries. The lateral ligaments are thought to be supported by the peroneus longus and brevis muscles because of their strength [42, 51].

These elements could weaken the peroneal tendons' capacity as a dynamic ankle stabilizer. This delayed process increases the risk of injury to the lateral ankle ligaments by taking longer to respond to changes in ankle position.

2.3.3.2. Extrintric Risk Factors

The extrinsic factors for CAI as follows:

- Type of sports: Field sports have the greatest rates of lateral ankle sprains such as soccer, volleyball and basketball.
- Level of competition.
- Footwear.
- Use of ankle braces and tape.
- Playing surface: It should be natural grass rather than artificial [38, 49].

2.3.4. Sign and Symptoms

The most common sign and symptoms that occur after ankle injuries can be listed as pain, difficulty in weight bearing weight, tenderness, swelling around the ankle and ecchymosis.

Patient history and physical examination constitute the first stage of ankle injury. In the first evaluation, it starts with the patient's history to understand the mechanism of injury and continues with ligament evaluations. This assessment is important for understanding the severity of the injury because complete tears present with sudden swelling, difficulty in physical activity, and difficulty bearing weight [36].

Chronic regional pain syndrome, neuropraxia, sinus tarsi syndrome, tendon disorders like peroneal tendinopathy, subluxation or dislocation, impingement syndromes, and fractures such anterior calcaneal fracture are additional related pathologies that may coexist with chronic ankle instability [2].

2.3.5. Assessment

Assessment should include the basics of any peripheral joint examination. Any deformity or asymmetrical changes pointing a fracture or dislocation should be examined. After an acute ankle sprain, edema or ecchymosis may be evident. Examining the lower limb for any hindfoot varus shift—where the heel stance is slightly inward—is necessary for chronic ankle instability. The midfoot cavus, ligament laxity, high arch of the foot, peroneal muscular testing, and hindfoot movement should all be assessed during the physical examination [2].

Foot and lower extremity evaluation while standing can help identify biomechanical risk factors. Palpation is very important for deciding whether imaging should be performed on the ankle examination.

Evaluation of the subtalar joint should be done bilaterally for comparison of both feet. Inversion and eversion angles vary from person to person. Manual muscle testing of for all movement of ankle should be assessed. In addition to these evaluations, special tests for the ankle can be applied [38].

2.3.5.1. Anterior Drawer Test

The anterior drawer test determines whether the talus has anteriorly subluxed from the tibia. The therapist provides a gentle and forceful anterior force to the heel while maintaining the foot in a neutral position with one hand and stabilizing the leg with the other. Comparing the result with uninjured side can be helpful for determination of ATFL tear [36].

2.3.5.2. Talar Tilt Test

This test evaluates excessive inversion of the injured ankle. The inversion force is applied to the ankle while it is in the neutral position and contrasted to the side that is unharmed. A positive test results in a ruptured CFL [36].

2.3.5.3. Eversion Stress Test

To assess the deltoid ligament, an eversion stress test is performed. The calcaneus is twisted laterally with one hand while the patient's leg is stabilized with the other while it hangs from the examination table [36].

2.3.5.4. External Rotation Test

With the ankle in a neutral posture and the knee flexed 90 degrees, the external rotation test is carried out. The examiner twists the foot outward while holding the ankle proximally steady with one hand and grasping the plantar of the foot with the other. Pain implies a syndesmotic sprain [36].

2.3.5.5. Squeeze Test

The leg is gently squeezed from the both sides at the gastrocnemius region during the test; discomfort denotes syndesmotic damage [36].

2.3.6. Treatment of CAI

The management of CAI can be grouped as surgical and conservative treatment. In both treatments, the goal is to restore normal function and regaining strength of the ankle. Also to stop future repetitive injuries are the main goal of rehabilitation and progressive treatment program suitable for the ankle is important. Although some patients believe that the relief of pain and descreasing of swelling symptoms is sufficient to return to physical activities, the likelihood of this condition becoming chronic and recurring increases in patients who do not complete an adequate rehabilitation program.

2.3.6.1. Surgical Approach

If the patient did not get positive results from other treatment methods, surgical method is recommended. The main task of three types of operations is to repair and reconstruct anatomical structures of unstable ankle. Anatomical repairs at 85% of patents had satisfactory and outstanding results [53].

By using tendon transplants or local tissues in anatomic reconstruction techniques, the damaged ligaments are restored. The most popular method is the Broström technique, which also involves repairing the ATFL and CFL commonly [2].

2.3.6.2. Conservative Treatment

2.3.6.2.A. Acute stage

Conservative treatment of lateral ankle sprains is mainly applied as cold application (cryotherapy) and early mobilization. The most commonly used treatment protocol for ankle injuries is the PRICE method in the acute stage. In the randomized control study of Vuurberg et al., [56] it was found that cold application did not have a significant effect on pain, function, and swelling in acute ankle injuries. Another randomized controlled trial by Bendahou et al. [108] compression stockings and non-compressive placebo were compared and no significant results were found around the pain or ankle circumference. Correcting imbalances between the injured and uninjured ankle and restoring normal function should be the primary goal in LAS rehabilitation. The main goal and focus of rehabilitation is to increase strength, balance and restore gait pattern.

Nevertheless, the use of PRICE is a reasonable intervention in the first phase of the injury. Other physical theray agents such as ultrasound and electrical stimulation can be used for recovery.

2.3.6.2.B. Therapeutic Modalities

Ultrasound (US): It was found that, After 7 days of injury, ultrasound and sham ultrasound showed no overall improvement in symptoms or disability, although after 14 days ultrasound was found more effective than immobilization.

Contrast Bath: this method includes applying hot and cold alternately and is effective in increasing circulation and decreasing swelling.

Electrical Stimulation: A biphasic current called a transcutaneous electrical neuromuscular stimulator (TENS) stimulates sensory neurons to block the pain-signaling pathway and to increase endorphin synthesis, which restores normal sympathetic function [36].

Theories have indicated that acute damage encourages arthrogenic inhibition, where pain and inflammatory symptoms block the activation of the stabilizing musculature, and chronic symptoms inhibit sensory output to the CNS due to deafferentation and relaxation.

Needle et al. studied twenty participants and evaluated reflexive and corticospinal excitability of ankle muscles, dynamic balance, and side hop test performance. NMES or TENS was applied to the ankle pronators for 5 sessions. The results suggest that, TENS modified neural excitability and may be capable of neuromodulation, rehabilitation exercises are recommended to provide a permanent treatment [54].

2.3.6.2.C. Immobilization and Bracing

Studies recommend that early mobilization with bracing and taping rather than rigid immobilization. Kerkhoffs et al. [55] found that rehabilitation programs that included both early mobilization and functional support of the ankle had a shorter return to sport as well as a greater decreasing in swelling and radiographic instability compared to immobilization. Some researchers have found that short term of immobilization (0-10 days) can help reduce pain and edema [56].

2.3.6.2.D. Manual Therapy

Adding manual therapy techniques to the treatment programs reduces pain in ankle sprains and accelerates functional recovery. Loudon et al. [109] suggested that the ankle dorsiflexion angle increased, the stride length increased, and the pain decreased with manual therapy methods. When we examined the randomized controlled study of Cleland et al., [110] the addition of manual therapy to the treatment programs caused an increase in foot and ankle capacity, an increase in LEFS score, and a decrease in pain values in the 6-month follow-up period. Considering mentioned findings, manual therapy techniques can be added into ankle sprain rehabilitation programs [38,56].

2.3.6.2.E. Exercise

The most commonly used exercise methods in individuals with CAI, strenghtening, balance exercises on different surfaces, proprioceptive exercises and neuromuscular training exercises [3, 4].

Weight-bearing exercises are widely employed to promote functional activity in the closed kinetic chain. In order to improve neuromuscular control of the injured ankle, rehabilitation should support the recovery of voluntary control over reflex responses, normal reflex responses, and normal patterned movements of the lower extremity [57].

After the injury, safe and efficient neuromuscular and proprioceptive training programs can be used for recovery process as tolerated. Alteration of neuromuscular activation patterns after ankle injury causes functional instability, changes in gait and increases the risk of repetitive injury.

When compared to traditional RICE therapy, early neuromuscular retraining within the first week after injury leads in higher activity levels without increasing pain, edema, or the rate of re-injury. Proprioceptive exercises significantly improved ankle functional outcome measures such the SEBT and FADI, according to (Functional Ankle Disability Index). Programs for neuromuscular retraining help to lower the incidence of repetitive trauma injuries and functional instability.

These initiatives attempt to raise functional outcome scores, muscle reaction times, and awareness of ankle joint position. Up to 12 months after an initial ankle sprain, they reduce the frequency of subsequent ankle sprains [42]. According to research by Wester et al., injured patients who followed a 12-week balance and proprioceptive training protocol were more than twice as likely to avoid a subsequent LAS than those who did not [111].

Balance exercise programs include single and double foot exercises on different surfaces and contribute to the development of proprioception. Tandem and progressive wobble board exercises can be used on uneven surfaces. Closed kinetic chain exercises are more effective for lower limbs for demanding the dynamic and reflexive aspect of proprioception. In upper extremities manual resistance also contribute to the proprioceptive input. This resistance can be arranged through the rehabilitation program and toleration of patients. Sports specificity training in rehabilitation program should be incorporated into proprioceptive concept [58, 59].

According to Urguden et al. [60], strengthening the muscles around the ankle following sprains, particularly in patients with chronic instability, facilitated the patients' return to regular life and sporting activities and helped avoid pointless surgery, particularly in situations with functional instability.

Han and Ricard [61] looked at how well a resistance training with band during four week program affected patients with and without a history of ankle sprains in terms of ankle-evertor strength and peroneus longus latency. They found that the peroneus longus's reflex latency and ankle-evertor strength did not change as a result of a four-week resistance exercise with band program [62].

2.4. Balance

The capability to maintain one's center of mass (COM) within the boundaries of their base of support is known as balance [63]. For useful daily activities, such as walking and functional mobility, as well as standing up, one must be able to balance [64].

A key element of motor skills, including posture maintenance and the execution of complicated tasks, is balance, which can be static or dynamic. Dynamic balancing refers to maintaining equilibrium while moving or regaining equilibrium after changing positions quickly and sequentially. Integration of sensory data from the visual, vestibular, and somatosensory systems is necessary for both static and dynamic balance (Shupert, Lindblad, & Leibowitz, 1983) [65].

Impairment of balance can be caused of musculoskeletal injury, head trauma, disease or ageing (Kinsey et. al., 1998) [66]. (Olmsted et al. 2002) and as a result of inadequacies, everyday functioning may be impaired [67].

When performing weight-bearing movements like standing, walking, hopping, jumping, and sprinting, balance is the interaction and harmony of automatic postural and voluntary motor movement of the trunk and limbs (muscles and joint sensation). Both trunk and leg inputs influence instinctive postural responses, and the central nervous system (CNS) makes anticipatory postural modifications when it anticipates automatic postural sways [68].

Unfortunately, any change in foot position or posture, or inability to adapt to the ground being stepped on, can cause an injury mechanism. As mentioned before, the ankle is the most frequently injured joint, and this acute problem can become chronic over time if not treated.

The position of the center of pressure depends on the position of the ankle joint and the activity of the leg muscle because the ankle joint plays a significant role in maintaining balance (plantarflexor and dorsiflexor). Patients with functional ankle instability will have trouble maintaining their balance when standing unilateral [41].

It is unknown how unilateral or bilateral CAI impacts the contralateral limbs and the sensorimotor system's spontaneous self-organization. Individuals with unilateral CAI showed mild balance abnormalities in the unaffected limb, according to explained variations in the descending pattern as the result of changes in central programming at the spinal level. "Using the double leg posture can highlight potential weaknesses in central programming and highlights the relationship between the involved limb and overall control in people with CAI [69].

Balance studies, according to Hale and McKeon, can be used as a preventative measure to decrease the frequency of initial ankle sprains or as a beneficial treatment to reduce recurrent ankle sprains after an initial acute ankle injury [70, 71, 72].

2.5. Proprioception

Afferent input of joint position sensation and awareness of stationary position and movement is known as proprioception. It is also regarded as a neuromuscular control condition [73].

Proprioception is component of somatic senses. Basically, three somatic senses:

1- Pain Sense
2- Thermoreceptive Sense
3- Mechanoreceptive Sense (Tactile and position sense)

Propriception include 2 types of position sense: static and dynamic. Static sense is concered with orientation of different body parts together. However dynamic sense or kinesthesia, let neuromuscular system feedback for the movement. This system can be explained as firstly, afferent input is assessed by the neuromuscular level then efferent output provide body to sustain movement on static and dynamic activities. Proprioception is also feedback system by which the body maintain the postural awareness during changing position, weight and resistence. While conscious proprioception is related to appropriate function of joint during activities, unconscious proprioception is about initiation of reflex stabilitation through muscle receptors [74].

Standing without using eyes while your vestibular system is healthy mostly depends on the numerous proprioceptive sensors operating normally. Ligamentous mechanoreceptors, Golgi tendon organs, and muscle spindles all transform mechanical distortion of the surrounding connective tissue into proprioceptive information [75].

Additionally, it involves both central and peripheral systems. Primer proprioceptive receptors are recognized as specific muscle spindles. Specialized fibers called receptors found inside muscle spindles control changes in muscle length and contraction speed. Whether a muscle is subjected to passive lengthening, spindle exafferent impulses are generated and perceived as a movement feeling, with rising velocities leading to an increasing reaction. The spindle mechanism is capable of anticipating the length change brought on by sensed velocity. Additionally, the direction of motion can be determined by looking at which muscles are contracting or lengthening.

It is proposed by [107] that cutaneous sensors also aid in the perception of joint position and motion. Joint structures also contain receptors that resemble cutaneous receptors. For instance, menisci and ligaments are slow adapting mechanoreceptors, whereas ruffini terminals are more superficially placed in the joint capsule. It results in the preservation of the intra-articular pressure, static joint position, and maybe joint mobility with reference to amplitude and velocity. In the connective tissues of the joints, Pacinian corpuscles are located deeper and have a lower mechanical threshold. They also adapt more quickly, making them more responsive to changes in velocity, specify force, determine joint motion (speed and direction), and perceive, produce, and forecast joint position [74].

2.5.1. Clinical Implications of Proprioception

Proprioception, along with other senses, is crucial for feedback and feedforward operations in motor control and can be employed alone or in conjunction with other senses. Proprioceptors play a part in motor planning and adaptation mechanisms that result in performance changes as a task is being carried out (feedback).

Due to the lack of feedbacks for adaptation, this makes it difficult to acquire new movements, develop movement quality, and manage over a number of repetitions. As soon as a stimulus is present, neuromuscular control processes it and produces an easily usable reactive efferent output [76].

2.6. The Term of Lumbopelvic Stabilization

The phrase "lumbopelvic stability" refers to the maintenance of ideal alignment of body segments with the spine, pelvis, and lower extremities. Both in a stationary position and during dynamic action, lumbar and pelvic stability must be maintained. Spinal muscles are crucial for lumbar stabilization, may be impacted by problems with the spinal column and disrupt lumbopelvic stabilization [77].

2.6.1. Lumbar Stabilization and Core Concept

The core stabilization program focusus on specific deep or local stabilizing muscles of the spine, sustaining the lumbar area in a neutral position during exercises also and activities of daily life.

The spinal column, which provides intrinsic stability, dynamic stability, and a brain control unit that evaluates and decides the stability and coordination needs of the muscle response comprise the spinal stabilization system, also known as the core system. The central stabilizing muscles, commonly referred to as the core muscles, are categorized according to their purpose. These are global muscles contributing in trunk movements which are rectus abdominis, erector spinas and external obiliquus and local muscles are transversus abdominis and lumbar multifidus while local muscles are crucial for stabilizing the core. By regulating joint stress, building muscles, increasing resistance, and improving posture, these exercise principles help to stabilize the spine and avoid lumbopelvic injuries [78].

It is now clear that the definition of stability encompasses both static posture and controlled movement. Therefore, tissue damage would result from altered movement patterns brought on by weak strength and flexibility, low endurance, and improper neural control. Ineffective muscle action and impaired spinal structural stability might result from tissue injury.

Described a model for spine stability concept and consist of three components.

1- Bone and ligamentous structures: stability of the spine.
2- Muscles: surround the spine. Muscles supply the support and stiffness at the intervertebral level.
3- Neural control system: coordinates muscular activity in terms of expected and unexpected forces [6].

2.6.2. Muscle Function and Lumbar Stability

TrA and multifidus are two of the muscles responsible for stabilizing the lumbar region of the spine. Multifidus contributes to posture and spinal movement, while TrA is important on thoracolumbar fascia mobility.

Deep and surface fibers are both present in the multifidi. The deep fibers of the multifidi are the first muscles to contract in response to a visual signal when an extremity is moved, and they fire regardless of the direction an extremity moves to govern intervertebral movement.

TrA is the deep muscle that first contracts during trunk movement. It activates when any limb moves and creates stiffness in the spine and SIJ in undesired movements. Other trunk muscles such as internal external obliques, rectus abdominis, iliopsoas also contribute to this spinal stability. Other paraspinal muscles and iliopsoas muscles listed appear to be stimulated to aid stability with direction and load-specific activity. The global muscles cannot provide control over each spinal segment and restricted ability to control shear forces compared with deep stabilizers.

This entire system is interconnected and termed as whole-body balance. The foundations of whole-body equilibrium include intervertebral control, regulation of spinal orientation, lumbopelvic stability, posture, balance, and proprioception [79].

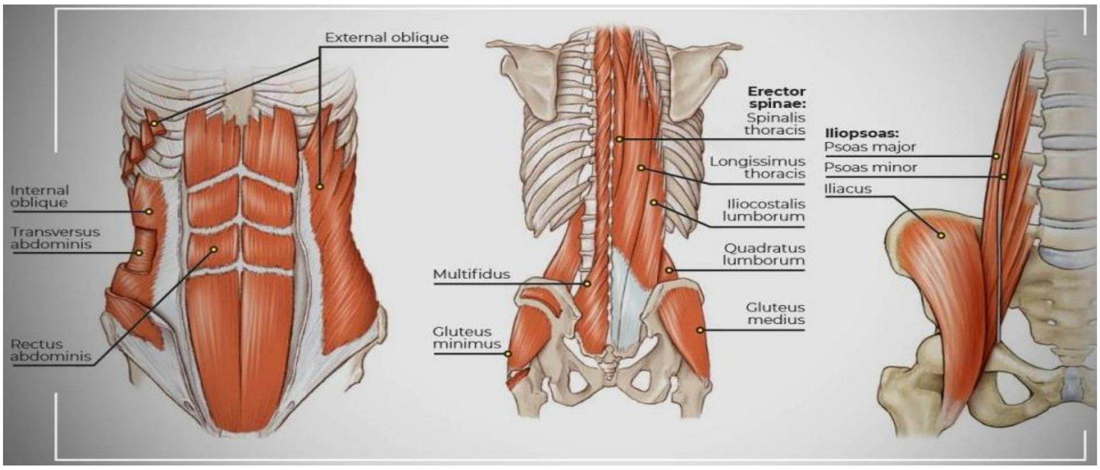

Figure 16: Core Muscles [79]

2.6.3. Stabilization Exercises

Exercises that challenge the spine's stability while enhancing muscle activity patterns and spine posture to offer "adequate stability" are together referred to as stabilization exercises. While sufficient stability is guaranteed, it is not at excessively high levels that would place an unwanted burden on the tissues.

The passive structures of the musculoskeletal system are ligaments, discs between the vertebrae and intra-articular capsules. Active structures form muscle mechanisms. These mechanisms must work together in order for a balance to occur in the body [80].

According to a study, the greater the need for stabilization of the spine, the greater the need for abdominal and core activation [80]. In one research some lumbopelvic exercises are performed which are; side bridge, abdominal curl, crossed arm and leg extension, sitting on a Swiss ball. They found that both the side bridge and abdominal curl creates highest abdominal activation levels however abdominal curl, bilateral activition of core muscles occur. Greatest level of spinal stability was observed in 4 point kneeling and crossed arm and leg extention [81].

2.6.4. Relationship Between Gluteal Muscle Strength and Lumbar Stabilization

Recovery of the neutral spinal position requires strengthening of the stabilization and abdominal muscles. The ability of the lumbar muscles to stabilize the spine, stabilization of the spine reduces when there is an imbalance between the extensor and trunk abdominal muscles. For example, Individual who have low back problems long time, can exprience decrease trunk activity, inhibition of the reflex muscle contraction mechanism and decrease of activity of the trunk for disuse, muscle atrophy. In this reason these problems may arise secondary damage mechanism. Any clinical problem related to low back problem create decrease in muscle strength, endurance, flexibility and limitation of range of motion.

The lumbar segment is stabilized by deep stabilizer muscles, which are strengthened by deep and superficial core muscles to produce co-ordination activity. In the process of lumbar segmental stabilization, the transversus abdominis (TrA) and multifidus contract more quickly than the other muscles, maintaining a person's body balance during all motions. Lumbar stabilization and segmental exercises can be used to strengthen the lumbar region's stability, and the proper alignment of the trunk and body can be maintained. Lumbar segmental stability is significantly influenced by the capacity of the hip muscles to be controlled voluntarily. The task of the gluteus maximus muscle is to transfer loads from the trunk to the lower extremities via the SIJ [7].

2.6.5. The Tissue Blood Flow After Exercise

The capacity for tissue healing and tissue health depend on tissue blood flow, which is also recommended as a gauge of the physiological consequences of therapeutic interventions. The mechanism underlying the circulatory effects of LPST must be understood. Because it's important to measure the LPS to determine whether LPST has an impact on motor control. 25 subjects were included in the study by. For this study, volunteers with mild to moderate low back pain between the ages of 20 and 55 are chosen. The subjects received three separate experimental lumbopelvic stability training conditions for a total of 15 minutes each, with a 48-hour rest between sessions. These conditions included placebo (passive cycling) and control (rest).

The results of this study showed that one session of lumbopelvic stability training can modify the physiology by increasing tissue blood flow. By giving tissues with more oxygen, nutrients, and hormones while also eliminating waste items, increasing tissue blood flow may aid in the healing process. Lumbopelvic stabilization exercises provide specific core training, restore motor control, induce inter-segmental stiffness, prevent shear force, and increase circulation. This reasons prevent the occurence of injury. In this research, significant improvement has found in the tissue blood flow among patients who practiced lumbopelvic stabilization exercises specifically [82].

2.7. The Term Thoracic Spine and Mobility

The thoracic spine is the longest part of the spine, located between the lower back and neck and consist of 12 vertebrae. Although its primary task was designed to be stability and power absorption, the thoracic spine has a wide range of motion and its mobility is vital to overall health and function [100].

Thoracic mobility plays a large role in posture, standing upright, and full breathing. Inactivity in this area can cause stiffness, pain in the neck or lower back, difficulty breathing, reduced range of motion and has a profound effect on the forces that affect the rest of the body [101, 102, 103].

Thoracic spine mobility is important for maintaining optimal posture; this allows the organs to function optimally while reducing the pressure on the lower back and lower extremity. Some studies in the literature have found that thoracic mobility is associated with conditions such as neck and low back pain. In addition, some studies have investigated how the angle of thoracic kyphosis affects balance [104, 105, 106].

3. MATERIALS AND METHOD

This study is randomized-controlled trial and conducted at Noi Physio Pilates Studio between November 2022 and January 2023 to investigate the effect of thoracic mobility or lumbopelvic stabilization exercises in patient with chronic ankle instability in terms of dynamic balance, flexibility and proprioception.

3.1.Subjects

A total of 30 patients between the ages of 20 and 45 were volunteered in this study. Participants were included in this study voluntarily. Each participants was informed about study plan and purpose then signed the consent form. Participants were selected in this study based on the CAIT questionnaire and who get 27 points or less from this questionnaire. Participants were divided into two groups randomly. This randomization is computer-based randomization and will be done via https://www.randomizer.org [112].

The estimated sample size his study was calculated by changing scores of CAIT used by a similar study after six weeks balance training [83].

As a result of the Power analysis using the G*Power program, when the effect size d (effect size): 1.077 is taken, it can be determined for Power:0.80 and α:0.05. The number of samples taken was determined as a minimum of n=15 individuals for each group.

3.1.1 Inclusion Criteria

- Being 20-45 year-old.
- Having at least two previous lateral ankle sprain of same ankle.
- At least one episode of "giving way" wtihin previous 6 months.
- Having persistent symptoms during functional activities and being free of.
- Symptoms from any previous lower limb injuries.
- No other lower extremity injuries.

3.1.2. Exclusion Criteria

- Having any systemic illness (eg. Rheumatoid arthritis, DM).
- Any surgery history related to fractures or disorders.
- Getting steroid injection or physiotherapy intervention previous 6 months.
- Being a pregnant and existence of tumor.

3.2. Flow of Research

Ethics committee approval required for this study was obtained from Marmara University Non-Interventional Ethics Committee with protocol number 92. Participants involveld in the study on a voluntary basis and written informed consent form was obtained from all subjcets who accepted the study (Appendix 1,2). Total of 30 subjects participated in research and all of them completed the rehabilitation program. The flow chart of the patients included the study is shown in Figure 17.

Participant were divided into 2 groups randomly and in additon to the rehabilitation protocols, each participants was given home exercise program including ankle strenghtening exercises. Home exercise program was prescribed as 3 times a week. First group was received thoracic mobility rehabilitation exercises and second group was received lumbopelvic stabilization exercises in supervision of physiotherapist twice a week for 8 weeks (16 sessions total).

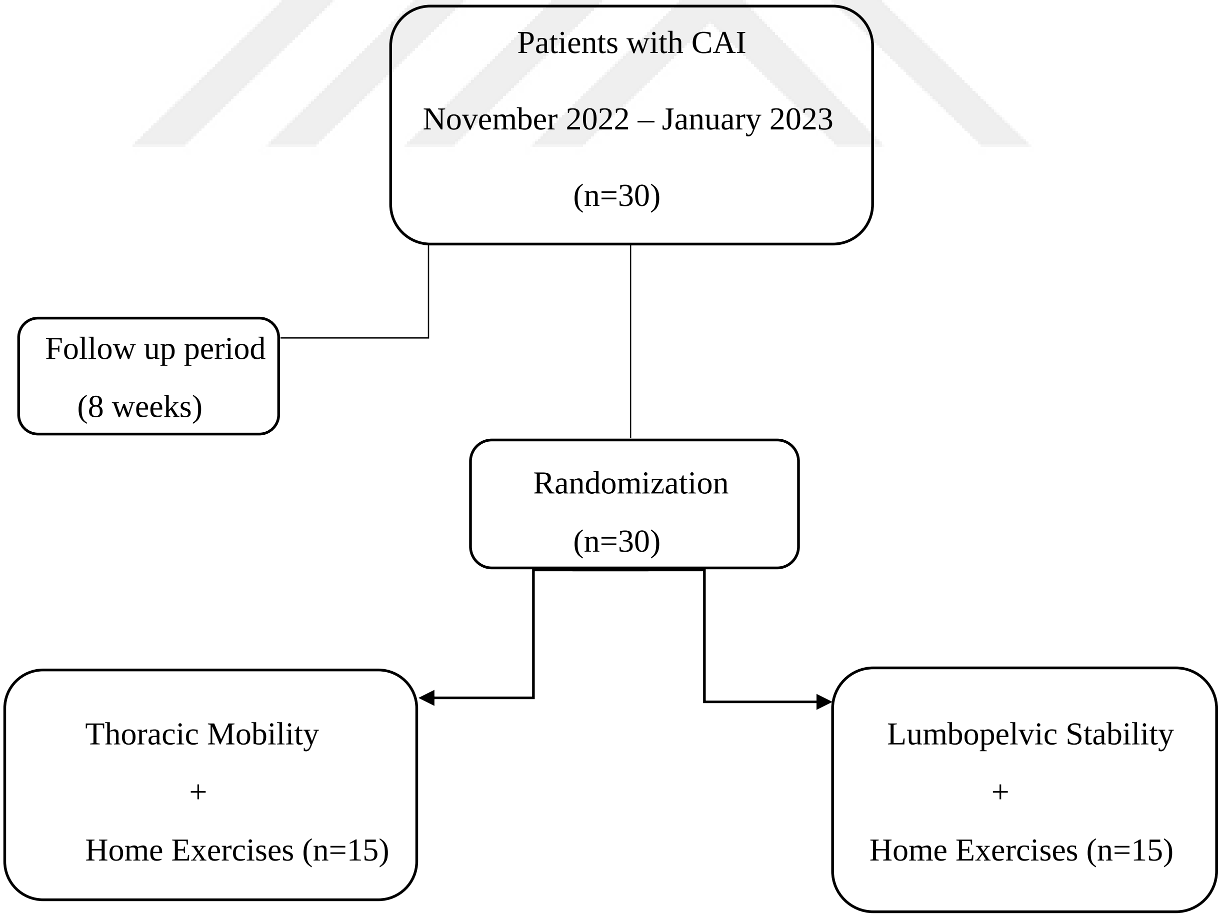

Figure 17: Flow of Chart

3.3. Study Protocol and Design

The participants were explained about purpose and content of the study according to consent form. Demographic information and consent form were filled in by all subjects who volunteered to participate the study. After the evaluation, participants were divided into 2 group which is thoracic mobility and lumbopelvic stabilization rehabilitation group. Same home exercises are given into both groups including ankle strengthening exercises with resistance band. Before starting to rehabilitation protocols, Y balance test, Active Straight Leg Raise Test and Joint Position Sense test were assessed for each participant. After the evaluation, participants were divided into 2 group which is thoracic mobility and lumbopelvic stabilization rehabilitation group. All sessions took 50 minutes, twice a week for 8 weeks and completed under the supervision of physiotherapist. Thoracic mobility exercises are thoracic extention on foam roller, sidelying thoracic rotation, quadruped thoracic rotation, squat with extention and rotation and lumbopelvic stabilization exercises are bridge with alternate leg, single leg bridge, four point kneeling with arm and leg extention, side plank on front arm with knee flexed (right,left) and sitting on a swiss ball and hip flexion.

3.4. Evaluation

Participants were evaluated pre treatment and post treatment (8 weeks) rehabilitation protocols and results were recorded. Measurements were made with electoronic goniometer for range of motion of ankle and hip joint. Moreover, Y balance test was used for assessing dynamic balance and joint position sense was used for ankle proprioception.

3.4.1. Demographic Information Form

Demographic Information Form were filled by participants and includes questions about age, gender, occupation, socio-demographic conditions, existing chronic disease, previous surgical condition and injuries, smoking and alcohol habits and exercise behaviors (Appendix 8.3).

3.4.2. Cumberland Ankle Instability Tool (CAIT)

Hiller et al developed the Cumberland Ankle Instability Tool (CAIT), which demonstrated high content validity and reliability. The questionnaire's main advantage is that it only has 9 items with scores ranging from 0 to 30, with lower scores indicating worse stability. A cutoff score of less than 27 in the test indicates chronic ankle instability. Because it has multiple answer options, the instrument's precision is increased. The CAIT uses a numeric value to assess the severity of instability and can be completed for both the left and right ankles, allowing you to assess both ankles separately [84]. (Appendix 8.5)

3.4.3. Y Balance Test

The Y Balance Test is a reliable and valid test that assess dynamic balance with reaching in 3 directions. The participants reach with one foot in anterior, posteriomedial, and posterolateral directions as far as possible while standing on the other foot on center. The angles between posterolateral and posteromedial should be 90 degrees. The participants are instructed as their hands on their pelvis and barefoot while conducting the test. They were asked to lie down 3 times in each direction and the these values were averaged for data analysis. The test was considered invalid if the person was unable to return from the point they were lying down, lifted their hands from their pelvis, and lost their balance [85].

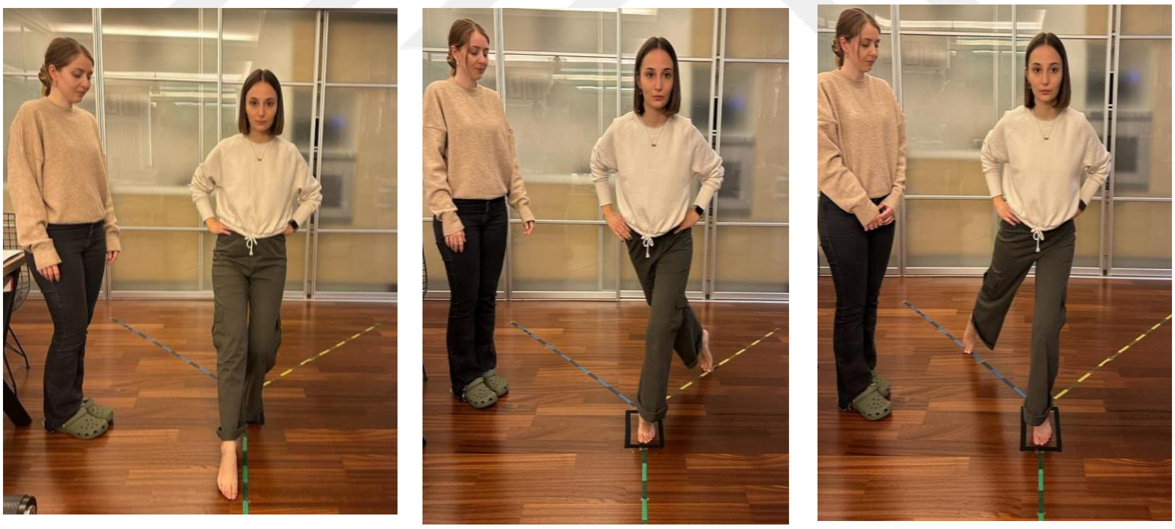

Figure 18: Y balance Test Anterior, Posterolateral and Posteromedial

3.4.4. Active Straight Leg Raise Test (ASLR)

Participants in the ASLR test were told to voluntarily elevate their right leg off the table as far as they could while maintaining a straight knee. Hip flexion was used to raise the right leg so that the heel was above the table, and it was kept there for around 5 seconds. A goniometer was used to measure and record the participant's hip flexion angle while they were in this position [86].

Figure 19: Active Straight Leg Raise Test

3.4.5. Joint Position Sense Test

Joint position sense test (JPS) is clinically the most applied test for assessing the proprioception of the limbs. The JPS can be defined as the awareness of the actual position of the extremity. Oftenly, JPS can be used in many joints in the body such as knee, elbow, ankle, hip and spine [99].

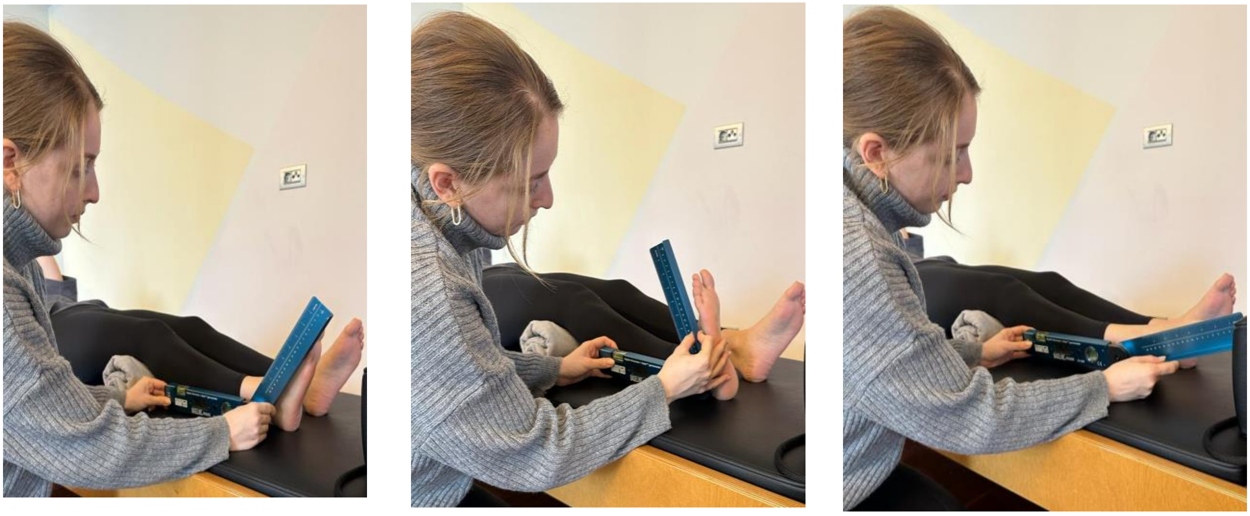

Figure 20: JPS Assessment

During this test, while the participant is lying on their back with eyes open, the related joint is passively brought to the specified angle and held in this position for 5 seconds. This process is repeated 3 times. After waiting for 30 seconds, the participant is asked to actively move it to the position closest to this angle. This angle is measured and recorded with a goniometer. Measurement of proprioception of lower extremity, joint position sense test is going to perform for hip, knee and ankle. Determined angles for joints; hip flexion angle as 75° , knee flexion angle as 50° and ankle dorsiflexion as 10° plantarflexion as 40°.

3.5. Rehabilitation Protocols and Invervention

After the assessments previously mentioned, participants were divided into 2 groups randomly. Each group was taken specified exercises twice a week for 8 weeks. Specified exercises were prescibed as 2 sets of 10 repetitons. Also home exercise program was given in addition to rehabilitation protocols as 3 sets 10 repetitons three days a week.

3.5.1. Group 1: Thoracic Mobility Rehabilitation

- Thoracic extention on foam roller: The participant is positioned in the supine with the knees are semi-flex. The foam roller is placed in the mid-thoracic region and asked to thoracic extention without moving their lumbar spine.
- Sidelying thoracic rotation: The participants are requested to lying on one side (both side should be perfomed) with a support under their head. Both knees are in a flex position. Without separating or moving lower extremity, they were asked to rotate their trunk with the help of his upper arm and perform thoracic rotation.
- Quadruped thoracic rotation: the participant stands in a four-point kneeling position with one hand behind the head for supporting. They done a thoracic rotation by turning his torso and head.
- Squat with extention and rotation: In a deep squat position, the participant reaches upwards and turns with one arm.

Figure 21: Thoracic Extention with Foam Roller

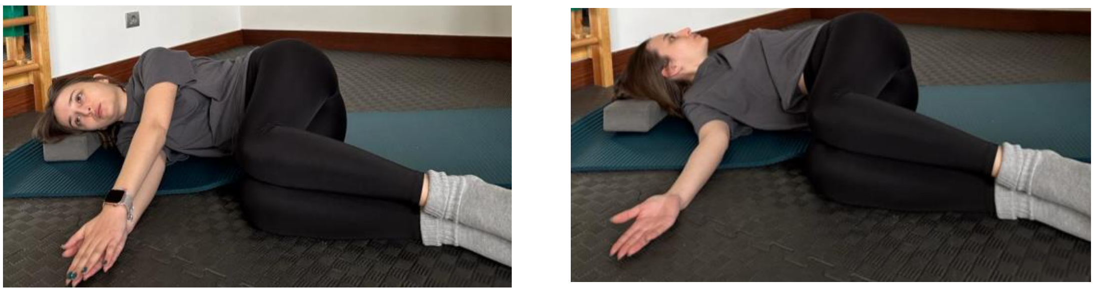

Figure 22: Sidelying Thoracic Rotation

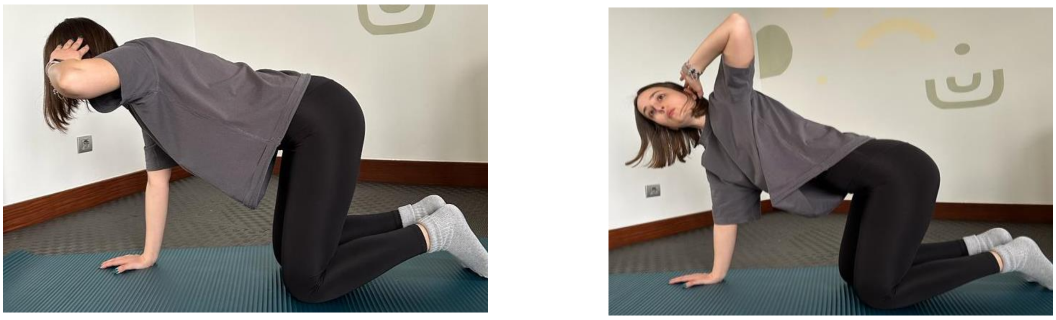

Figure 23: Quadruped Thoracic Rotation

Figure 24: Squat with Extention and Rotation

3.5.2. Group 2: Lumbopelvic Stabilization Rehabilitation

- Bridge with alternate leg: The participants is requested to bring their legs into table top position (hip and knees are in 90°) during bridge exercise while keeping their pelvis neutral.
- Single leg bridge: The bridge exercise is performed with one leg, while other one in extended position. Both limb should be perfomed.
- Four point kneeling with arm and leg extention: In four point kneeling position crossed arm and leg is extended while neutral pelvis position. Trunk should be stabilized as much as possible.
- Side plank on front arm with knee flexed (right, left): While lying on one side, legs are in semi-flexion. The elbow should be placed directly under the shoulder and head is directly in line with spine. Other arm can be aligned along the upper side of body.

- Sitting on a Swiss Ball and hip flexion: During this exercises participants are requested to sit on Swiss Ball with neutral spine and pelvis position with stretching arms across. Without moving their pelvis, hip flexion is instructed one by one.

Figure 25: Bridge with Alternate Leg

Figure 26: Single Leg Bridge

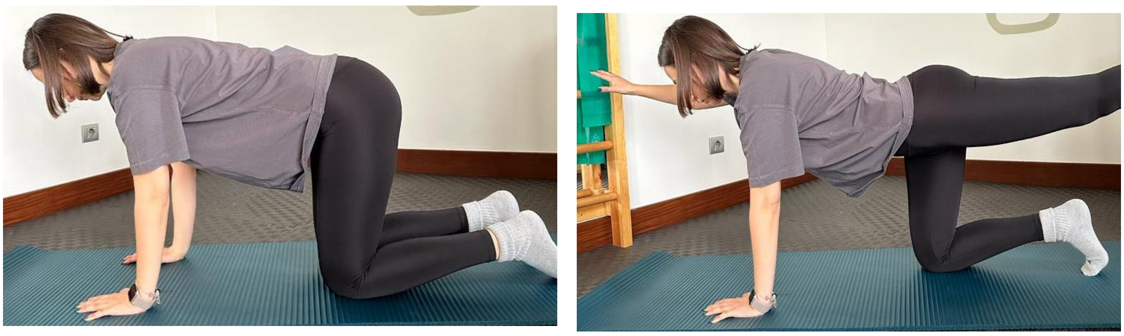

Figure 27: Four Point Kneeling with Arm and Leg Extention

Figure 28: Side Plank on Front Arm with Knee Flexed

Figure 29: Sitting on a Swiss Ball and Hip Flexion

3.5.3. Home Exercises

Ankle strengthening exercises were given jointly for both groups. These exercises were performed with a resistance exercise band include all the movements of the ankle (dorsiflexion, plantarflexion, inversion and eversion), were performed 3 days a week for a total of 3 sets of 10 repetitions.

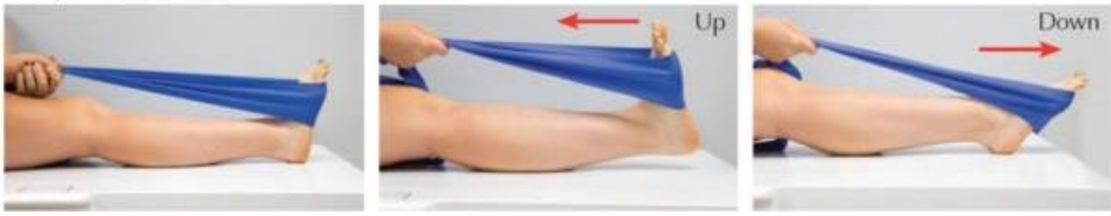

Figure 30: Dorsiflexion and Plantarflexion Strenghtening [87]

Figure 31: Eversion and Inversion Strenghtening [87]

Table 1. Exercise Protocol of Thoracic Mobility Group (Group 1)			
Name Of Exercises	**Repetition/Set**	**Intensity**	**Duration**
1)Thoracic Extension	10 reps x 2 sets	Twice a week	8 weeks
2)Sidelying Thoracic Rotation	10 reps x 2 sets	Twice a week	8 weeks
3)Quadriped Thoracic Rotation	10 reps x 2 sets	Twice a week	8 weeks
4)Squat With Extension and Rotation	10 reps x 2sets	Twice a week	8 weeks

Table 2. Exercise Protocol for Lumbopelvic Stabilization Group (Group 2)			
Name of Exercises	**Repetition/Set**	**Intensity**	**Duration**
1)Bridge With Alternate Leg	10 reps x 2 sets	Twice a week	8 weeks
2)Single Leg Bridge	10 reps x 2 sets	Twice a week	8 weeks
3)Four Point Kneeling With Arm and Leg Extension	10 reps x 2 sets	Twice a week	8 weeks
4)Side Plank on Front Arm With Knee Flexed	10 reps x 2 sets	Twice a week	8 weeks
5)Sitting on a Swiss Ball and Hip Flexion	10 reps x 2 sets	Twice a week	8 weeks

Table 3. Home Exercises for Both Groups			
Name of Exercises	**Repetition/Set**	**Intensity**	**Duration**
1)Dorsiflexion Strengthening	10 reps x 3 sets	Three days a week	8 weeks
2)Plantarflexion Strengthening	10 reps x 3 sets	Three days a week	8 weeks
3)Inversion Strengthening	10 reps x 3sets	Three days a week	8 weeks
4)Eversion Strengthening	10 reps x 3 sets	Three days a week	8 weeks

4. RESULTS

Table 4. Demographic Details of the Participants*

Variable (N=30)	N	%	Mean±Stan. Deviation
Sex			
Female	21	70,0	
Male	9	30,0	
Total	30	100,0	
Doing Sports			
No	1	3,3	
Yes	29	96,7	
Total	30	100,0	
Type of Sports			
Not doing sports	1	3,3	
Swimming	4	13,3	
Pilates	25	83,3	
Total	30	100,0	
Education			
High School	1	3,3	
Undergraduate	24	80,0	
Postgraduate	5	16,7	
Total	30	100,0	
Systemic			
No	30	100,0	
Taking Medicine			
No	21	70,0	
Yes	9	30,0	
Total	30	100,0	
Using Alcohol			
No	5	16,7	
Yes	25	83,3	
Total	30	100,0	
Smoking			
No	13	43,3	
Yes	17	56,7	
Total	30	100,0	
Surgical History			
No	24	80,0	
Yes	6	20,0	
Total	30	100,0	
Sprain History			
Yes	30	100,0	
Number of Sprains			
2	18	60,0	
3	9	30,0	
4	3	10,0	
Total	30	100,0	
Sprains in the Last 6 Months			
No	17	56,7	

Yes	13	43,3	
Total	30	100,0	
Feeling of “Giving way” in the Foot in the Last 6 Months			
Yes	30	100,0	
Foot having Discharge			
Right	16	53,3	
Left	14	46,7	
Total	30	100,0	
Extremity Injuries in the Last 6 Months			
No	30	100,0	
Age			31,93±7,31
BMI			22,22±3,05

*Frequency Analysis

According to the distribution of demographic characteristics of the participants; 70% are female while 30% are male; 96,7% do sports; 83,3% do pilates; 80% are undergraduates; 70% do not take medicine; 83,3% use alcohol; 56,7% smoke cigarettes; 80% have surgical background; all of them have experienced sprains; the maximum number of sprains is two (60%); 56,7% have experienced sprains in the last six months and all of them have experienced a feeling of “giving way” in the foot. The findings show that none of the participants have experienced lower extremity injuries in the last six months. The average age of the participants is 31,93 and the average body mass index is 22,22 (Table 4).

Table 5. Pretest-Posttest Assessment of Y Balance Test Values *

	Thoracic Mobility (n=15)				**Lumbopelvic Stabilization (n=15)**			
	Mean	**SD**	**Z**	**p**	**Mean**	**SD**	**Z**	**p**
Left Anterior (Pre)	62,88	11,98	-2,608	,009	69,33	8,21	-,973	,330
Left Anterior (Post)	65,28	12,36			70,82	8,91		
Left Posterolateral (Pre)	58,25	9,80	-3,181	,001	64,26	8,06	-,063	,950
Left Posterolateral (Post)	62,06	7,32			63,96	7,30		
Left Posteromedial (Pre)	59,32	13,72	-2,802	,005	59,08	8,97	-3,046	,002
Left Posteromedial (Post)	63,76	11,39			65,97	7,58		
Right Anterior (Pre)	63,49	8,81	-2,795	,005	68,34	9,93	-,284	,776
Right Anterior (Post)	65,33	8,21			68,38	10,96		

Right Posterolateral (Pre)	62,22	10,99	-2,471	,013	63,99	7,17	-1,887	,059
Right Posterolateral (Post)	64,52	10,48			66,58	4,84		
Right Posteromedial (Pre)	57,18	8,62	-3,173	,002	63,20	7,42	-1,363	,173
Right Posteromedial (Post)	60,92	8,78			66,58	4,84		

*Wilcoxon Test

A comparison of the pre-posttest scores the participants have earned in Y Balance tests has shown that there was a significant difference between the pretest and posttest values of left anterior test, left posterolateral, left posteromedial, right anterior, right posterolateral and right posteromedial tests ($p<.05$). It has been found that the left anterior pretest score (X: 62,88±SD: 11,98) was lower compared to the left anterior posttest score (X: 65,28±SD: 12,36); the left posterolateral pretest score (X:58,25±SD: 9,80) was lower than the left posterolateral posttest score (X: 62,06±SD: 7,32); the left posteromedial pretest score (X: 59,32±SD: 13,72) was lower than the left posteromedial posttest score (X: 63,76±SD: 11,39). The right anterior pretest score (X: 63,49±SD: 8,81) was lower than the right anterior posttest score (X: 65,33±SD: 8,21); the right posterolateral pretest score (X:62,22±SD: 10,99) was lower than the right posterolateral posttest score (X: 64,52±SD: 10,48); the right posteromedial pretest score (X: 57,18±SD: 8,62) was lower than the right posteromedial posttest score (X: 60,92±SD: 8,78) (Table 5).

A comparison of the pretest and posttest scores the participants have earned in Y Balance tests has shown that only the left posteromedial test has revealed a significant difference between the groups ($p<.05$); while there was no significant difference between the groups in the other tests ($p>.05$). It has been found that the pretest score (X: 59,08±SD: 8,97) of the left posteromedial test was lower than the posttest score (X: 65,97±SD: 7,58) (Table 5).

Table 6. Pretest-Posttest Evaluation of the Joint Position Sense*

	Thoracic Mobility (n=15)				Lumbopelvic Stabilization (n=15)			
	Mean	**SD**	**Z**	**P**	**Mean**	**SD**	**Z**	**p**
Joint Position Sense Hip Right (Pre)	69,13	6,92	-2,017	,044	71,09	2,14	-1,421	,155
Joint Position Sense Hip Right (Post)	70,71	6,80			68,76	5,50		
Joint Position Sense Hip Left (Pre)	68,58	8,40	-2,131	,033	67,40	7,38	-2,557	,011
Joint Position Sense Hip Left (Post)	70,86	5,73			70,53	5,24		
Joint Position Sense Knee Right (Pre)	53,41	6,32	-2,359	,018	50,60	5,76	-1,321	,186
Joint Position Sense Knee Right (Post)	55,92	6,77			52,05	4,33		
Joint Position Sense Knee Left (Pre)	56,04	7,02	-,597	,551	56,65	7,51	-1,005	,315
Joint Position Sense Knee Left (Post)	56,73	5,77			59,10	6,91		
Joint Position Sense Dorsiflexion R. (Pre)	17,54	11,94	-2,841	,004	13,07	3,28	-,565	,572
Joint Position Sense Dorsiflexion R. (Pt)	14,87	9,21			12,60	1,74		
Joint Position Sense Dorsiflexion L. (Pre)	15,80	5,81	-2,103	,035	15,20	3,68	-2,948	,003
Joint Position Sense Dorsiflexion L. (Pt)	14,22	4,04			13,38	2,49		
Joint Position Sense Plantarflexion R. (Pre)	38,64	6,97	-,028	,977	43,83	8,36	-,094	,925
Joint Position Sense Plantarflexion R. (Post)	38,30	5,08			44,24	7,28		
Joint Position Sense Plantarflexion L. (Pre)	40,74	8,83	-,596	,551	41,82	7,51	-,227	,820
Joint Position Sense Plantarflexion L. (Post)	40,92	6,25			41,45	4,53		

***Wilcoxon Test**

A comparison of the pretest and posttest scores the participants have earned in the Joint Position Sense tests has shown that there was a statistically significant difference between the pretest and posttest values earned in the hip right, hip left, knee right, dorsiflexion right and left tests (p<.05). It has been found that the hip right pretest score (X: 69,13±SD: 6,92) was lower than the posttest score (X: 70,71±SD: 6,80); the hip left pretest score (X: 68,58±SD: 8,40) was lower than the posttest score (X: 70,86±SD: 5,73); the knee right pretest score (X: 53,41±SD: 6,32) was lower than the posttest score (X: 55,92±SD: 6,77). According to the results, the dorsiflexion right pretest score (X: 17,54±SD: 11,94) was higher than the posttest score (X: 14,87±SD: 9,21); the dorsiflexion left pretest score (X: 15,80±SD: 5,81) was higher than the posttest score (X: 14,22±SD: 4,04). There was no significant difference between the pretest and posttest scores earned in the knee left test, plantarflexion right and left tests (p>.05) (Table 6).

A comparison of the pretest and posttest scores the participants have earned in the Joint Position Sense tests has shown a statistically significant difference between the pretest and posttest scores earned only in the hip left and dorsiflexion left tests (p<.05). There was no significant difference between the other test groups (p>.05). It has been found that the hip left pretest score (X: 67,40±SD: 7,38) was lower than the posttest score (X: 70,53±SD: 5,24); the dorsiflexion left pretest score (X: 15,20±SD: 3,68) was higher than the posttest score (X: 13,38±SD: 2,49) (Table 6).

Table 7. Pretest-Posttest Evaluation of Active Straight Leg Raise*

	Thoracic Mobility(n=15)				**Lumbopelvic Stabilization (n=15)**			
	Mean	**SD**	**Z**	**P**	**Mean**	**SD**	**Z**	**P**
Single Leg Raise Test R. (Pre)	77,09	13,38	-3,423	,001	68,38	8,38	-3,011	,003
Single Leg Raise Test R. (Post)	80,86	11,82			74,32	7,58		
Single Leg Raise Test L. (Pre)	77,36	10,35	-3,414	,001	71,98	8,29	-1,790	,073
Single Leg Raise Test L. (Post)	80,30	10,14			75,28	6,93		

***Wilcoxon Test**

A comparison of the Active Straight Leg Raise pretest and posttest scores of the participants has shown a statistically significant difference between the groups in the single leg raise test right and left tests (p<.05). According to the results, the pretest score (X: 77,09±SD: 13,38) of the single leg raise test (right) of the participants was lower than the posttest score (X: 80,86±SD: 11,82) and the pretest score (X: 77,36±SD: 10,35) of the single leg raise test (left) was lower than the posttest score (X: 80,30±SD: 10,14) (Table 7).

Pretest scores earned by the participants in the single leg raise test were compared with the posttest scores and only in the left tests was there a statistically significant difference between the groups (p<.05). It was found that the single leg raise (left) pretest score (X: 68,38±SD: 8,38) of the participants was lower than the posttest score (X: 74,32±SD: 7,58) (Table 7).

Table 8. CAIT Pretest-Posttest Evaluation*

	Thoracic Mobility(n=15)				Lumbopelvic Stabilization (n=15)			
	Mean	SD	Z	p	Mean	SD	Z	p
Cait Test R. (Pre)	21,86	6,06	-3,198	,001	68,38	8,38	-3,011	,003
Cait Test R. (Post)	24,46	6,19			74,32	7,58		
Cait Test L. (Pre)	24,53	4,94	-2,585	,010	71,98	8,29	-1,790	,073
Cait Test L. (Post)	25,73	3,82			75,28	6,93		

***Wilcoxon Test**

As a result of the comparison of pretest-posttest scores earned by the participants in the cait test, a significant difference has been found between the groups for right and left (p<.05). The pretest score (X: 21,86±SD: 6,06) for the cait test (right) was lower than the posttest score (X: 24,46±SD: 6,19); and the pretest score (X: 24,53±SD: 4,94) for the cait test (left) was lower than the posttest score (X: 25,73±SD: 3,82) (Table 8).

When the pretest and posttest scores of the participants for the cait test right and left, there was a significant difference between the groups for right and left (p<.05). The pretest score (X: 23,33±SD: 6,85) of the participants for the cait test (right) was lower than the posttest score (X: 24,86±SD: 5,65); and the pretest score (X: 20,93±SD: 8,17) for the cait test (left) was lower than the posttest score (X: 22,66±SD: 6,66) (Table 8).

A Comparison of the Pretest-Posttest Values of the Thoracic Mobility Group and the Lumbopelvic Stabilization Group

Table 9. A Comparison of the Pretest Scores of the Groups Earned for Each Test Value*

	TMG(n=15) Mean±SD	LSG(n=15) Mean±SD	Mann Whitney U	p
Left Antrerior (Pre)	62,88±11,98	69,63±8,21	69,00	,071
Left Posterolateral (Pre)	58,25±9,80	64,26±8,06	66,50	,056
Left Posteromedial (Pre)	59,32±13,72	59,08±8,97	112,00	,983
Right Antrerior (Pre)	63,49±8,81	68,34±9,93	82,50	,213
Right Posterolateral (Pre)	62,22±10,99	63,99±7,17	80,00	,177
Right Posteromedial (Pre)	57,18±8,62	63,20±7,42	68,00	,065
Single Leg Raise Test R. (Pre)	77,09±13,38	68,38±8,38	62,00	,036
Single Leg Raise Test L. (Pre)	77,36±10,35	71,98±8,29	81,00	,191
Cait Test R. (Pre)	21,86±6,06	23,33±6,85	101,50	,645
Cait Test L. (Pre)	24,53±4,94	20,93±8,17	79,50	,164
Joint Position Sense Hip Right (Pre)	69,13±6,92	71,09±2,14	100,50	,618
Joint Position Sense Hip Left (Pre)	68,58±8,40	67,40±7,38	93,50	,430
Joint Position Sense Knee Right (Pre)	53,41±6,32	50,60±5,76	79,50	,170
Joint Position Sense Knee Left (Pre)	56,04±7,02	56,65±7,51	101,00	,633
Joint Position Sense Dorsiflexion R. (Pre)	17,54±11,94	13,07±3,27	89,50	,339

Joint Position Sense Dorsiflexion L. (Pre)	15,80±5,81	15,20±3,68	112,00	,983
Joint Position Sense Plantarflexion R. (Pre)	38,64±6,97	43,83±8,36	64,50	,046
Joint Position Sense Plantarflexion L. (pre)	40,92±6,25	41,45±4,53	111,50	,967

***Mann Whitney U Test**

A comparison of the test values between the thoracic mobility group and the lumbopelvic stabilization group of participants has resulted in no significant difference between the groups (p>.05).

A comparison of the test values between the thoracic mobility group and the lumbopelvic stabilization group of participants has resulted in no significant difference in the tests other than the single leg raise right pretest (p>.05). The single leg raise right pretest score (X: 77,09±SD: 13,38) of the thoracic mobility group was higher than that of the lumbopelvic stabilization group (X: 68,38±SD: 8,38) (p<.05). The plantarflexion right pretest value (X: 38,64±SD: 6,97) of the thoracic mobility group was lower than that of the lumbopelvic stabilization group (X: 43,83±SD: 8,36) (p<.05). There were no significant differences in the other test groups (p>.05) (Table 9).

Table 10. A Comparison of the Posttest Scores of the Groups Earned for Each Test Value

	TMG(n=15) Mean±SD	LSG(n=15) Mean±SD	Mann Whitney U	p
Left Antrerior (Post)	65,28±12,36	70,82±8,91	77,50	,146
Left Posterolateral (Post)	62,06±7,32	63,96±7,30	94,50	,454
Left Posteromedial (Post)	63,76±11,39	65,97±7,58	92,00	,394
Right Antrerior (Post)	65,33±8,21	68,38±10,96	92,50	,406
Right Posterolateral (Post)	64,52±10,48	66,58±4,84	74,50	,114
Single Leg Raise Test R. (Post)	80,86±11,82	74,32±7,58	69,50	,074
Single Leg Raise Test L. (Post)	80,30±10,14	75,28±6,93	87,50	,299
Cait Test R. (Post)	24,46±6,19	24,86±5,65	102,00	,660
Cait Test L. (Post)	25,73±3,82	22,66±6,66	84,00	,225
Joint Position Sense Hip Right (Post)	70,71±6,80	68,76±5,50	59,50	,028
Joint Position Sense Hip Left (Post)	70,86±5,73	70,53±5,24	100,00	,604
Joint Position Sense Knee Right (Post)	55,92±6,77	52,05±4,33	72,50	,096
Joint Position Sense Knee Left (Post)	56,73±5,77	59,10±6,91	88,00	,309
Joint Position Sense Dorsiflexion R. (Post)	14,87±9,21	12,60±1,74	89,50	,337

Joint Position Sense Dorsiflexion L. (Post)	14,22±4,04	13,38±2,49	106,50	,803
Joint Position Sense Plantarflexion R. (Post)	38,30±5,08	44,24±7,28	48,50	,008
Joint Position Sense Plantarflexion L. (Post)	40,92±6,25	41,45±4,53	111,50	,967

*Mann Whitney U Test

According to the results, there was a significant difference between the subject groups for the joint position sense hip right test and the joint position sense plantarflexion test ($p<.05$); while there was no significant difference between the groups for the other tests. The hip right posttest value (X: 70,71±SD: 6,80) of the thoracic mobility group was higher than that of the lumbopelvic stabilization group (X: 68,76±SD: 5,50); while the plantarflexion right posttest value (X: 38,30±SD: 5,08) of the thoracic mobility group was lower than that of the lumbopelvic stabilization group (X: 44,24±SD: 7,28) (Table 10).

5. DISCUSSION

Ankle injuries are a condition that seriously affects not only athletes but also the general population. Although people's initial symptoms resolve quickly, they may experience ongoing and long-lasting symptoms such as pain and instability. Continued repetitive lateral ankle sprains are called chronic ankle instability (CAI) [37].

The syndrome known as chronic ankle instability (CAI) is characterized by recurrent incidents or sensations that the ankle is "giving way" as well as ongoing symptoms. These signs may include discomfort, a reduction in strength, or a reduction in the ankle's range of motion (ROM), as well as a lack of self-reported function. Additionally, persistent ankle sprains lasting longer than a year after the first injury [40].

According to studies in the literature, exercises including ankle strengthening, balance on different surfaces, proprioceptive and neuromuscular exercises are an effective treatment protocol in these individuals with CAI, but which treatment protocol is more effective is being investigated. In general, the studies has been investigated the effectiveness of these treatments protocols in terms of balance, proprioception, strength and functionality parameters in exercise protocols applied in individuals with CAI.

Proprioception disorder may predispose to CAI as well as become a condition that may occur after injury. Proprioception can be defined as afferent input of joint position sense and stationary position and movement awareness. It is also considered as condition of neuromuscular control [90].

In the conducted a study with thirty-six individuals with CAI were grouped into 3 divisions according to their ages. They are then instructed to perform strength and balance workouts for six weeks. Joint position sense (JPS), static and dynamic balance (CAIT), and the lower extremity functional scale were all measured as part of the study (LEFS). Strengthening exercises including isometric exercises in all four direction (dorsiflexion, plantarflexion, inversion and eversion) and all exercises done bilaterally progressed to dynamic resistance exercises using resistive band. Participants started balance exercises and postural stability exercises when they were able to transfer loads without pain. Results said that there are significant improvement ($P<0.01$) in every outcomes among all age groups. Especially the plantar flexion JPS gotten better in all groups ($P<0.01$). Static and dynamic balance, the development was found in all groups. Additionally, following therapy, there were notable changes between CAIT and LEFS (P 0.01) [91].

In Ma T. Et al meta analysis a total of 21 studies were selected. Inclusion criteria were JPS and kinesthetics in participants with a history of ankle sprains and CAI symptoms compared to intact contralateral or healthy controls. Exclusion criteria were whether the study used tests that mixed directions of joint movement or included subjects with bilateral injuries by comparing limbs. Results showed that patients with CAI had ankle kinesthesia deficicency in inversion and plantarflexion, both JPS deficits in inversion respectively. In comparision of two groups, CAI patients had kinestesia in ankle in terms of inversion and eversion [92].

According to our result, a comparison of the pretest and posttest scores the participants have earned in the Joint Position Sense tests has shown that there was a statistically significant difference between the pretest and posttest values earned in the both hip, both dorsiflexion and right knee (p<.05).

Molla-Casanova et al. conducted a randomized controlled trial with a total of 457 volunteers. The aim of this study is to investigate the effectiveness of strength and balance exercises on individuals with CAI. The parameters evaluated were functionality, instability and dynamic balance. FAAM, FADI, side hop test and Ankle Joint Functional Assessment tool questionnaire were used for functionality evaluation. CAIT, VAS, and maximal inversion in lateral drop landing were used to assess instability. SEBT and overall balance index were used for dynamic balance. In the comparison with the control group, the short-term effect of balance exercises was examined, while the effectiveness of the strength and balance test on daily activities was also compared.

While the balance group included exercises such as one single leg stance, hopping, standing on different floors, the other group did strengthening and resistive exercises. Compared to classical exercise methods, balance exercises have more effects on functionality (0.81 (0.48, 1.14)), ankle instability (0.77 (0.27, 1.26)), and dynamic balance (0.83 (0.57, 1.10)). However, when compared to strength training the effectiveness of strength training was found to be high only in functionality. (0.49 (0.06, 0.92)) [88].

Anguish and Sandrey conducted a 4-week single-blinded randomized controlled trial that included 2 different types of balance exercise programs. Dynamic balance, and JPS test was evaluated in 18 participants with CAI. The progressive hop-to-stabilization balance (PHSB) or the SLB program started and completed the study over a 6-month. (FAAM) Activities of Daily Living (ADL) subscale, FAAM-Sports subscale, SEBT;

ankle JPS (all movements) were used before and after 4 week intervention. They found a significant main effect for all outcomes, as posttest results improved for the both groups. The main effect of group was significant only for the FAAM-Sports, with the SLB group improving more than the PHSB group. (SLB posttest = 82.65 6 5.1 versus PHSB posttest =71.69 6 9.4; P = .006) [89].

In our results showed that, a comparison of the pretest and posttest scores the participants have earned in Thoracic Mobility Group Y Balance tests has shown that there was a significant pretest and posttest values in all directions (p<.05). A comparison of the pretest and posttest scores the participants have earned in Y Balance tests has shown that only the left posteromedial direction has revealed a significant difference between the groups (p<.05); while there was no significant difference between the groups in the other tests (p>.05).

Although our study did not directly measure hip and dorsi ROM, it evaluated them before and after the JPS test and obtained significant results. In the literature, there are some studies investigating ROM and dynamic balance.

Basnett conducted a study in 45 participants with unilateral or bilateral CAI. The purpose of the study investigate the relationship between ankle dorsiflexion range of motion and reach distance in patients with CAI. Ankle dorsiflexion ROM was measured using a digital inclinometer during a weight-bearing lunge. The SEBT was used as a functional test to evaluate dynamic balance. participants performed the 3 reach directions (anterior, posterolateral, and posteromedial). Statistical result showed that there were fair positive correlations between dorsiflexion ROM and the anterior reach direction (P < .001), posterolateral reach direction (P = .03) and the composite SEBT scores (P = .02). There was little or no relationship between ankle dorsiflexion and the posteromedial reach direction (P = .47) [50].

In this study, the pretest-posttest scores of the participants in the joint position sense tests between the groups were compared, there was a statistically significant difference between the pretest and posttest scores only in the left hip and left dorsiflexion tests (p<.05). There was no significant difference between the other test groups (p>.05). Left hip pre-test score (X: 67.40±Sd: 7.38) was lower than the post-test score (X: 70.53±Ss: 5.24); It was concluded that the left dorsiflexion pre-test score (X: 15.20±Ss: 3.68) was higher than the post-test score (X: 13.38±Ss: 2,49).

Tamura et al. worked case control study in 17 college soccer players experienced for more than 8 years. All players are right dominant foot. They divided into two groups according to CAIT. Individuals with a score of 28 or less on CAIT were included in the CAI group. People who get 28 or more are included in non-CAI group. The modified SEBT test was used to evaluate the dynamic balance. In this test, 3 directions were used as anterior, posteromedial and posterolateral. Looking at the results, except for the hip adduction angle (p 0.00), there was no difference in hip ROMs between the dominant and nondominant legs ($p > 0.05$). Additionally, the dominant leg with CAI exhibited a significant hip internal rotation range of motion (ROM) as well as a reduced dynamic balance capacity while reaching in the posterolateral direction. However, the findings indicated that there was no relationship between dynamic balance ability and trunk and hip ROMs [93].

Tahoon et al. evaluate a total of 42 participants and compare their hamstring flexibility in both individuals with CAI and normal control group based on their ankle health status (CAI or the uninjured control). Any lower extremity injury, any surgery or fracture, any low back dysfunction needed medical invervention within a year, any continued and rehabilitation program were exclusion criterias for this research. These individuals have a history of at least 1 year prior to the start of the study and unilateral ankle inversion injury requiring at least one day of protected weight bearing and/or immobilization after injury. Individuals who had an ankle injury were included in the CAI group based on functional ankle instability questionnaire patient reported a tendency to bend or repeatedly rotate the ankle during functional activity and rebouted ankle sprain and feel their ankle chronically be weaker, more painful, and/or feeling a loss of functionality relative to the other foot or before the injury. Digital inclinometer was used to evaluate hamstring flexibility was evaluated by using of passive knee extension test (PKE) The results revealed that there was a significant reduction in hamstring flexibility in CAI group in compared with control group ($t=5.167$, $p= 0.0001$*) [94].

A comparison of the Active Straight Leg Raise pretest and posttest scores of the participants has shown a statistically significant difference between the groups in the both legs ($p<.05$).

Although we did not give hip specific strengthening exercises in our study, some exercises in the lumbopelvic group naturally include hip strengthening exercises. Hip strength and some studies have been done in the related literature.

Smith et al conducted prospective randomized controlled clinical trial in 26 participants with CAI to search the effects of hip strengthening on neuromuscular control in peope with CAI. They were randomly grouped as training or control groups and measured with Hand-Held Dynamometer for hip external rotation and abduction strength. The intervention was 3 times a week hip strenthening program with resistive band or no intervention. Participants were evaluated on four clinical measures which are SEBT (A, PM and PL directions) Balance Error Scoring System (BESS), hip external rotation strength, hip abduction strength. The Foot and Ankle Ability Measure (FAAM) was used for activities of daily living and sports subscales before and after the 4 weeks period. Results showed that the intervention group has showed importantly improvement post-test measures compared with the control group in term of hip abduction strength ($p < .01$), hip external rotation strength ($p < .01$); SEBT reach in the anterior. The training group significantly improved posttest measures compared with the control group for hip abduction strength ($P < .01$); hip external rotation strength ($P < .01$); Star Excursion Balance Test in all directions ($P < .01$); Balance Error Scoring System total errors (training: 9.9 [6.3] errors, control: 21.2 [6.3] errors, $P < .01$); and the Foot and Ankle Ability Measure-sports score (training: 88.0 [12.6], control: 84.8 [10.9], $P < .01$) As a results, it is showed that subjects with CAI exhibited significant improvement with 4 - weeks hip strengthening program in terms of neuromuscular control, strength, and sport related self-reported function. These improvements supported that the supervised hip strengthening may be effective and beneficial training associated with CAI. However, the protocol did not produce significant improvements in self-reported function associated with activities of daily living [95].

The term lumbopelvic stabilization and the term core stabilization are often intertwined in the literature. Lumbopelvic stability is a term that maintain optimal body segment alignment with the spine, pelvis, and lower extremities. There have been some studies investigating the effect of core stabilization studies on chronic ankle instability.

McCann studied 30 people aged between 18 and 40 in his study and divided these people into 3 groups equally (CAI, ankle sprain copers (COP), and healthy controls (CON)) . Unilateral hip bridge, trunk flexion endurance, Biering-Sorensen, and side plank tests exercises were given to these individuals for the evaluation of the TrA and LM muscles by diagnostic ultrasound imaging. FAAM-ADL and Sport FAAM-S subscales were used for self-reported evaluation of function. When we looked at the results, COP had significantly greater TrA contractillty than CAI and CON ($p<0.05$). Although not statistically significant a large effect size suggest that CAI had lower TrA contractility than CON. Although LM contractility did not differ between groups, TrA contractility was significantly lower in individuals with CAI [96].

Sahranvard et al. studied the randomized controlled trial in 30 participants to investigate the impact of a six-week core stability program on people with CAI's ability to keep dynamic postural control. A randomization process assigned 30 participants to the experimental or control group. Both groups received a 6-week intervention (core stability exercises) in addition to traditional physiotherapy. According to the SEBT results, there was an improvement in balance in all directions in the experimental and control groups (P 0.05), but the improvement in the experimental group was greater than the improvement in the control group, and this difference was significant (P 0.05). All participants were evaluated right before the exercise program and right after the 6-week program [97].

In another study interested in 8 week core stabilization training in Y balance, Dastmanesh and Shojaeddin studied as randomized controlled trial focused on core stabilization training on postural control in which individuals CAI. They were randomly seperated as control and CAI groups. The control group maintained the same activity level prior to study enrollment. Before and after the 8-week intervention dynamic postural control values are collected from all groups (healthy, CAI and control groups). Any lower extremity injuries were excluded and subjects who experienced "giving way" and at least 1 ankle sprain resulting in swelling, pain, and temporary loss of function were included in the study. The participants with any lower extremity injuries in the previous 6 months were excluded. Subjects in CAI and healthy groups participated in 24 supervised training sessions, three sessions per week. Each session lasted about 30 minutes and focused on the progressive core stabilization for strengthening core muscles. 5 types of core stability exercises were selected. The results show a noticeable increase in the mean reach distance of the control and CAI groups in all directions after 8 weeks of training. A substantial interaction between time and groups was found in the results of the Y balance test ($p \leq 0.05$). Additionally, there was a significant main impact of time (p 0.05). The difference in the mean reach distance between participants with CAI and healthy individuals supported the benefits of strengthening the core stabilizer muscles for postural control [98].

To the best of our knowledge, although core stabilization, dynamic balance exercises, proprioception exercises, neuromuscular exercises are frequently used in chronic ankle instability, the effect of thoracic mobility exercises on these parameters has not been investigated yet. However, some studies have investigated the effect of thoracic mobilization on balance and postural control.

Joeng et al. studied in 18 participants and investigate. The effect of thoracic mobilization on static and dynamic balance in people with kyphosis angle greater than 40°. Participants were asked to use a treadmill for 5 minutes for warm-up and cool-down periods. After the evaluation, Kaltenborn three-phase mobilization techniques was used as a thoracic mobilization technique after pre-post tests. Results are collected as three stages: before the intervention, 3 and 6 weeks after the intervention. The results of this study showed that the angle of thoracic kyphosis decreases and body COP, dynamic balance significantly $p<.05$ improved after applying TM [7].

According to the results, there was a significant difference between the subject groups for the joint position sense hip (right) test and the joint position sense plantarflexion test ($p<.05$); while there was no significant difference between the groups for the other tests. The hip posttest value (X: 70,71±SD: 6,80) of the thoracic mobility group was higher than that of the lumbopelvic stabilization group (X: 68,76±SD: 5,50); while the plantarflexion right posttest value (X: 38,30±SD: 5,08) of the thoracic mobility group was lower than that of the lumbopelvic stabilization group (X: 44,24±SD: 7,28) (Table 7).

6. CONCLUSION

In conclusion, the results showed that there is an improvement in the Y balance test values of thoracic mobility group. When the two groups were compared, a significant difference was found between the groups only in the PM direction.

In Joint Position Sense tests, both hip proprioception and right knee proprioception increased significantly on thoracic mobility group. Dorsiflexion proprioception angle also improved significantly in both groups. Improvement was seen in both groups in the Active Straight Leg Raise Test. Although the CAIT test evaluated before and after was below the cut-off value (≤27), post test showed that it increased significantly. Hip joint position values of the participants approached determined value (75°) according to the lumbopelvic group in the thoracic mobility group. When the plantar flexion value was compared before and after the values, it was found that the thoracic group was closer to determined value (40°) than the lumbopelvic group.

Considering the popular exercise protocols used in CAI such as balance, proprioception neuromuscular training protocols, it is recommended that, thoracic mobility exercises can be added to rehabilitation programs in patient with chronic ankle instability.

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8. APPENDIX

8.1. Bilgilendirilmiş Gönüllü Olur Formu

Sayın Katılımcı,

Katıldığınız bu çalışma bilimsel nitelikte bir araştırma olup konusu "Torasik Mobilite ve Lumbopelvik Stabilizasyon Egzersizlerinin, Kronik Ayak Bileği İnstabilitesi Olan Kişilerde Alt Ekstremite Fleksibilite, Dinamik Denge ve Propriyosepsiyon Üzerine Etkisi "dir. Bu çalışma, Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Spor Fizyoterapisi Anabilim Dalı'nda yürütülmekte olup, Ecem Nur TAKINDI'nın yüksek lisans tezi kapsamında yapılmaktadır.

Araştırmanın amacı torasik mobilite ve lumbar stabilizasyon egzersizlerinin kronik ayak bileği instabilitesi yaşayan bireylerde verilen ev egzersizlerine ek olarak etkinliğini araştırmak ve alt ekstremite propriyosepsiyon ve dinamik denge ve fleksibilite üzerine etkisi olup olmadığını gözlemlemektir. Bu araştırmaya katılması beklenen tahmini gönüllü sayısı 30 kişidir. Çalışma haftanin 2 günü toplam 8 hafta sürecek şekilde toplam 16 egzersiz seansı olarak planlanmıştır. Çalışmanın başında "Y Denge Testi" , "Aktif Düz Bacak Kaldırma Esneklik Testi" "Alt Ekstremite Eklem Pozisyon Hissi" ölçümü yapılacaktır. Ardından 16 egzersiz seansı boyunca bu egzersizler araştırmacı takibinde tamamlanacaktır. Ayrıca bu egzersizlere ek olarak ev egzersiz programı verilecek ve 8 hafta boyunca bu egzersizlerin yapılması istenecektir. Seanslar tamamlandıktan sonra yukarıda belirtilen ölçümler tekrar değerlendirilecektir.

Bu çalışma gönüllülük esnasına dayanır. Gönüllünün tüm kayıtları ve kimliği araştırmanın yayımlanması durumu dahil gizli tutulacaktır ve kamuoyuna açıklanmayacaktır. Etik kurul ve ilgili diğer sağlık otoriteleri gönüllünün orijinal tıbbi kayıtlarına doğrudan erişimi bulunsa da bu bilgiler gizli tutulacaktır. Araştırmada gönüllünün araştırmaya katılmaya devam etme isteğinin etkilenebileceği yeni bilgiler ortaya çıktığında gönüllü veya kanuni temsilcisi zamanında bilgilendirilecektir. Gönüllünün bu çalışmaya 16 seans boyunca devamlılık göstermesi ve belirlenen egzersizleri araştırmacıyla birlikte tamamlaması beklenmektedir. Çalışmaya katılmama ve çalışmanın herhangi bir aşamasında, hiçbir yaptırıma maruz kalmadan çalışmadan ayrılma hakkına sahipsiniz. Araştırmada yer almanız sebebiyle size hiçbir ödeme yapılmayacak ve hiçbir ücret talep edilmeyecektir. Bu formu imzalamanız katılım için onam verdiğiniz anlamına gelmektedir.

Araştırmayla ilgili daha fazla bilgi almak için araştırmacı Ecem Nur TAKINDI'ya günün 24 saatinde ……… numaralı telefondan ulaşabilirsiniz.

Araştırmanın bilgilendirilmiş gönüllü olur formundaki tüm yazılı ve sözlü açıklamaları okudum ve anladım. İster doğrudan ister dolaylı olarak meydana gelebilecek herhangi bir sağlık sorunumun ortaya çıkması durumunda her türlü tıbbi müdahalenin sağlanacağı güvencesi araştırmacı tarafından güvence edilmiştir. Bu çalışma sonuçlarının yayın, rapor ve benzeri bilimsel dokümanlarda kullanılmasını kabul ediyorum. Araştırmaya gönüllü olarak katıldığımı ve istediğim zaman çalışmadan ayrılabilme hakkımın olduğunu biliyor, söz konusu araştırmaya hiçbir baskı ve zorlama olmaksızın kendi rızamla katılmayı kabul ediyorum.

Gönüllünün **Tarih**

Adı-Soyadı:

Adresi:

Telefon Numarası:

İmzası:

Araştırma hakkındaki tüm bilgiler katılımcıya açıklanmış olup yazılı onamı alınmıştır.

Araştırmacının **Tarih**

Adı- Soyadı

Adresi:

Telefon Numarası:

İmzası:

8.2. Etik Onay Formu

T.C.
MARMARA ÜNİVERSİTESİ
Sağlık Bilimleri Fakültesi
Girişimsel Olmayan Klinik Çalışmalar Etik Kurulu

PROJENİN ADI	: "Torasik Mobilite ve Lumbopelvik Stabilizasyon Egzersizlerinin, Kronik Ayak Bileği İnstabilitesi Olan Kişilerde Alt Ekstremite Fleksibilite, Dinamik Denge ve Propriyosepsiyon Üzerine Etkisi"
PROJENİN YÜRÜTÜCÜSÜ	: Dr. Öğr. Üyesi Elif Tuğçe ÇİL
PROJEDEKİ ARAŞTIRICILAR	: Ecem Nur TAKINDI
ONAY TARİHİ VE SAYISI	: 24.11.2022/92

Sayın: Dr. Öğr. Üyesi Elif Tuğçe ÇİL

"92" protokol numaralı "Torasik Mobilite ve Lumbopelvik Stabilizasyon Egzersizlerinin, Kronik Ayak Bileği İnstabilitesi Olan Kişilerde Alt Ekstremite Fleksibilite, Dinamik Denge ve Propriyosepsiyon Üzerine Etkisi" İsimli projeniz Fakültemiz Etik Kurulu tarafından incelenmiş oy birliği ile etik yönden uygun olduğuna karar verilmiştir.

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sbfetikkurul@gmail.com
http://sbf.marmara.edu.tr

8.3. Hasta Bilgi Formu

1. Adınız Soyadınız:

2. Cinsiyetiniz: Kadın ( ) Erkek ( )

3. Medeni haliniz : Evli ( )   Bekar ( )

4. Boyunuz (cm):

5. Kilonuz(kg):

6. Vücut Kitle İndeksi(kg/m2)

7. Spora Katılım ( ) Evet ( ) Hayır

8. Yaptığınız spor:

( ) Futbol   ( ) Basketbol   ( ) Voleybol   ( ) Hentbol ( ) Atletizm ( )Tenis ( ) Yüzme ( ) Diğer:

9. Eğitim durumunuz : ( )İlköğretim   ( )Lise   ( ) Lisans   ( ) Lisansüstü

10. Sistemik Herhangi bir hastalığınız var mı?

Evet ( )   Hayır( )

11. Sürekli kullandığınız bir ilaç var mı? Var ise:

Adı……………………..Dozu………………….Ne kadar süredir……….

12. Sigara kullanıyor musunuz?

( )Hiç içmedim ( ) İçtim, bıraktım ( )Halen içiyorum

13. Kaç yıldır sigara içiyorsunuz?

( ) 10 yıl   ( )10 yıldan az   ( )10 yıldan fazla

14. Günde kaç adet sigara içiyorsunuz?

( )1 paketten az ( )1 paket ( )1 paketten fazla

15. Alkol kullanıyor musunuz?

( )Evet ( ) Hayır

16. Herhangi bir ameliyat geçirdiniz mi?

( )Evet ( ) Hayır

17. Daha önce ayak bileği burkulması geçmişiniz var mı?

( )Evet ( ) Hayır

18. Cevabınız “evet” ise, her bir ayak bileğinizde kaç burkulma oldu?

( )Sağ: ( ) Sol:

19. Cevabınız “evet” ise, son 6 ay içinde herhangi bir burkulma meydana geldi mi?

( )Evet ( ) Hayır

20. Son altı ay içinde her iki ayak bileğinizde de “boşalma hissi’’ yaşadınız mı?

( )Evet ( ) Hayır

21. Cevabınız evet ise, hangi ayak bileğinde “boşalma hissi’’ yaşadınız?

( )Sağ ( ) Sol ( ) Her ikisi

22. 21.Son 6 ayda ayak bileği burkulması dışında herhangi bir alt ekstremite yaralanmanız oldu mu?

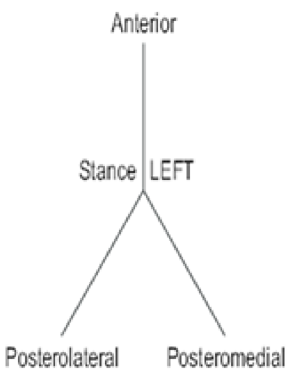
( )Evet ( ) Hayır

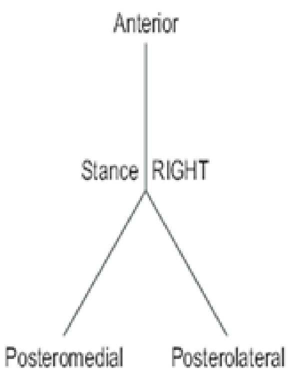
8.4. Assessment Form

ACTIVE SINGLE LEG RAISE TEST									
BEFORE					**AFTER**				
RIGHT:	1:	2:	3:	O:	RIGHT	1:	2:	3:	O:
LEFT:	1:	2:	3:	O:	LEFT:	1:	2:	3:	O:
JOINT POSITION SENSE TEST									
HIP(75°)									
BEFORE	:				**AFTER**				
RIGHT	1:	2:	3:	O:	RIGHT	1:	2:	3:	O:
LEFT	1:	2:	3:	O:	LEFT	1:	2:	3:	O:
KNEE(50°)									
BEFORE	:				**AFTER**				
RIGHT	1:	2:	3:	O:	RIGHT	1:	2:	3:	O:
LEFT	1:	2:	3:	O:	LEFT	1:	2:	3:	O:
ANKLE DF (10°)									
BEFORE	:				**AFTER**				
RIGHT	1:	2:	3:	O:	RIGHT	1:	2:	3:	O:
LEFT	1:	2:	3:	O:	LEFT	1:	2:	3:	O:
ANKLE PF (40°)									
BEFORE	:				**AFTER**				
RIGHT	1:	2:	3:	O:	RIGHT	1:	2:	3:	O:
LEFT	1:	2:	3:	O:	LEFT	1:	2:	3:	O:

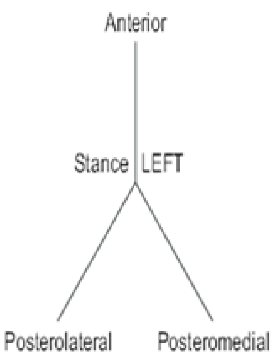
Y BALANCE TEST

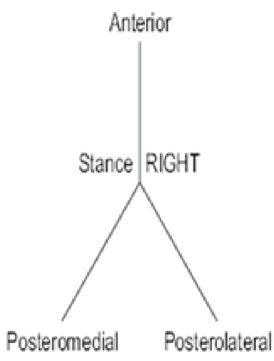
BEFORE





AFTER





8.5. Cumberland Ankle Instability Tool

CUMBERLAND AYAKBİLEĞİ İNSTABİLİTE ANKETİ

AD-SOYAD: DOĞUM TARİHİ:

		SOL	SAĞ
1) Ayak bileğim ağrıyor.	Hiçbir zaman		
	Spor sırasında		
	Düz olmayan zeminde koşarken		
	Düz zeminde koşarken		
	Düz olmayan zeminde yürürken		
	Düz zeminde yürürken		
		SOL	SAĞ
2) Ayak bileğimde güvensizlik hissediyorum.	Hiçbir zaman		
	Spor sırasında ara ara		
	Spor sırasında sık sık		
	Günlük aktiviteler sırasında ara ara		
	Günlük aktiviteler sırasında sık sık		
		SOL	SAĞ
3) Keskin dönüşler sırasında ayak bileğimi güvensiz hissediyorum.	Hiçbir zaman		
	Koşarken ara ara		
	Koşarken sıklıkla		
	Yürüdüğümde		
		SOL	SAĞ
4) Merdiven inerken ayak bileğimi güvensiz hissediyorum.	Hiçbir zaman		
	Hızlı indiğimde		
	Bazı durumlarda		
	Her zaman		
		SOL	SAĞ
5) Tek ayak üzerinde durduğumda ayak bileğimi güvensiz hissediyorum.	Hiçbir zaman		
	Parmak ucumda		
	Normal basarken		
		SOL	SAĞ
6) Ayak bileğimi güvensiz hissediyorum.	Hiçbir zaman		
	Yana sıçradığım zaman		
	İleriye sıçradığım zaman		
	Zıplayıp yere düştüğüm zaman		
		SOL	SAĞ
7) Ayak bileğimi güvensiz hissediyorum	Hiçbir zaman		
	Düz olmayan zeminde koşarken		
	Düz olmayan zeminde jog koşusu sırasında		
	Düz olmayan zeminde yürürken		
	Düz zeminde yürürken		
		SOL	SAĞ
8) Ayak bileğim burkulur gibi olduğunda onu engelleyebiliyorum:	Hemen		
	Çoğu zaman		
	Bazen		
	Hiçbir zaman		
	Hiç böyle bir his yaşamadım.		
		SOL	SAĞ
9) Ayak bileğim burkulur gibi olduktan sonra, ayak bileğim normale döner:	Neredeyse hemen		
	1 günden kısa sürede		
	1-2 gün içinde		
	2 günden fazla sürede		
	Hiç böyle bir his yaşamadım.		

8.6. Özgeçmiş

Kişisel Bilgiler

Adı	Ecem Nur	**Soyadı**	TAKINDI
Doğum Yeri		**Doğum Tarihi**	
Uyruğu	Türkiye	**TC Kimlik No**	
E-mail		**Tel**	

Öğrenim Durumu

Derece	Alan	Mezun Olduğu Kurumun Adı	Mezuniyet Yılı
Doktora			
Yüksek Lisans			
Lisans	Fizyoterapi ve Rehabilitasyon	**T.C. Yeditepe Üniversitesi**	2017
Lise	-		

Başarılmış birden fazla sınav varsa(KPDS, ÜDS, TOEFL; EELTS vs), tüm sonuçlar yazılmalıdır

Bildiği Yabancı Dilleri	Yabancı Dil Sınav Notu (#)
İngilizce	

İş Deneyimi (Sondan geçmişe doğru sıralayın)

Görevi	Kurum	Süre (Yıl - Yıl)
Kurucu Fizyoterapist	Noi Physio Pilates Studio	2019-
Fizyoterapist	Toprak Hastanesi	2018-2019

Bilgisayar Bilgisi

Program	Kullanma becerisi

*****Çok iyi, iyi, orta, zayıf olarak değerlendirin

Bilimsel Çalışmaları
SCI, SSCI, AHCI indekslerine giren dergilerde yayınlanan makaleler

Diğer dergilerde yayınlanan makaleler

Uluslararası bilimsel toplantılarda sunulan ve bildiri kitabında (*Proceedings*) basılan bildiriler

Hakemli konferans/sempozyumların bildiri kitaplarında yer alan yayınlar

Diğer (Görev Aldığı Projeler/Sertifikaları/Ödülleri)
