



T.C.
YEDİTEPE UNIVERSITY
INSTITUTE OF HEALTH SCIENCES
MASTER'S PROGRAM IN SPORTS PHYSIOTHERAPY

**THE EFFECTS OF COMBINED
NEURO-VESTIBULAR-OCULAR EXERCISES
AND MYOFASCIAL RELEASE ON
PROPRIOCEPTION AND PERFORMANCE
IN FOOTBALL PLAYERS WITH
CHRONIC ANKLE INSTABILITY**

Master Thesis

Büşra KOCAKILIÇ

İSTANBUL – 2023



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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.

10.06.2023

Büşra KOCAKILIÇ



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LIST OF SYMBOLS AND ABBREVIATIONS

AITFL	: Anterior Inferior Tibiofibular Ligament
ATFL	: Anterior Talofibular Ligament
BMI	: Body Mass Index
CAI	: Chronic Ankle Instability
CAIT	: Chronic Ankle Instability Tool
CFL	: Calcaneofibular Ligament
CMR	: Compressive Myofascial Release
CT	: Computed Tomography
DFROM	: Dorsi Flexion Range Of Motion
FI	: Functional Instability
FIFA	: Federation Internationale de Football Association
FTCL	: Fibulotalocalcaneal Ligament
IASTM	: Instrument Assisted Soft Tissue Mobilization
LAS	: Lateral Ankle Sprain
LESS	: Landing Error Score System
LTCL	: Lateral Talocalcaneal Ligament
MAS	: Medial Ankle Sprain
MFR	: Myofascial Release
MI	: Mechanical Instabilit
MRHOG	: Myofascial Release Hands-on Therapy Group
MRI	: Magnetic Resonance Imaging
MWM	: Mobilization With The Active Movement Technique
NVOEG	: Neuro-vestibular-ocular Exercises Group
OAR	: The Ottawa Ankle Rules
PITFL	: Posterior Inferior Tibiofibular Ligament
PNF	: Proprioceptive Neuromuscular Facilitation
PTFL	: Posterior Talofibular Ligament
ROM	: Range Of Motion
SEBT	: Star Excursion Balance Test
SPSS	: Statistical Package for Social Science
STJN	: Subtalar Joint is in Neutral Position
US	: Ultrasonography

VR : Vestibular Rehabilitation
VRT : Vestibular Rehabilitation Training



ABSTRACT

KOCAKILIÇ, B. (2023). The Effects of Combined Neuro-vestibular-ocular Exercises and Myofascial Release on Proprioception and Performance in Football Players with Chronic Ankle Instability, Yeditepe University, Institute of Health Sciences, Department of Sport Physiotherapy, Master Thesis, Istanbul.

The aim of this study is to investigate the effects of myofascial release therapy applied with combined neuro-vestibular-ocular exercises on proprioception and performance in football players with chronic ankle instability. Neuro-vestibular-ocular exercises are an approach that combines neuromuscular training with vestibular-ocular training techniques. As far as we know, there is no study investigating the effectiveness of these treatments in chronic ankle instability and examining the superiority of training programs (myofascial relaxation and neuromuscular-vestibular-ocular exercise). At the same time, there is no study investigating the effectiveness of combined neuromuscular and vestibular-ocular exercises in the football player group. This study was carried out at Asım Kara Sports Facilities and Kartalspor Facilities between September 2022 and April 2023. Gülsuyuspor A team and infrastructure team, Kartalspor A team and infrastructure team players participated in the study. A total of 60 football players between the ages of 18-30 were included in the study on a voluntary basis. has been done. The players were randomly divided into two groups. Demographic information and informed consent form were filled in all subjects who volunteered to participate in the study in accordance with the research criteria. After evaluation, subjects in the NVOE group were transferred to the Neuro-Vestibular-ocular exercise group (n=30). Myofascial release(n=30) was applied to the players in the second group by the physiotherapist. The workouts were done two days a week for eight weeks, and each workout lasted approximately 60 minutes. Participants' CAIT scores were evaluated before and after treatment. By measuring joint position sense with a goniometer, proprioception evaluation and kick speed, 30 m sprint, zig-zag agility test and Landing error score system (LESS) were evaluated under the heading of performance. According to statistical analysis, significant changes were observed in proprioception and performance before and after treatment in both groups. ($p<0.05$). However, the neuro-vestibular-ocular exercise group was found to be superior between the two treatment groups. ($p<0.05$). In conclusion, neuro-vestibular-ocular exercises and myofascial release should be included in chronic ankle treatment.

Key Words: chronic ankle instability, anklesprain, football player, neuromuscular, vestibulo-ocular, training, myofascial release



ÖZET

KOCAKILIÇ, B. (2023). Kronik Ayak Bileği İnstabilitesi Olan Futbolcularda Kombine Nöro-vestibüler-oküler Egzersizler ve Miyofasyal Gevşemenin Propriosepsiyon ve Performansa Etkisi, Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi Anabilim Dalı, Yüksek Lisans Tezi, İstanbul.

Bu çalışmanın amacı, kronik ayak bileği instabilitesi olan futbolcularda kombine nöro-vestibüler-oküler egzersizlerle birlikte uygulanan miyofasyal gevşetme tedavisinin propriosepsiyon ve performans üzerindeki etkilerini araştırmaktır. Nöro-vestibüler-oküler egzersizler, nöromusküler eğitim ile vestibüler-oküler eğitim tekniklerini birleştiren bir yaklaşımdır. Bildiğimiz kadarıyla, kronik ayak bileği instabilitesinde bu tedavilerin etkinliğini araştıran ve eğitim programlarının (miyofasiyal gevşeme ve nöromusküler-vestibüler-oküler egzersiz) üstünlüğünü inceleyen bir çalışma bulunmamaktadır. Aynı zamanda futbolcu grubunda kombine nöromusküler ve vestibüler-oküler egzersizlerin etkinliğini araştıran bir çalışma bulunmamaktadır. Bu çalışma Eylül 2022 - Nisan 2023 tarihleri arasında Asım Kara Spor Tesisleri ve Kartalspor Tesisleri'nde gerçekleştirilmiştir. Çalışmaya Gülsuyuspor A takımı ve altyapı takımı, Kartalspor A takımı ve altyapı takımı oyuncuları katılmıştır. Çalışmaya 18-30 yaş arası toplam 60 futbolcu gönüllülük esasına göre dahil edilmiştir. yapılmıştır. Oyuncular rastgele iki gruba ayrılmıştır. Çalışmaya katılmaya gönüllü olan tüm deneklere demografik bilgiler ve bilgilendirilmiş onam formu araştırma kriterlerine uygun olarak doldurulmuştur. Değerlendirme sonrasında NVOE grubundaki denekler Nöro-Vestibüler-oküler egzersiz grubuna (n=30) aktarılmıştır. İkinci gruptaki oyunculara fizyoterapist tarafından miyofasyal gevşetme (n=30) uygulandı. Antrenmanlar sekiz hafta boyunca haftada iki gün yapılmış ve her antrenman yaklaşık 60 dakika sürmüştür. Katılımcıların CAIT skorları tedaviden önce ve sonra değerlendirilmiştir. Gonyometre ile eklem pozisyon hissi ölçülerek, propriosepsiyon değerlendirmesi ve performans başlığı altında tekme hızı, 30 m sprint, zig-zag çeviklik testi ve İniş hata skor sistemi (LESS) değerlendirildi. İstatistiksel analize göre, her iki grupta da tedavi öncesi ve sonrası propriosepsiyon ve performansta anlamlı değişiklikler gözlemlendi. ($p<0.05$). Ancak nöro-vestibüler-oküler egzersiz grubu iki tedavi grubu arasında daha üstün bulunmuştur. ($p<0.05$). Sonuç olarak, nöro-vestibüler-oküler egzersizler ve miyofasiyal gevşetme kronik ayak bileği tedavisine dahil edilmelidir.

Anahtar Kelimeler: kronik ayak bileđi instabilitesi, ayak bileđi burkulması, futbolcu, nöromüsküler, vestibülo-oküler, antrenman, miyofasiyal gevşetme



1. INTRODUCTION

Ankle sprains are a common musculoskeletal condition that can affect individuals both in athletic and non-athletic populations (1). Within the domain of sports, ankle sprains account for a significant proportion of injuries, comprising approximately 38% to 45% of reported cases (2). Furthermore, ankle sprains can result in persistent physical impairments, with up to 70% of individuals experiencing chronic ankle instability (CAI) (3). In the context of football, ankle sprains represent the most frequent type of injury, accounting for nearly 67% of all ankle injuries (4). The primary etiology of ankle sprains is often associated with inversion trauma, which occurs during varying degrees of plantar flexion. This mechanism of injury places strain on the anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL), and posterior talofibular ligament (PTFL), potentially leading to their stretching or tearing and subsequent development of an ankle sprain. Excessive supination and inversion of the plantar flexed foot, while the tibia is externally rotated, are commonly implicated in the occurrence of ankle sprains (5).

Individuals presenting with persistent symptoms, characterized by a recurrent "giving away" sensation in the ankle, subsequent to recurrent ankle sprains lasting for a minimum duration of one year, are commonly diagnosed with chronic ankle instability (CAI). Recent investigations have elucidated that a considerable proportion, up to 70%, of individuals initially affected by acute lateral ankle sprains may develop CAI within a relatively brief period following the initial injury. The prevalence of CAI was shown to be 40% one year following the first lateral ankle injury in a prospective cohort study (3). Around 24% of all ankle sprains are repeated sprains, and 17.5% of players who have ankle injuries miss more than six weeks of soccer practice. Recurrent ankle sprains can occur in up to 73% of athletes, and 59% of these athletes claim that CAI affects their ability to perform athletically (7). Ankle instability is discovered in athletes who experience recurrent ankle sprains. Ankle instability that is functional makes up around 40% of them. Due to less static and dynamic support in the joint, functional ankle instability generates the impression that a re-sprain will happen at any moment. It has been shown that this syndrome affects both functional performance and everyday life activities (4).

A comprehensive rehabilitation plan for ankle injuries should encompass various phases, each targeting specific aspects of recovery and functional restoration. The initial phases of rehabilitation focus on the effective management of acute and subacute pain

and swelling. Therapeutic interventions employed during this stage typically include range-of-motion exercises to promote joint mobility, strengthening exercises to enhance muscle strength and stability, and soccer-specific functional training to address sport-specific movements and demands (9-12). It is crucial to continue proprioceptive training even after returning to the game to minimize the chances of recurrence (9-12). To address swelling and provide support to the injured ankle ligament, a compression bandage can be employed (13-15). The use of semi-rigid orthoses and air-cast orthoses may be advantageous in preventing ankle sprains, particularly for athletes who have experienced repeated instability (13-15). Bracing offers an advantage over simple taping as the latter tends to lose its efficacy in restraining inward and outward movements after approximately 20 minutes (15).

The basic approach of treating conservative CAI is generally regarded as the most effective way to manage the condition and avoid reinjury. Proprioception and neuromuscular control have been shown to improve after rehabilitation treatments (16). Clinicians employ various therapeutic interventions, including stretching, manual therapy, electrotherapy, ultrasound, and exercise, as part of their treatment approach.

Clinicians frequently employ manual therapy techniques to address musculoskeletal limitations and restrictions, aiming to alleviate pain and restore mobility. These techniques encompass the manual manipulation of the affected region with the aim of addressing myofascial restraints. The term "myofascial" pertains to the interconnected network of muscle and fascia encompassing and connecting the musculoskeletal system. The presence of adhesions within the fascia can impede joint range of motion (ROM) and restrict the flexibility of soft tissues such as muscles, ligaments, and tendons, consequently diminishing the capacity for muscle power generation (21).

The effects of manual therapy approaches on tissue extensibility and ROM in the setting of open chain movements, where the limb has unrestricted mobility, have been investigated in earlier research projects (17–20). However, as the majority of activities involve closed chain movements, it becomes more pertinent to assess the efficacy of manual therapy in terms of closed chain ROM. Compressive myofascial release (CMR) and instrument-assisted soft tissue mobilization (IASTM) are two notable techniques used frequently to mobilize soft tissues. CMR entails the application of compression and sustained myofascial tensions to the targeted area with the intention of inducing a release (22). On the other hand, IASTM involves the utilization of specially designed instruments to identify and address myofascial restrictions (23). Training the fascial network is very

important for athletes, dancers and movement scientists. If an individual's fascia is well trained to provide optimum elasticity and flexibility, his performance can be enhanced effectively and at the same time he can greatly protect himself from injury (24).

Therapeutic exercise routines that address particular weaknesses, such as ROM , manual therapy(mobilization with the active movement technique (MWM) described by Mulligan, soft tissue mobilization,etc...),PNF, balance, strength,(theraband protocols, isokinetic strength protocols ,etc...)and functional training, are typically used as part of clinical intervention for patients who have experienced recurrent ankle sprains (6). One of the exercise options used in CAI management is neuromuscular training.

Neuromuscular training has emerged as a viable approach for managing and preventing ankle instability. The primary objectives of neuromuscular training encompass enhancing neuromuscular control, augmenting joint stability, and mitigating the risk of injury. These training regimens typically encompass a repertoire of exercises, such as strengthening exercises, stretching routines, plyometric activities, and balance exercises (26). By utilizing afferent impulses and the brain systems in charge of dynamic joint control, neuromuscular training's fundamental goal is to improve subconscious motor capabilities. In order to maximize sensory control and compensatory functional stability, the suggested method for neuromuscular training places a strong emphasis on the application of biomechanical and neuromuscular ideas (27).

Vestibular exercise training is a specialized type of physical therapy that aims to alleviate dizziness and imbalance caused by peripheral vestibular dysfunction. It focuses on stimulating the central nervous system to compensate for the dysfunction in the vestibular system, which is responsible for maintaining balance and spatial orientation. Through targeted exercises and therapies, vestibular exercise training helps the individual adapt and improve their balance and reduce symptoms of dizziness (28). The focus of this approach is to help the body adapt and compensate for problems with the vestibular system of the inner ear, ultimately improving balance and reducing the symptoms of dizziness. Basic exercises for vestibular rehabilitation; oculo-motor and gaze stabilization exercises including head-eye movements; These are postural stability exercises that are applied by maintaining balance during dynamic and static movements that become increasingly difficult by changing the smoothness of sensory stimuli, and are familiarization exercises that are shown as the repetition of movements and positions that cause dizziness.

In addition, conditioning, strengthening, flexibility and proprioceptive exercises are added to the vestibular rehabilitation prescription (29). If sensory and balance information is not accurate, an athlete may experience delayed reaction time, may not be able to maintain symptoms such as dizziness, disorientation or a feeling of instability may be seen in people who struggle with balance or have difficulties in recovering after a change of direction (30). Many ankle rehabilitation protocols currently lack a crucial component; this is training or retraining of the vestibular-ocular reflex (VOR). In order to maintain balance and visual stability during dynamic activities, this reflex, which synchronizes eye movements with head movements, is crucial. Including VOR training or retraining in ankle rehabilitation can help increase the integration of sensory information and improve overall balance and stability.

The aim of this study is to investigate the effects of myofascial release therapy applied with combined neuro-vestibular-ocular exercises on proprioception and performance in football players with CAI. Neuro-vestibular-ocular exercises are an approach that combines neuromuscular training with vestibular-ocular training techniques. As far as we know, there is no study investigating the effectiveness of these treatments in CAI and examining the superiority of training programs (myofascial relaxation and neuromuscular-vestibular-ocular exercise). At the same time, there is no study investigating the effectiveness of combined neuromuscular and vestibular-ocular exercises in the football player group.

Hypotheses of the study;

H0: There is no difference between the two groups in the effects of neuro-vestibular-ocular exercises and myofascial release on proprioception and performance in football players with CAI.

H1: There is a difference between the effects of myofascial release and neuro-vestibular-ocular activities on proprioception and performance in football players with CAI.

2.GENERAL INFORMATION

2.1. Anatomy of the Ankle

The human foot comprises three primary anatomical divisions, namely the rearfoot, midfoot, and forefoot, as depicted in Figure 2.1. These divisions are instrumental in understanding the complex movement of the foot. The ankle complex, which is crucial for foot motion, consists of three interconnected joints: the subtalar joint, the talocrural joint, and the distal tibiofibular syndesmosis joint. These joints collaboratively facilitate synchronized movements of the hindfoot in three distinct planes: the sagittal plane, frontal plane, and transverse plane. The sagittal plane permits the foot to execute plantar flexion (movement of the foot downward) and dorsiflexion (movement of the foot upward). In the frontal plane, the foot can undergo inversion (inward rolling of the foot) and eversion (outward rolling of the foot). Furthermore, the transverse plane allows for internal rotation (twisting the foot inward) and external rotation (twisting the foot outward). These intricate triplane movements are essential for ensuring optimal function and mobility of the foot. To enable efficient and coordinated motion, it is imperative that the joints within the ankle complex maintain proper alignment and functionality. This harmonious interaction among the rearfoot, midfoot, and forefoot is crucial for promoting effective movement (31-33).

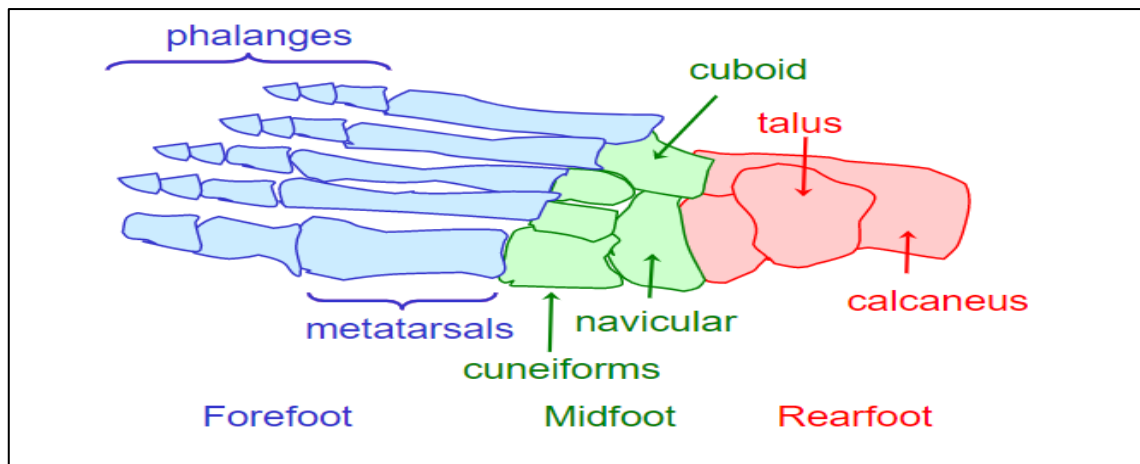


Figure 2. 1. The general relationship of the bones and major joints of the foot and ankle (24)

Mechanically, the hind foot does not move alone or independently. Instead, coordinated movement of the talocrural and subtalar joints allows the hindfoot to move

around an oblique axis of rotation. This oblique axis of rotation restricts the hindfoot to move only within the cardinal planes (sagittal, anterior and transverse). It is this complex interaction and coordination between the talocrural and subtalar joints that provides multi-plane ROM and functional stability to the hindfoot. The combined calcaneal motions of pronation and supination are rearfoot motions. It includes the combined movements of pronation, eversion, dorsiflexion and external rotation of the foot in the open kinetic chain. On the other hand, supination in the open kinetic chain includes inversion, plantar flexion, and internal rotation of the foot.

In a closed kinetic chain, it involves the foot in supination, inversion, dorsiflexion, and internal rotation. In contrast, pronation in the closed kinetic chain involves the foot rotating externally, inversion, and plantar flexion. In weight-bearing activities, these movements are crucial for maintaining the foot and ankle complex's general stability and mobility (Figure 2.2) (34,35).

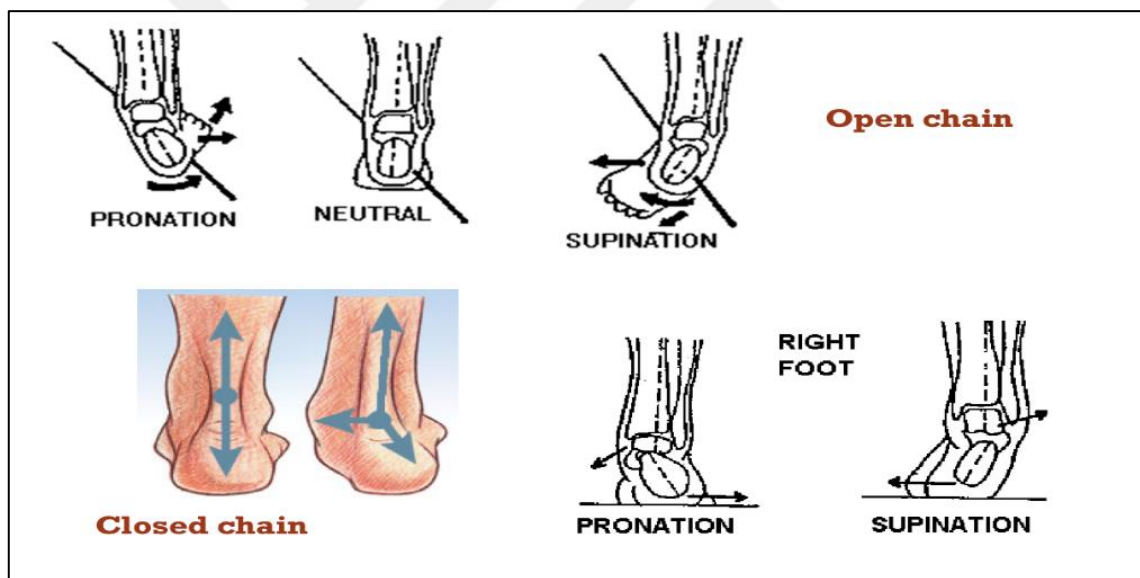


Figure 2. 2. Combined calcaneal movements of pronation and supination hindfoot movements

2.1.1. Tibiotalar (Talocrural) Joint

As shown in Figure 2.3 (36,37), the trochlea of the tibial plafond, the talus, and the medial and lateral malleoli all contribute to the articulation of the talocrural joint.

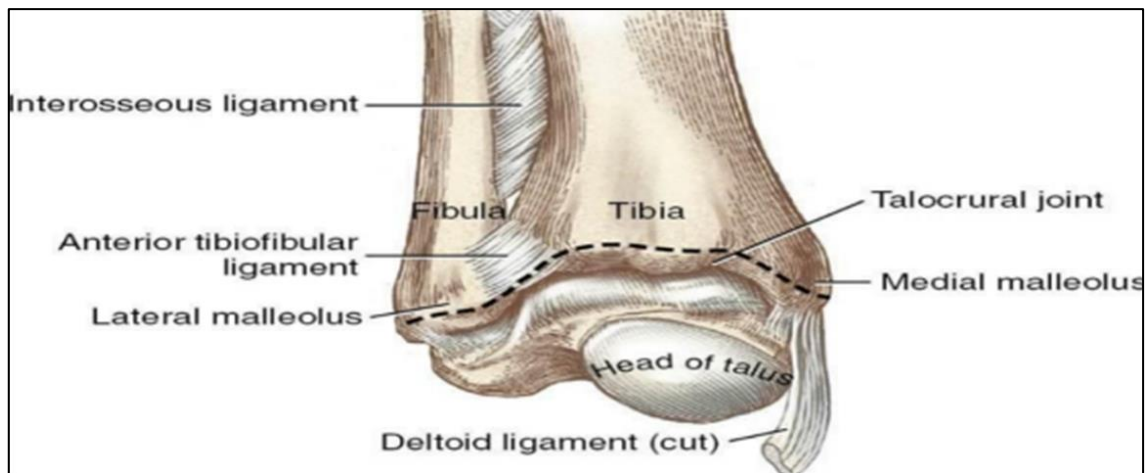


Figure 2. 3. The talocrural joint articulation

The talocrural joint, which is also referred to as the "mortise," serves a crucial role in weight-bearing activities and facilitates the transfer of torque from the lower leg to the foot. Structurally resembling a wooden joint, the talocrural joint functions as a hinge joint primarily responsible for the movements of dorsiflexion (upward movement of the foot) and plantar flexion (downward movement of the foot) (35). The rotational axis of the talocrural joint is established by the talar body and the apices of both malleoli. In relation to the medial malleolus, the lateral malleolus is situated posteriorly and inferiorly. Initially, this axis displays a slight inclination superiorly and anteriorly as it moves from the lateral to the medial side of the talus. However, as it progresses through both malleoli, it acquires a slight posterior inclination. While the primary movement of the talocrural joint occurs in the sagittal plane, there are also motions taking place in the frontal (side-to-side) and horizontal (rotational) planes around the oblique rotation axis (32, 36, 37). In the horizontal plane, the axis of the talocrural joint deviates from the medial to lateral axis by approximately 6° , while in the frontal plane, it deviates by around 10° . As a result, during plantar flexion, there is a slight adduction (inward movement) and inversion (inward rolling) of the foot, whereas dorsiflexion involves a minor abduction (outward movement) and eversion (outward rolling) of the foot. For a visual representation of the relationship between the talocrural joint and its movements, please refer to Figure 2.4.

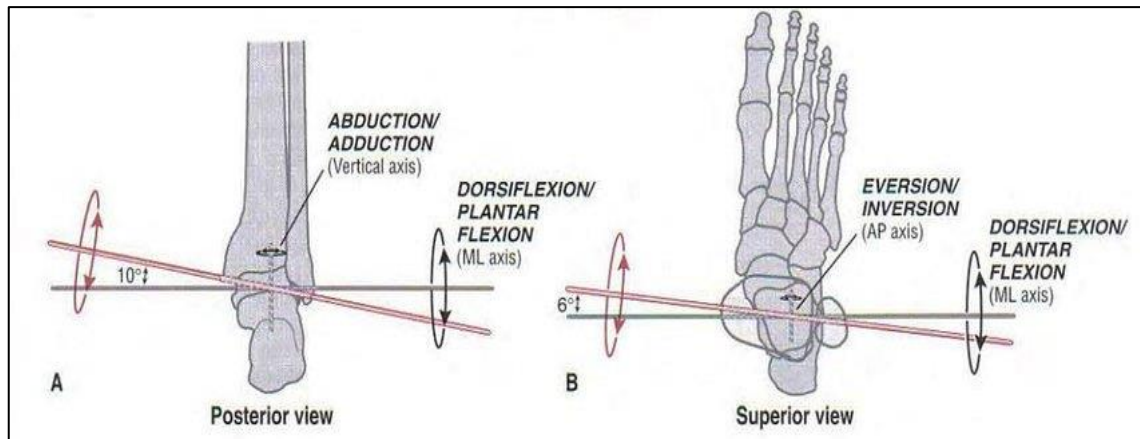


Figure 2. 4. The oblique axes of rotation can be observed from a posterior (A) and superior (B) perspective (24).

The articular surfaces of the talocrural joint play a vital role in maintaining ankle stability by preventing excessive rotation and translation of the talus when it is subjected to load. In addition, when the ankle is not bearing weight, stability is ensured through the combined action of multiple ligaments, the joint capsule, and the musculotendinous units (32, 35).

The talocrural joint, referred to as the "mortise," is enveloped by a thin protective capsule that receives external reinforcement from collateral ligaments, including the anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL), posterior talofibular ligament (PTFL), and deltoid ligament, all of which play a pivotal role in upholding the stability of the ankle joint. Specifically, the deltoid ligament, which originates from the medial malleolus of the tibia, extends its support to the medial aspect of the ankle, forming attachments to various bones within the foot, such as the talus, navicular, and calcaneus. Conversely, the lateral side of the ankle relies on the ATFL, PTFL, and CFL to maintain stability. Positioned anteriorly, the ATFL connects the talus to the fibula, particularly at the lateral malleolus, while the CFL runs from the calcaneus to the fibula, offering lateral support to the ankle joint. Meanwhile, the PTFL, situated posteriorly, establishes a connection between the talus and the fibula. In unison, these ligaments work collaboratively to limit excessive joint mobility, provide stability, and safeguard the talocrural joint against undue stress and forces (32, 35, 36).

Extending anteriorly and medially towards the talar neck, the ATFL establishes its attachment to the anterior portion of the lateral malleolus, and when observed from the frontal plane, it assumes an angle of approximately 44.8 degrees, as illustrated in Figure

2.5 (36, 38). In terms of its anatomical measurements, the ATFL is characterized by an estimated breadth, length, and thickness of 7.2 mm, 24.8 mm, and 2 mm, respectively (38, 39). The primary role of the ATFL is to prevent the anterior displacement of the talus within the mortise and to restrict excessive internal rotation and inversion of the talus with respect to the tibia, thereby ensuring ankle joint stability and function (35). Notably, among the various lateral ligaments, the ATFL is the most frequently damaged, making it particularly susceptible to injury and impairment (33, 36).

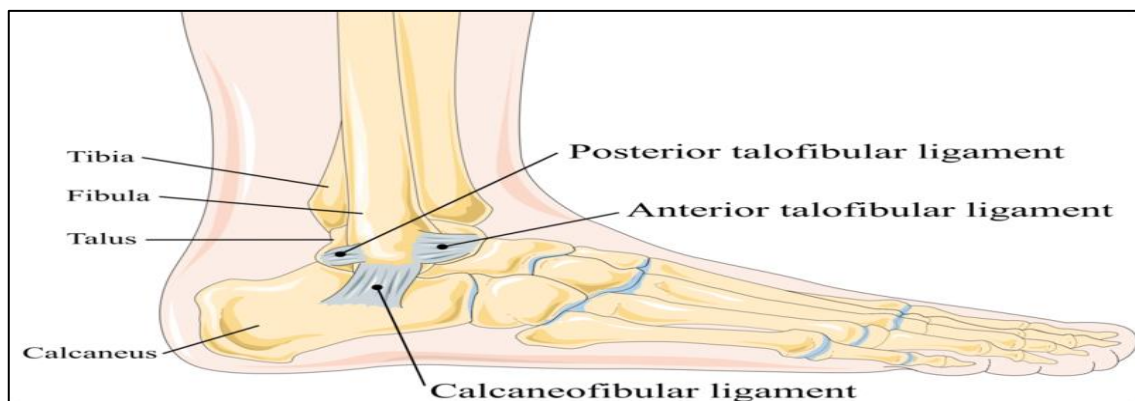


Figure 2. 5. Lateral Collateral Ligaments of the right ankle

CFL stretches inferiorly and posteriorly from the tubercle on the lateral surface of the calcaneus to the tip of the lateral malleolus. Figure 2.5 (36, 38) shows how it produces an angle with the fibula that is between 133° and 150° . The CFL has an average length of 35.8 mm (38), and a width of about 5.3 mm. The CFL, which is situated beneath the peroneal tendons (28), prevents excessive inversion at the talocrural and subtalar joints. When the ankle is in a dorsiflexed position, it is under the most tension (36, 35). Working in conjunction with the ATFL, the CFL restricts inversion throughout the entire ROM, encompassing both plantar flexion and dorsiflexion. Notably, both ligaments are involved in approximately two-thirds of lateral ligament injuries (36).

As illustrated in Figure 2.5, the PTFL originates from the posteromedial side of the lateral malleolus, attaching to the lateral tubercle of the talus. It then follows a horizontal course in a posteromedial direction, spanning across the posterior portion of the talus. The primary function of the PTFL is to stabilize the talus within the mortise and limit excessive abduction of the talus, particularly during dorsiflexion (36). It is worth noting that isolated injuries to the PTFL are less common compared to other lateral ankle

ligaments. PTFL ligament injuries are typically observed in cases of severe ankle sprains that involve concomitant rupture of both the ATFL and the CFL (35, 39).

Moving on to the medial collateral ligament, also known as the deltoid ligament, it possesses a triangular shape, as depicted in Figure 2.6. The deltoid ligament initiates at the apex of the medial malleolus and extends inferiorly and posteriorly, ultimately attaching to the medial surface of the talus. The tibionavicular component of the deltoid ligament anchors to the navicular bone, while the tibiocalcaneal portion inserts into the sustentaculum tali of the calcaneus (32, 36, 40).

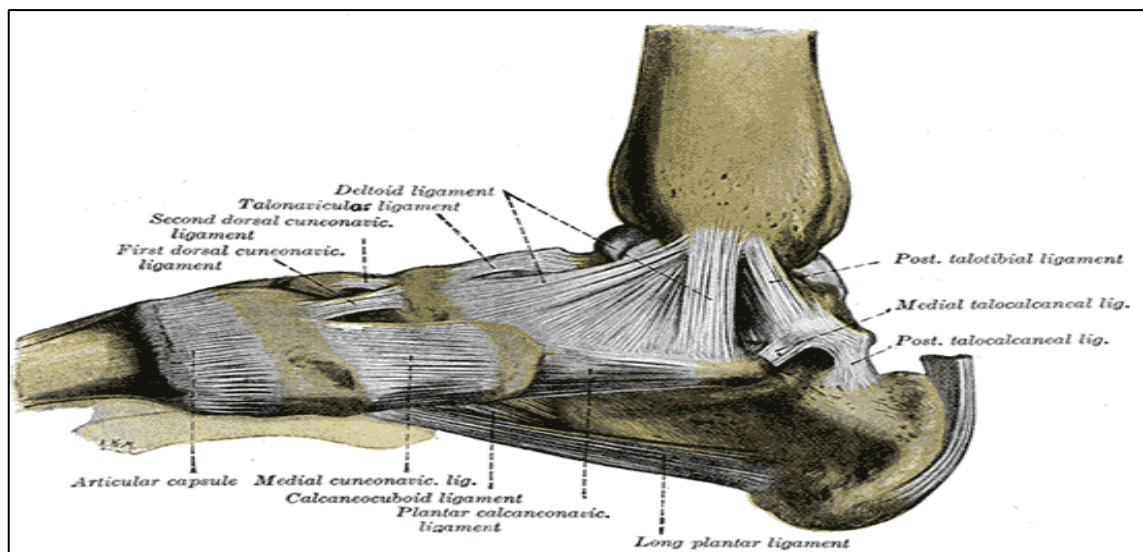


Figure 2. 6. The right ankle's Deltoid Ligament

The medial capsule of the talocrural joint receives reinforcement from deeper tibiotalar fibers, which are crucial for maintaining ankle stability (33, 36). These deeper fibers within the medial capsule provide supplementary support and contribute to the overall strength of the joint. The fibers that connect the talus (one of the bones in the foot) and the tibia (shin bone) in the medial area of the ankle joint are referred to as "tibiotalar fibers" in this context. These fibers are essential for stabilizing the joint and limiting the talus's ability to move excessively or shift in respect to the tibia.

Through the reinforcement of the medial capsule by the tibiotalar fibers, the ankle gains enhanced protection against forces that may potentially result in injury or instability. The collaborative action of the medial capsule, encompassing the tibiotalar fibers, in conjunction with the ligaments and other supporting structures, plays a crucial role in ensuring the proper functioning and stability of the talocrural joint. Of note, among

the lateral ankle ligaments, the deltoid ligament exhibits exceptional strength, boasting a tensile strength of 714 N. Its primary function involves the prevention of talar movement in the direction of abduction (outward movement) and lateral translation (sideways shifting). Due to its inherent durability and the protective barrier provided by the lateral malleolus, sprains of the deltoid ligament are exceptionally rare (33, 36, 41).

2.1.2 Subtalar (Talocalcaneal) Joint

The subtalar joint, composed of the talus and the anterior and posterior surfaces of the calcaneus, constitutes a complex joint within the foot. This joint plays a significant role in the biomechanics of the foot and ankle, exerting a substantial influence on their overall functionality. By facilitating coordinated movement and interaction between the talus and the calcaneus, the subtalar joint contributes to the intricate mechanics of the foot and ankle. Figure 2.7 provides a visual representation of this joint and its relation to the bones involved.

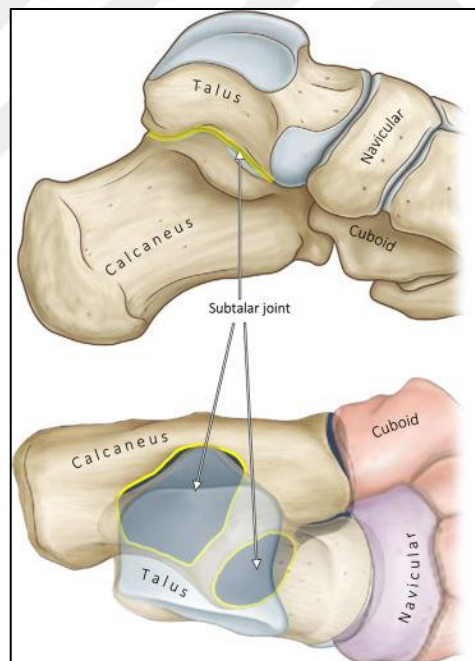


Figure 2. 7. Subtalar Joint

In terms of both anatomy and movement, the anterior articulation of the subtalar joint is comparable to a ball and socket joint. The front calcaneal surfaces and proximal navicular surfaces make up the socket component, and the head of the talus makes up the ball component.

In terms of its position within the foot, the anterior articulation of the subtalar joint can be observed to occupy a relatively more medial location compared to the posterior articulation. Furthermore, this anterior articulation of the subtalar joint is characterized by a higher axis of rotation, indicating the specific axis around which rotational movements occur. This rotational axis is approximately oriented at 42 degrees on the horizontal plane and 16 degrees on the sagittal plane, representing the precise orientation and position of the rotation axis within the subtalar joint during various movements. To gain a comprehensive understanding of the subtalar joint and its intricacies, Figure 2.8 (a-b) provides a valuable visual depiction, illustrating the anterior articulation and the corresponding rotation axis in a clear and illustrative manner.

The unique arrangement of the anterior articulation and its axis of rotation contribute to the specific movements and biomechanics observed at the subtalar joint, particularly during inversion and eversion of the foot. The movement of the calcaneus in relation to the talus during pronation and supination is not limited to a fixed angle but rather occurs in an arc perpendicular to the axis of rotation.

Pronation and supination are complex movements involving a combination of motions at multiple joints within the foot and ankle complex. These movements include inversion and eversion of the foot, as well as abduction and adduction of the subtalar joint.

During pronation, the foot undergoes a series of movements that involve the calcaneus rolling inward, the talus tilting downward and rotating medially, and the foot arch flattening. This allows for shock absorption and adaptability to uneven surfaces.

In contrast, supination is the opposite movement, where the foot undergoes a series of motions involving the calcaneus rolling outward, the talus tilting upward and rotating laterally, and the foot arch becoming more rigid. Supination provides stability and propulsion during activities such as jumping, running, and walking.

The tarsal canal and sinus tarsi are anatomical structures that delineate the region between the anterior and posterior articulations of the subtalar joint. This area is enclosed by an articular capsule consisting of both a fibrous and synovial membrane.

The capsule surrounding each articulation is reinforced and supported by several ligaments. The medial, lateral, and posterior talocalcaneal ligaments play a crucial role as secondary stabilizers for the subtalar joint. These ligaments provide additional support and help maintain the integrity of the joint capsule.

Apart from the talocalcaneal ligaments, there are additional deep and peripheral ligaments within the subtalar joint that play a crucial role as the main stabilizers. These

ligaments, in conjunction with other surrounding structures, contribute to the overall stability and proper functioning of the joint. The precise names and specific details of the ligaments within the subtalar joint can vary, and it is important to consult anatomical references or medical professionals for accurate and detailed information pertaining to your specific case or concerns. (34–36).

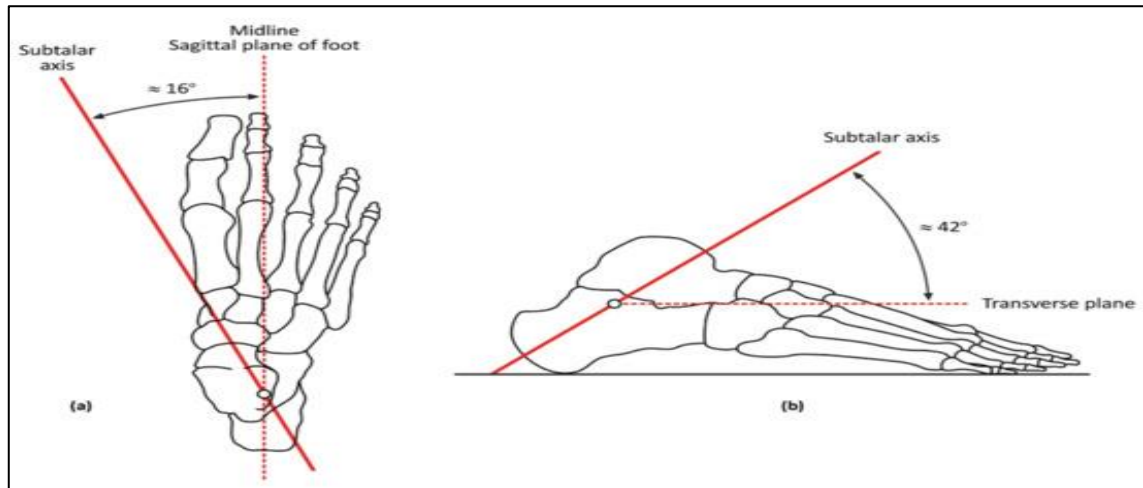


Figure 2. 8. (a) Inclination of STJ in transverse plane and (b) inclination of STJ in sagittal plane

CFL, a peripheral ligament, limits internal rotation and excessive inversion of the joint, whereas the deltoid ligaments prevent external rotation and excessive eversion of the calcaneus. The lateral talocalcaneal (LTCL) and fibulotalocalcaneal (FTCL) ligaments are other peripheral ligaments that help to prevent the subtalar joint from moving excessively in the supination direction. (34–36). Among other interosseous and cervical ligaments and deep ligaments intrude between the calcaneus and talus. These ligaments act as a barrier to separate the anterior and posterior joint capsules and offer nonmuscular support to the subtalar joint. These ligaments’ function is to restrict excessive motions, particularly inversion (34–36).

Subtalar joint injuries occur in conjunction with talocrural joint lateral ligament damage. Isolated subtalar joint injuries are quite rare. Subtalar instability is associated with 10% of CAI (39).

2.1.3 Distal Tibiofibular Syndesmosis Joint

The distal tibiofibular joint is classified as a syndesmosis by anatomists due to its structural composition and functional characteristics. This particular joint is formed by

the articulation between the medial surface of the distal fibula and the lateral aspect of the distal tibia, known as the fibular notch. In a syndesmosis, the connection between the bones is primarily facilitated by fibrous connective tissue. The distal tibiofibular joint exemplifies this anatomical arrangement, wherein the fibrous ligaments play a pivotal role in maintaining stability and preserving the alignment of the tibia and fibula. Notably, the posterior and anterior tibiofibular ligaments are notably strong and contribute significantly to the overall integrity of the joint. Through their fibrous composition, these ligaments afford the distal tibiofibular joint a degree of limited mobility while providing indispensable support to ensure optimal joint function.

Compared to other types of joints, such as synovial joints that have a joint cavity and allow for more extensive movement, syndesmosis joints like the distal tibiofibular joint have less mobility. The fibrous connections between the tibia and fibula in this joint allow for stability and transmit forces between the two bones. (Figure 2.9). The tibia and fibula are separated by the interosseous membrane, a thick, fibrous connective tissue that stabilizes and supports the joint. It enables coordinated action of the ankle joint and aids in maintaining the correct alignment of the tibia and fibula during movement. In order to keep the joint stable and limit excessive movement between the tibia and fibula, these ligaments are essential (Figure 2.10) (35,36,42).

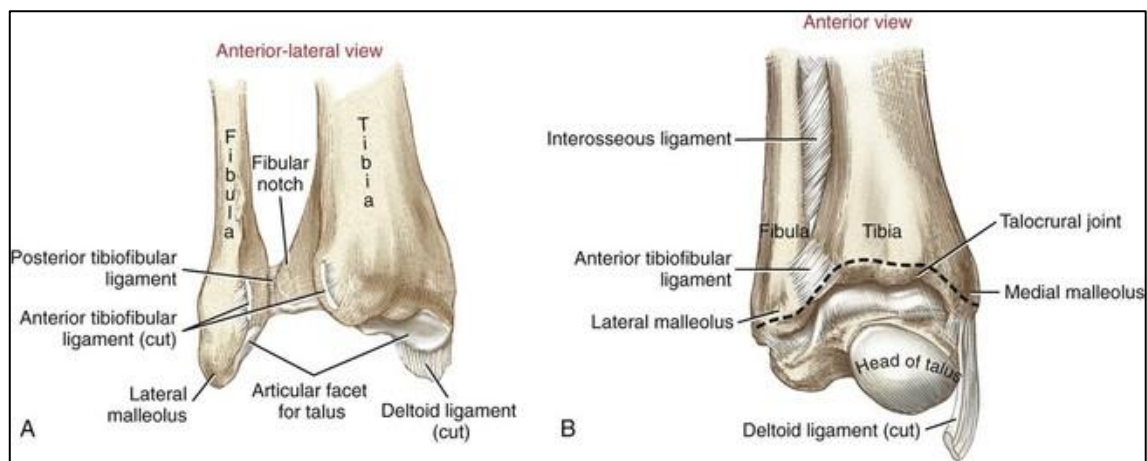


Figure 2. 9. View of the right distal tibia and fibula from the front

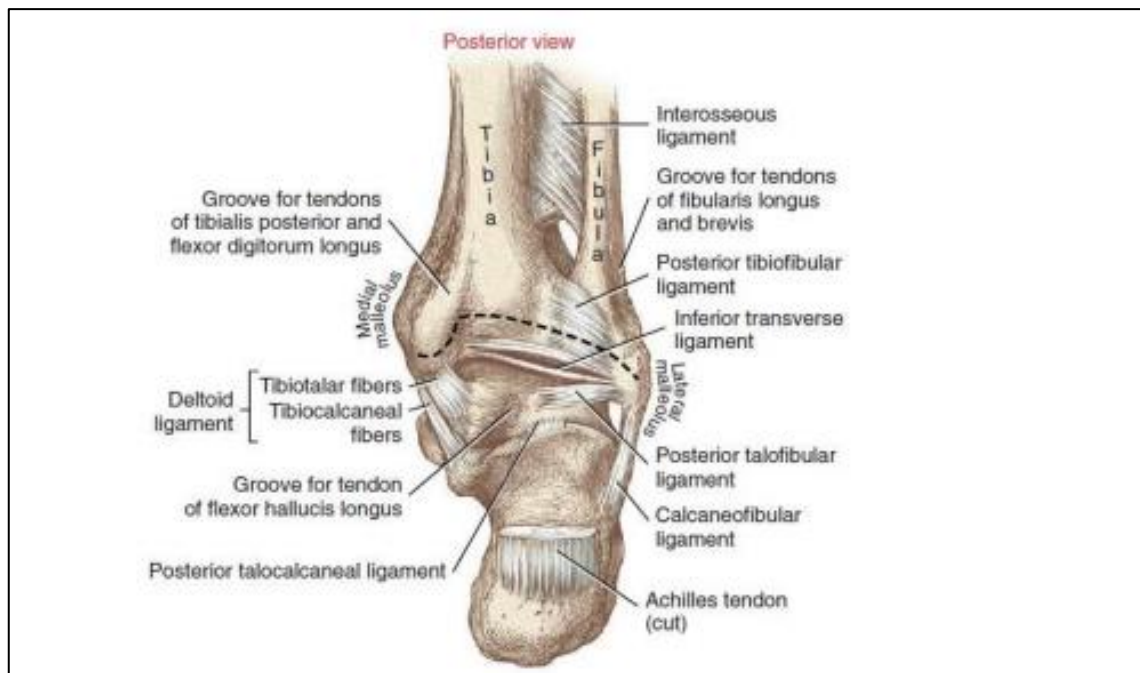


Figure 2. 10. In the posterior view of the right ankle, certain ligaments of the ankle joint are demonstrated: Posterior talofibular ligament (PTFL), Calcaneofibular ligament (CFL), Posterior deltoid ligament

The aforementioned ligaments are essential for giving the ankle joint dynamic support and stability. They make it easier for the fibula to firmly resist movement within the fibular notch, stabilizing the ankle mortise in the process. For the talocrural joint to operate properly, these two bones' structural integrity is necessary.

The distal tibia and fibula are strongly connected by the interosseous tibiofibular ligament, which also acts as a stabilizer. The distal interosseous membrane is carried on by it. In addition, AITFL and PITFL support the distal tibiofibular joint. These ligaments play a part in controlling the foot's excessive external rotation and the distal fibula's excessive movement in relation to the tibia.

The AITFL, although weaker compared to the PITFL, is frequently susceptible to injury, especially during eversion movements, resulting in a condition known as a high ankle sprain. (35,36,42).

2.1.4. Muscles and Tendons

The lower leg's muscles and tendon groups are crucial in supporting the ankle joint. Together, these muscle and tendon groups stabilize the ankle joint, manage movement, and preserve its normal alignment. The foot muscles and ankle muscles regulate the

precise joint movements and also provide the support, propulsion, and shock absorption needed for movement. The most movements in the foot and ankle is produced by twelve extrinsic muscles that originate in the thigh and insert into the foot. There are four groups that make up these extrinsic muscles. (Fig. 2.11).

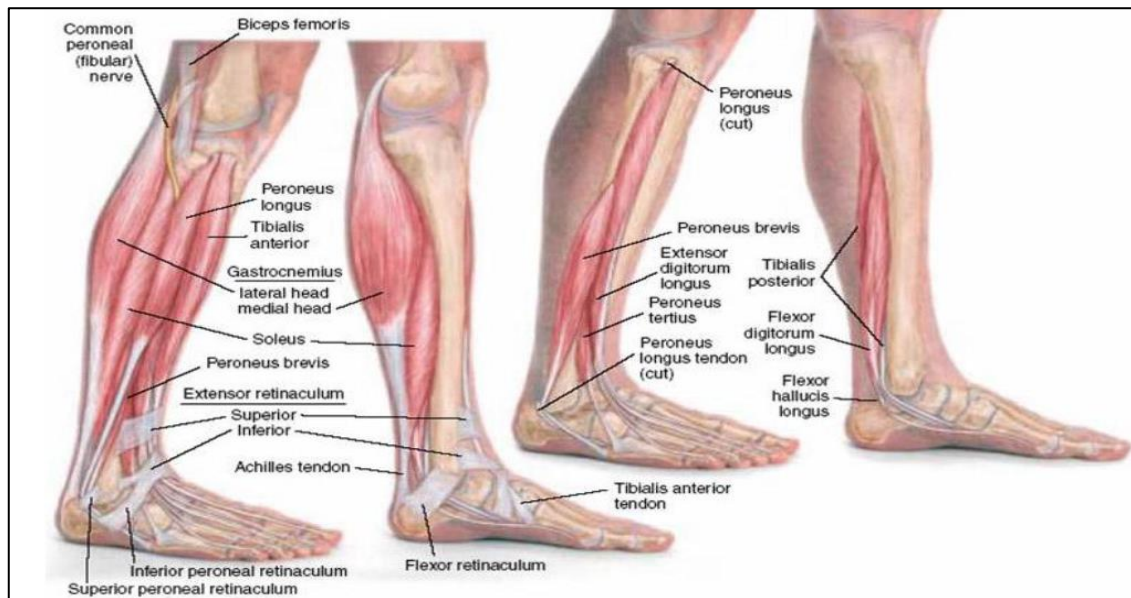


Figure 2. 11. Lower Leg Muscles

The anterior compartment of the lower leg houses several muscles, including the extensor digitorum longus, tibialis anterior, and extensor hallucis longus. These muscles are innervated by the peroneal nerve and play a key role during the swing phase of gait. Their primary function is to dorsiflex the talocrural joint and contribute to eccentric foot landing. In the lateral compartment, the fibularis longus and fibularis brevis muscles are located. The fibularis brevis muscle receives innervation from the superficial peroneal nerve. During the swing phase, the foot and ankle contribute to the pronation action. Moving to the posterior compartment, the plantaris, soleus, and gastrocnemius muscles are situated. In the deep posterior compartment, which includes the flexor digitorum longus, tibialis posterior, and flexor hallucis longus muscles, innervation is provided by the tibial nerve. These muscles are involved in various functions such as plantar flexion, inversion, and toe flexion. Figure 2.12 provides a visual representation of the innervation patterns of these muscles (36, 43).

Even if each group performs a separate activity, the intrinsic muscle group in the ankle is there. Together, they function to provide support for the foot's dorsal and plantar

surfaces. It is looked at in two different anatomical areas. Four layers of analysis are done on the abductor hallucis-innervated plantar surface tibial nerve muscles. The foot's muscles can be categorized into different layers based on their anatomical location. In the first layer, we find the abductor hallucis brevis, abductor digiti minimi, and flexor digitorum brevis muscles. Moving to the second layer, we have the lumbrical muscles and quadratus plantae. The third layer comprises the flexor digiti minimi brevis, adductor hallucis, and flexor digiti hallucis muscles. Lastly, in the fourth layer, we have the plantar and dorsal interosseal muscles, which are innervated by the tibial nerve.

During weight-bearing, the intrinsic plantar muscles contract in a coordinated manner, leading to a reduction in the distance between the calcaneus and the metatarsal heads. This contraction contributes to the overall stability of the foot and plays a role in motor function. Additionally, these plantar muscles also have neural involvement in ankle stability. On the dorsal surface of the foot, we find the extensor digitorum brevis and extensor hallucis brevis muscles, which are innervated by the peroneal nerve. It is important to note that the extensor digitorum brevis is the only intrinsic muscle located in the dorsal region of the foot.

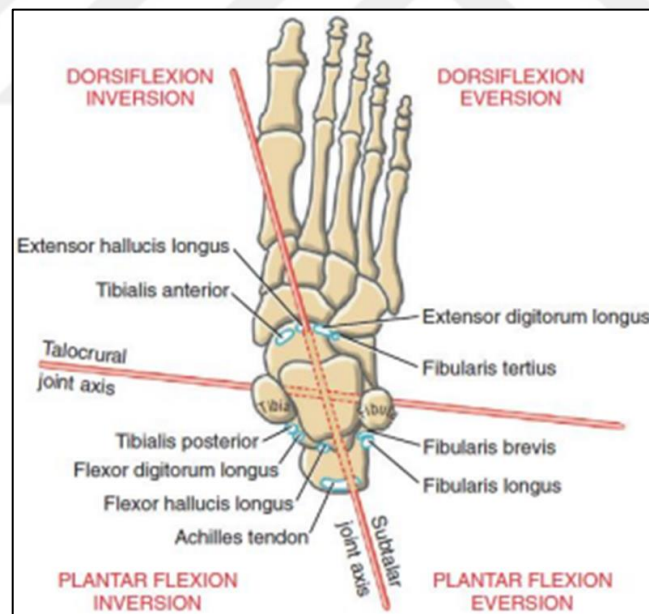


Figure 2. 12. It is shown how the lower leg muscles behave depending on where they are in relation to the axis of rotation at the joints.

Depending on their various actions, the muscles function either eccentrically or concentrically. Concentric activities are commonly used to characterize the muscles surrounding the ankle complex, while eccentric movements provide dynamic stability to

the joints. In order to prevent lateral ankle sprains and manage subtalar joint supination, the fibularis longus and brevis are crucial. The muscles of the anterior compartment are crucial in the eccentric contraction that stabilizes the lateral ankle complex during forced supination of the subtalar joint. This mechanism helps control and resist excessive inversion (rolling inward) of the foot, providing stability to the lateral ankle. The tibialis anterior, in particular, acts eccentrically to control the speed and extent of supination, preventing the foot from rolling too far inward and potentially causing injury. This dynamic stabilization helps maintain balance and support the foot during weight-bearing activities. The muscles of the anterior compartment, by reducing the amount of plantar flexion during supination, contribute to guarding against lateral ligament damage. Supination and severe plantar flexion can put undue strain on the lateral ligaments of the ankle, increasing the risk of injury. The contraction of the muscles in the anterior compartment helps control and limit the amount of plantar flexion, thereby reducing the strain on the lateral ligaments and providing additional protection against ligamentous damage. This muscle action is an important part of the ankle's overall stability and injury prevention mechanism (35).

2.1.5. Innervation

Motor innervation for the muscles encompassing all compartments of the foot and ankle originates from nerves arising from the sciatic nerve. The sciatic nerve derives its contribution from the L4-S3 spinal nerve roots of the sacral plexus. Within the foot and ankle, the two primary ramifications of the sciatic nerve are the tibial nerve and the common fibular nerve, both of which fulfill motor and sensory functions. Specifically, the deep branch of the common fibular nerve, also known as the deep fibular nerve, innervates the muscles residing in the anterior compartment of the leg, including the tibialis anterior and the extensor muscles. Conversely, the superficial branch of the common fibular nerve, referred to as the superficial fibular nerve, provides sensory innervation to the dorsum (superior aspect) of the foot. The tibial nerve, which additionally provides motor innervation to the muscles situated in the posterior compartment of the leg, supplies the gastrocnemius, soleus, and flexor muscles, along with the plantar surface of the foot. Furthermore, distinct regions of the foot and ankle receive sensory innervation from other nerves, such as the sural nerve (a branch of the tibial nerve) and the saphenous nerve (a branch of the femoral nerve). More specifically,

the deep fibular nerve innervates the muscles within the anterior compartment, while the superficial fibular nerve innervates the muscles in the lateral compartment, notably the fibularis longus and fibularis brevis. Sensory innervation to the lateral and dorsal surfaces of the lower extremity and foot is also conferred by the superficial fibular nerve. The tibial nerve assumes responsibility for innervating the muscles in the posterior compartment, including the gastrocnemius, soleus, and flexor muscles, as well as the remaining intrinsic muscles of the foot via its terminal branches. Sensory innervation to the skin surrounding the medial aspect of the ankle and the heel is provided by the sensory branch of the tibial nerve. Of noteworthy importance, proprioception, an indispensable aspect for the proper coordination and control of the ankle complex, entails the awareness of one's own position and movement. This is further facilitated by the presence of muscle spindles, specialized sensory receptors embedded within the fibularis muscles, which contribute to proprioception by relaying information regarding muscle length and tension. In essence, the intricate innervation pattern involving the deep fibular nerve, superficial fibular nerve, tibial nerve, along with the presence of mechanoreceptors and muscle spindles, collectively play a pivotal role in governing motor control, sensory feedback, and proprioceptive awareness within the ankle complex (35, 36, 44).

2.1.6 Ankle Biomechanics

The human body's link with the ground is provided by the foot and ankle, which are dynamic structures. Although the lower extremity joints and tissues are handled and evaluated independently from each other, from a functional point of view, all lower extremity, foot and ankle joints work harmoniously. Since the ankle joint affects the whole body and is linked to other lower limbs, it cannot be considered as a biomechanically independent structure. The foot and ankle joint must cooperate with other lower extremity joints to work most effectively and efficiently with the least amount of energy consumption. One of the most important tasks of the foot is to carry the weight of the body, to push the body back and forth while running and walking. Overall, the ankle joint acts as a crucial link between the lower extremity and the foot, supporting body weight transfer, providing adaptability to various surfaces, and contributing to overall balance and stability during locomotion. (41).

Even when the ankle is subjected to stress factors from routine activities, it has a fairly significant level of compliance, indicating that the large load-bearing surface of the

ankle will cause less stress than the hip or knee (42). Thanks to the complex structure of the ankle, it can carry weights that are significantly heavier than the body weight. (41). The foot performs the closed kinetic chain and weight bearing functions while the ankle is in contact with the ground. At this stage, while tibia and fibula movement is allowed, if rotational forces in the femur are not absorbed by the knee, the force is reflected in the ankle bones (43).

In the post-propulsion phase of gait, the ankle acts as a stable support structure to maintain a smooth and upright posture without excessive muscle activation and energy expenditure. In addition, the ankle works flexibly, providing shock absorption on a variety of surfaces. Thanks to the rotational movements of the ankle, it adapts to different floors and transmits the reaction forces from the ground to higher parts (41).

It has been discovered that internal tibial rotation causes movement to be transmitted along the ankle joint and transformed into inversion in the subtalar joint. A rigid longitudinal arch is the result of these rotations locking the transverse tarsal joint. The calcaneus is everted and the longitudinal arch is unlocked as a result of the ankle and subtalar joints transmitting the tibia's outward rotation, creating a flexible foot (44).

The lower ends of the lateral and medial malleoli are where the ankle joint's mechanical axis, or rotational axis, passes. An imaginary line that connects the bases of the medial and lateral malleoli is the ankle joint's axis of rotation or mechanical axis. For rotational movements like dorsiflexion and plantar flexion at the ankle joint, this axis acts as a reference. The foot raises during dorsiflexion, bringing the top of the foot closer to the shin. This movement occurs around the anterior-posterior axis, which is slightly superior and anterior to the axis passing through the malleoli. On the other hand, the foot slides downward and the toes point away from the shin during plantar flexion. Although slightly posterior to the malleoli axis, this movement revolves around the same axis. (45). The axis of the ankle joint is positioned inward with respect to the knee joint but rotates 20° to 30° from the outside to the inside (44). In the coronal plane, the longitudinal axes of the tibia and the ankle make an angle of 80° (10° varus). These two axes' combined angle ranges from 68° to 88° (45). The axis of the ankle joint diverges medially when measured from the ends of the malleolus even if the tibial plafond is parallel to the ground. The articular surface of the talus is shaped more like a cone with a medially directed apex than a cylinder. There are noticeable variances even if the apical angle is roughly 26 degrees (44).

The ankle joint complex exhibits major movements in different planes: sagittal, transverse, and frontal. In the sagittal plane, the primary movements are plantarflexion (pointing the foot downward) and dorsiflexion (bringing the foot upward). Abduction (movement away from the midline) and adduction (movement toward the midline) occur in the transverse plane. The primary movements in the frontal plane are inversion (tilting the foot inward) and eversion (tilting the foot outward). Supination and pronation, which refer to the position of the plantar surface of the foot, are motions that take place in three dimensions in coordination with the subtalar and tibiotalar joints. Plantar flexion, inversion, and adduction work together to produce supination, which turns the foot's sole medially. Conversely, pronation results in the sole pointing laterally and is a result of a combination of eversion, dorsiflexion, and abduction (42). At the tibiotalar joint, the ankle joint complex primarily conducts plantarflexion and dorsiflexion movements in the sagittal plane. Although there are common ranges seen, the ROM of the ankle joint complex might vary between individuals (42).

It should be recognized that the ROM required for daily activities may be lower than the maximum ROM achievable by a joint. For instance, during normal walking, the ankle typically requires a maximum of 30 degrees of dorsiflexion. Climbing stairs may require a greater range, with approximately 37 degrees of dorsiflexion, and descending stairs may require even more, with approximately 56 degrees of dorsiflexion. These ranges of motion are essential for normal gait, balance, and functional activities involving the ankle joint complex.(42)

2.2. Ankle Problems in Sports

There is an inherent risk of harm in every recreational activity and sport. Sports activities frequently entail high-impact movements, abrupt changes in direction, and repetitive motions, all of which can place a lot of strain on the joints in the foot and ankle. Athletes seek for speedy recovery and an early return to their sport or activity since in sports, time is frequently of the importance. Therefore, it is essential to identify injuries quickly and to treat them accordingly. This entails appropriate treatment, recuperation, and targeted treatments made to match the kind and degree of the injury. Maximizing healing, regaining function, and reducing the risk of further injury are the objectives. In addition to managing injuries, preventive measures play a vital role in sports. In order to lower the risk of foot and ankle injuries, athletes and sports professionals concentrate on

injury prevention techniques such as suitable warm-up and cool-down routines, adequate footwear, strengthening and conditioning activities, and biomechanical assessment. Overall, a comprehensive approach that combines early diagnosis, effective treatment, rehabilitation, and injury prevention strategies is essential in the management of sports-related foot and ankle injuries. This method attempts to improve optimal performance while also facilitating an early return to sport and minimizing long-term effects. Athletes are susceptible to foot and ankle injuries for a variety of reasons, both inherent and extrinsic. Intrinsic factors refer to the individual characteristics of the athlete, such as their biomechanics, anatomy, muscle imbalances, flexibility, and previous injury history. These factors can affect the alignment, stability, and function of the foot and ankle, making them more vulnerable to injuries (46-49,53-55).

Extrinsic factors, on the other hand, are external factors that can influence injury risk, such as the type of sport or activity, playing surface, footwear, training techniques, and environmental conditions. For instance, sports like soccer, basketball, and tennis that frequently include running, jumping, and cutting movements place a great deal of stress on the foot and ankle, increasing the risk of injury. One of the most common sports-related foot and ankle injuries is an ankle sprain. These injuries take place when the ligaments that surround the ankle joint are strained or torn, typically as a result of a sudden twisting or rotating of the foot. In syndesmotic injuries, often known as high ankle sprains, the ligaments connecting the tibia and fibula are harmed. Midfoot sprains and Lisfranc injuries can occur during activities that involve forceful impacts or twisting motions. Turf toe injuries result from hyperextension of the big toe, often seen in sports played on artificial turf surfaces. Tendon ruptures, such as Achilles tendon ruptures, can occur during explosive movements or when the tendon is subjected to excessive stress. Overuse syndromes, including Achilles tendonitis, tibial stress syndrome (also known as shin splints), and stress fractures, can develop gradually due to repetitive stress and inadequate rest and recovery. It is important for athletes and sports professionals to be aware of these common foot and ankle pathologies and injuries. Foot and ankle injuries in sports can be prevented or at least less severe by using adequate training methods, suitable footwear, injury prevention programs, and seeking early diagnosis and treatment (46-48).

Joint/ligament sprains account for roughly 15-20% of elite football injuries and are most commonly found in the foot, ankle, and knee joints (49,53). Elite teams frequently have a substantial player shortage as a result of ankle and knee medial collateral ligament sprains. Medical teams operating in these clubs are likely to gain from new findings in

this field, for example. Ankle balance/neuro-muscle training is crucial for preventing ankle sprains from recurring (54). The second-most frequently injured body part after the knee is the ankle, which is why ankle injuries, especially ankle sprains, are among the most prevalent injuries in sports.

Athletes are more likely to get ankle injuries in field games and team sports that require running, jumping, abrupt changes of direction, and physical contact. Sports such as rugby, football (soccer), handball, volleyball and basketball often require dynamic movements and agility, increasing the chances of landing awkwardly, colliding with other players, or having the ankle forcefully twisted during gameplay. The nature of these sports, with frequent lateral movements, pivoting, and landing on uneven surfaces, can place significant stress on the ankle joint and its surrounding structures. Additionally, the potential for direct contact and collisions further increases the risk of ankle injuries (55).

2.2.1. Ankle Sprains

Both the general public and the athletic community frequently experience ankle injuries. Ankle sprains affect roughly 1 in every 10,000 people everyday in the general population (57). The most frequent injury in the world of sports is an ankle sprain, which also adds significantly to the overall injury load when engaging in sports activities. The reported prevalence of ankle sprains may vary slightly across studies but generally falls within the range of 38% to 45% of all sports injuries (57).

Compared to certain other sports, basketball and soccer have a higher percentage of ankle injuries. This is probably because these sports include a lot of fast direction changes, abrupt stops and starts, jumping, and landing, all of which can place a lot of stress on the ankle joint and raise the risk of sprains. In soccer, it has been discovered that the risk of injury is 4 to 6 times higher during a game than it is during practice. The physical demands and probable contact with other players, combined with the intense and competitive nature of games, raise the risk of ankle injury.

In the plantar inversion and flexion positions, the ankle lateral ligaments are most vulnerable to damage, putting the most strain on the anterolateral ligament (ATLL). By expanding the moment arm of the response force, touching the ground in this position can result in a significant overreaction supination torque (32). When the foot is elevated and unexpected contact with the floor or an object occurs, the lateral ankle ligament complex may be damaged. This can occur while jogging on an uneven terrain, stepping

into a gap, or landing on another athlete's foot after a leap (59). Ankle soft tissue injuries comprise 82.8% ATFL, 66.9% CFL, and 34.2% PTFL. The most commonly injured ankle group is the lateral ligaments (2).

The ATFL is the most often injured ligament during an inversion injury. If the impact is high enough, the posterior talofibular and calcanofibular ligaments can be damaged. When the foot is dorsiflexed and inverted, the calcanofibular ligament is damaged. A dorsiflexion and an external rotation force are typically used to sprain syndesmosis. An eversion / outward rotation injury injures a strong deltoid ligament (59). Because the PTFL is physically positioned deep within the peroneal tendons, isolated PTFL injury is uncommon (2). Furthermore, when compared to PTFL, ATFL, and CFL, it is shorter, thicker, and stronger, resulting in a lower injury rate (60).

In clinical practice, healthcare professionals classify ankle ligament injuries into three grades to assess the severity of the injury. These grades are categorized as follows: grade I, indicating a mild injury; grade II, indicating a moderate injury; and grade III, indicating a severe injury. This grading system helps in evaluating and determining appropriate treatment approaches for ankle ligament injuries.

Grade I injuries are characterized by ligament stretching without macroscopic rupture, minor swelling or discomfort, minimum or no loss of functionality and mechanical joint instability.

Grade II is a partial ligament rupture with considerable discomfort, edema, and associated structures. There is mild to severe joint instability and loss of joint mobility.

A *Grade III* classification is given to a complete ligament rupture accompanied by severe swelling, bleeding, and pain. This grade indicates a loss of function, substantial abnormal joint movement, and instability (61).

The possibility of recurrent sprains and the emergence of chronic instability are significant aspects of ankle sprains. Researchers have found that people who have already sprained their ankle are more likely to sustain additional sprains. Up to 80% of those who have already experienced an ankle sprain are thought to experience more sprains in the future. Furthermore, a substantial proportion, up to 72%, of individuals may develop persistent symptoms or CAI, which can adversely affect their athletic performance and daily functioning (58).

Deltoid ligament complex damage or disruption results from severe external rotation and eversion of the ankle, which causes medial ankle sprains (MAS). On the medial (inside) side of the ankle, the deltoid ligament, a powerful ligament, stabilizes the

joint. The foot is jerkily forced outward (everted) and the ankle is externally rotated during a medial ankle injury. This combination of movements puts excessive stress on the deltoid ligament, leading to stretching or tearing of its fibers. The main stabilizer of the medial compartment is the complex of deltoid ligaments. Generally, this injury develops when an athlete collides with another competitor during a competition. Football and gymnastics have the highest rates of MAS (63).

Deltoid ligament injuries are rarer than lateral ligament injuries. The medial malleolus has a considerable eversion, is longer than the lateral malleolus, and is supported by stronger ligaments than the lateral ligaments, which are the causes of this scenario (62).

2.2.2. Syndesmotic Sprain (High Ankle Sprain)

When the foot is bent upwards (dorsiflexed) and experiences a rotational force from the outside, it can cause syndesmotic injuries. These injuries disrupt the normal functioning of the syndesmotic ligaments, which connect the fibula (the smaller bone in the lower leg) to the tibia (the larger bone in the lower leg). As a result, external rotation of the foot occurs, and the fibula moves backward in relation to the talus (the bone that forms the ankle joint). This abnormal movement puts stress on the syndesmotic ligaments and can lead to further complications (66).

Uys and Rijke (64) conducted a study revealing a frequent occurrence of low-grade lateral ankle ligament sprains alongside high-grade syndesmosis injuries. Conversely, a low-grade syndesmosis injury may be followed by lateral ligament sprains of both low and high degrees. In a separate investigation by De César et al. (65), it was found that among 56 patients with lateral ankle sprains, 17.8% also presented with concurrent syndesmotic injury. These findings underscore the importance of conducting a comprehensive assessment of ankle injuries, taking into consideration the possibility of concurrent ligamentous injuries, irrespective of the specific mechanism of injury. Such a holistic approach is crucial to ensure accurate diagnosis and appropriate management strategies for optimal patient outcomes.

2.2.3. Lateral Ankle Sprain (LAS)

Lateral ankle sprains represent a prevalent form of injury affecting the lower extremities, particularly in the realm of sports. These sprains often result in damage to the

passive ligamentous structures located on the lateral aspect of the ankle. The lateral ligaments of the talocrural joint, namely the ATFL, CFL, and PTFL, are frequently implicated in such sprains. It is worth noting that approximately 85% of ankle sprains occur as a result of an inversion mechanism, wherein the foot experiences an inward rolling motion. This mechanism places significant stress on the lateral ligaments, making them susceptible to injury. Two mechanisms that frequently result in lateral ankle sprains are talocalcaneal plantarflexion (pointing the toes downward) and subtalar inversion (rolling the foot inside). The joint capsule between the lateral malleolus, the bony protrusion on the outside of the ankle, and the lateral talar neck, a section of the talus bone, is also damaged. The ATFL is most stressed during plantarflexion, and it is more sensitive to injury during inversion. Isolated ATFL injuries account for around 70% of all lateral ankle sprains (69). The CFL, one of the lateral ankle ligaments, stands out due to its presence in both the subtalar and talocrural joints. During dorsiflexion, the PTFL is stretched, whereas during plantarflexion, it is relaxed. The lateral compartment's least injured ligament is the one that connects the talus to the lateral malleol (38). Injuries to the lateral ligamentous complex of the ankle joint frequently result in osteokinematic symptoms such pain, edema, and restricted joint motion (LAS). When attempting to walk, run, or perform other forms of exercise, these symptoms may have an impact. Following a lateral ankle sprain, the development of CAI is a significant complication (68).

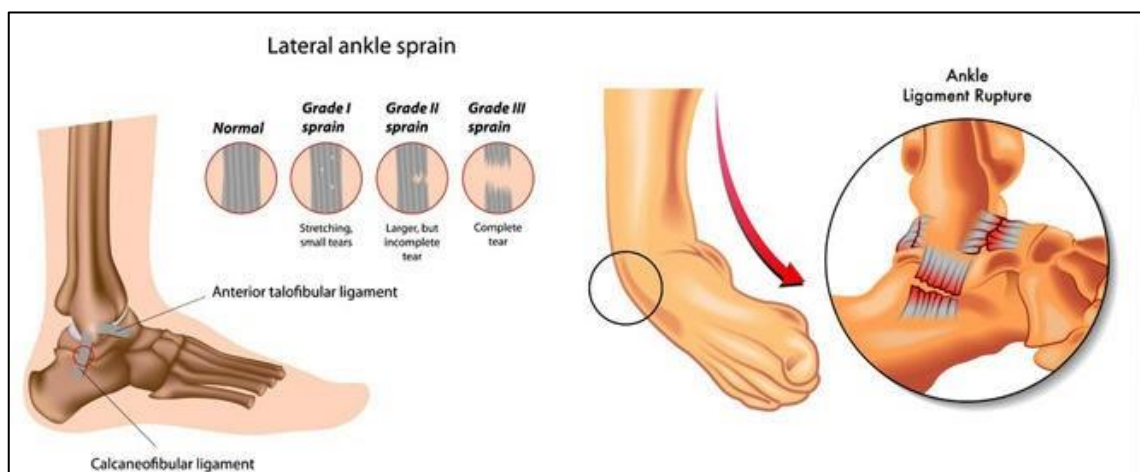


Figure 2. 13. Inversion position is the main mechanism of lateral ankle sprains.

2.3. Chronic Ankle Instability (CAI)

A disease known as CAI is one that lasts longer than a year and is characterized by recurrent instances or sensations of the ankle "giving way" as well as enduring symptoms. These signs include a lack of self-reported function, soreness, a loss of strength, and decreased ankle ROM (59). Sequelae are fairly common following injury to the ankle ligaments. In 10% to 30% of people with lateral ligament damage, persistent symptoms are possible (61). Due to recurrences, individuals with a history of acute ankle instability following a lateral ankle sprain are predicted to have a prevalence of CAI between 40% and 70%. Athletes including basketball players, runners, and volleyball players appear to be more likely to have CAI (3).

If an ankle sprain occurs again within six months of the initial injury and/or the joint begins to give way, CAI is assumed (71). CAI following a lateral ankle sprain often presents with a range of common symptoms. These symptoms include persistent synovitis or tendinitis, stiffness in the ankle joint, soreness, swelling, muscular weakness, and a recurring sensation of the ankle "giving-way." These signs and symptoms point to the continuous instability and functional limitations that CAI patients suffer (61).

The term CAI encompasses both functional instability (FI) and mechanical instability (MI), which are used to describe different aspects of the condition. Patients may report symptoms related to FI, which refers to a subjective sense of ankle instability and movement beyond the normal ROM. On the other hand, MI refers to objective signs of ankle laxity and excessive joint movement beyond the physiological range. Considering both FI and MI can help in understanding the comprehensive nature of ankle instability and its associated symptoms. Increased hindfoot inversion laxity or severe anterior talocrural excursion were indicators of MI of the ankle joint (72). Joint movement outside the range of voluntary control but within typical physiological bounds was described as FI (73).

Mechanoreceptors are located in the joint capsule, ligaments, muscles, and ankle, as well as on the skin that surrounds them (74). The central nervous system's ability to receive afferent signals from these receptors is disrupted, which is the main cause of functional instability. As a result, there will be a deficit in reflex stabilization (75). Patients refer to this occurrence as giving way (75,35,76).

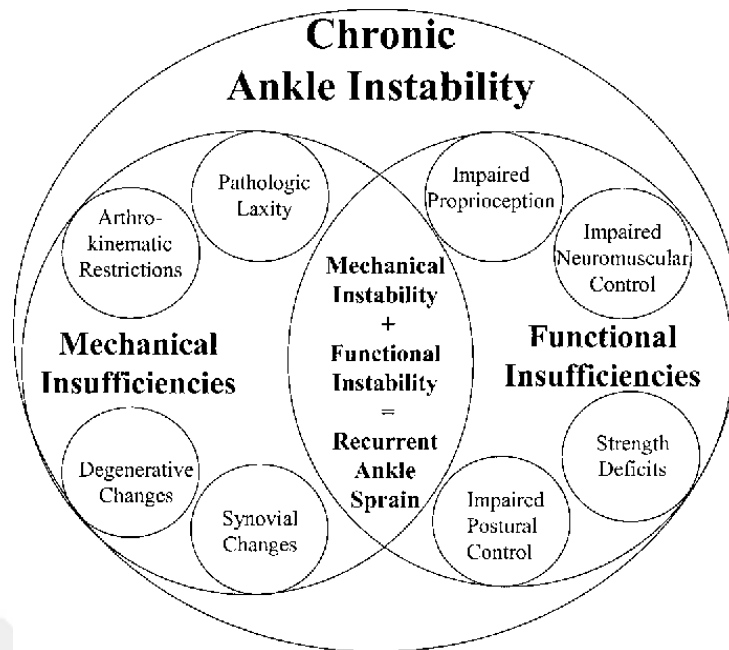


Figure 2. 14. Factors causing CAI

2.3.1. Risk Factors

Numerous studies have found a number of extrinsic and intrinsic factors that make athletes more prone to ankle sprains. There is a higher risk of ankle instability for a variety of reasons. These variables include tibial varum (bowleg), severe talar tilt, limb dominance, height, weight, BMI, and age. Foot morphology, particularly having a wide foot, has been associated with an elevated risk of ankle instability. Additionally, certain traits have been identified as contributing factors. These include a delayed response time of the peroneus brevis muscle (a muscle involved in ankle stability), increased concentric strength of the plantar flexor muscles (muscles responsible for pointing the foot downward), diminished eccentric force for inversion (weakened ability to control inward ankle movement), and decreased passive proprioceptive sense in inversion (reduced ability to perceive the position of the foot during inward movement). Other contributing factors include poor postural stability, impaired proprioception (sense of joint position and movement), higher strength ratios between plantar flexors/dorsiflexors and evertors/inverters, and inadequate or inappropriate rehabilitation. Extrinsic risk factors include taking part in some high-risk sports or activities, the level of competitiveness, the kind of footwear worn, the conditions of the playing surface, and the usage of ankle taping or support (74–81).

2.3.1.1. Foot Characteristics

The foot and ankle complex may have morphological variations due to CAI. In terms of calcaneus, individuals with CAI have a higher propensity for varus alignment (78). In addition to a greater varus angle, persons with CAI have a higher medial curvature than those with the cavovarus foot type (79).

2.3.1.2. Pathological Laxity

Pathological ankle joint laxity can result after ligamentous injury to the ATFL, CFL, and deltoid ligament. This laxity refers to an abnormal looseness or instability of the joint that results from the ligament injury. The degree of lateral ankle ligament injury is correlated with the degree of pathological laxity, meaning that more severe ligament injuries are associated with greater instability.

Pathological laxity can have significant implications for the affected joint. It can lead to mechanical instability, which means that the joint may not be able to maintain proper alignment and stability during movements. Further structural damage may result from this, especially during athletic or occupational activities that demand quick changes in direction and rapid motions.

Various methods can be used to diagnose pathological laxity. Physical examination techniques, such as stress testing of the ankle joint, can help assess the stability and detect abnormal laxity. Instrumented arthrometry, which involves using specialized devices to measure joint stability, can provide objective measurements of laxity. Additionally, stress radiography, which involves imaging the joint under stress, can also be used to assess laxity and joint stability (41).

2.3.1.3. Arthrokinematic Deficiencies

Mechanical instability of the ankle can be exacerbated by arthrokinematic deficits in the ankle joints. These deficiencies, particularly in the inferior tibiofibular joint, may result from frequent ankle sprains and limit the ROM of the joints. In individuals with CAI, the distal fibula may shift anteriorly and inferiorly, which restricts the lateral malleolus' ROM in its new location. This restricted mobility may cause the ATFL to become more lax in its resting position, allowing for a greater ROM of the talus before

the ligament contracts. The displacement of the fibula may have an impact on the recurrence of ankle instability (41).

ROM in the ankle can contribute to ankle instability. Specifically, limited dorsiflexion range of motion has been recognized as a risk factor for lateral ankle sprains. The talocrural joint, which is responsible for ankle dorsiflexion and plantarflexion, may be unable to achieve its optimal position during weight-bearing if it lacks full extension or dorsiflexion. This can create a biomechanical imbalance that facilitates internal rotation and inversion of the foot, increasing the likelihood of lateral ankle sprains. In the closed kinetic chain, excessive subtalar pronation frequently offsets insufficient dorsiflexion. Multiple ankle sprain sufferers frequently have a reduced range of dorsiflexion, according to studies (41,83).

2.3.1.4. Degenerative and Synovial Changes

Mechanical instability of the ankle can be attributed to deficiencies caused by two main factors: synovial hypertrophy and degenerative changes in the ankle joint. Synovial hypertrophy refers to the abnormal thickening of the synovial membrane, which lines the joint capsules. The talocrural joint (ankle joint) and the posterior subtalar joint capsules are commonly affected by synovitis, which is inflammation of the synovial membrane. Synovitis leads to recurrent episodes of ankle pain and instability. The hypertrophic synovial tissue can become trapped or compressed between the relevant bones of the ankle, resulting in discomfort and compromising the stability of the joint. The presence of pain and recurring instability is a characteristic feature of synovitis. CAI has also been associated with degenerative joint lesions in the ankle. Degenerative changes refer to the progressive breakdown of joint structures, such as cartilage and ligaments, over time. In the context of CAI, these degenerative joint lesions contribute to the instability of the ankle (84). The combination of synovial hypertrophy and degenerative joint lesions can further exacerbate ankle instability, leading to ongoing issues with pain and limitations in functionality. It is crucial to accurately diagnose and manage these underlying joint conditions in order to address ankle instability effectively. Treatment options may include the use of anti-inflammatory medications, physical therapy to improve joint stability and proprioception, and, in severe cases, surgical intervention to address structural abnormalities and alleviate symptoms (41).

2.3.1.5. Proprioception and Sensation Impairment

The capacity to detect and perceive bodily position, movement, and forces acting on the muscles and joints is known as proprioception. It combines input from the vestibular system in the inner ear with sensory data from a variety of receptors located in the muscles, tendons, ligaments, and joints. Proprioception plays a crucial role in motor control and coordination, allowing us to maintain balance, perform precise movements, and have a sense of body awareness. (85). Individuals susceptible to recurrent ankle sprains are more likely to have impaired ankle proprioception, as measured by kinesthetic sense and joint position (86). The majority of studies show that diminished joint position sensation impairs proprioception in CAI individuals (87). According to recent studies, alterations in the peroneal muscles' muscle spindle activity may have a higher effect on ankle proprioceptive deficits than alterations in the activity of the joint's mechanoreceptors (88).

2.3.1.6. Neuromuscular Control

CAI patients have been found to have impaired neuromuscular-firing methods. This has frequently been shown by measuring the reflexive peroneal muscle reaction time to inversion-related disturbances. Methodological discrepancies between researchers can lead to contradictory results in the literature (89). Impaired peroneal muscle responsiveness could be caused by a lack of proprioception, abnormal neuromuscular firing patterns, or a sluggish nerve conduction velocity. The neuromuscular response of the lower leg muscles, in particular the peroneal muscles, to perturbations applied to the side of the foot and ankle has been the subject of several investigations. When compared to other muscles like the quadriceps and hamstring, the peroneal muscles have been discovered to have a substantially faster reflex time (76). During movements like walking, running, or jumping, the appropriate muscles are activated before the foot makes contact with the ground. This preactivation helps to prepare the muscles for the upcoming movement and provide stability to the ankle joint. Endurance training may lead to neuromuscular adaptations, which may affect the synthesis and removal of metabolic substrates. In sports like football that involve prolonged periods of activity, fatigue can impact the muscular response to inversion and other perturbations. Fatigue may lead to a decreased ability of the muscles to respond quickly and effectively, increasing the risk of ankle injuries. Understanding the neuromuscular responses and adaptations in the lower

leg muscles is important for injury prevention and optimizing athletic performance. Training programs that target neuromuscular control and proprioception can help improve the muscular response to perturbations and enhance ankle stability during dynamic movements.

2.3.1.7. Deficiency in Postural Control

Postural control is the capability to uphold stability and balance during various static and dynamic tasks. Individuals with CAI frequently exhibit impairments in postural control, which can heighten their susceptibility to recurring ankle sprains and additional injuries. In order to generate a sufficient efferent neuromuscular response, effective integration of afferent visual, vestibular, and somatosensory data is required (90). Any of these defects can result in postural control loss (82). Numerous studies have discovered that persons with CAI have poor postural control, which is most likely brought on by problems with proprioception and neuromuscular control (35).

By creating dynamic limitations during joint movement and loading, neuromuscular control aids in postural control and functional joint stability (90). Any injury to mechanoreceptors, alterations in normal sensory input, and sensory information processing have an impact on neuromuscular regulation. Consequently, it can lead to harm or impairment in maintaining dynamic joint stability, postural control, and functional ankle stability (91,92).

Researchers have assessed postural control in people with CAI using both static and dynamic outcome measures. Static postural control assessments typically involve measuring balance while standing still, such as performing single-leg balance tests or measuring postural sway on a force plate. These tests offer insightful data regarding a person's capacity for balance in a fixed position.

When balancing on one leg, the foot naturally undergoes a continuous movement of pronation and supination in order to maintain the body's center of gravity aligned over the base of support. This mechanism is referred to as the "ankle strategy." As opposed to persons who are unharmed, subjects with CAI appear to utilize a stronger "hip strategy" to preserve unilateral balance. The hip technique performs less well in maintaining unilateral stance than the ankle technique. The most likely reason of a shift in postural control strategy is anomalies in central neuromuscular control brought on by ankle joint dysfunction (35).

Dynamic postural control evaluations, on the other hand, are thought to be more capable of spotting postural control issues in those with CAI. Balance is the capacity to maintain dynamic postural control during dynamic movements or transitions, such as coming down from a jump or changing lanes while jogging. To keep stability throughout these actions, quick modifications in muscle activation and joint motions are necessary.

By evaluating dynamic postural control, researchers can assess the individual's ability to effectively adapt to changing movement demands and maintain balance. This can provide valuable insights into the functional limitations and impairments associated with CAI. Dynamic postural control assessments often involve examinations like the Star Excursion Balance Test (SEBT) and Y-Balance Test, or various hopping and cutting maneuvers. These tests require the individual to perform movements that challenge their balance and control, simulating the demands of sports and daily activities. (85).

2.3.1.8. Strength Weaknesses

Studies in the literature include various perspectives on the relationship between CAI and muscle strength. The first is the reduction of strength in the evertor muscles of the ankle. There is evidence that CAI reduces evertor muscle strength (86,87) and that in patients with ankle sprains, inverter muscle strength is greater than evertor muscle strength (88).

According to a different theory, the inability of the evertor muscles to contract eccentrically (lengthening while generating force) hinders the control of inversion movement (inward rolling of the foot) in individuals with ankle instability (89). Specifically, the peroneus longus muscle shows reduced activity in individuals with ankle instability during the downward movement in a single-leg stance after a jump (93). Interestingly, when assessing muscle strength measurements between the affected limb and the corresponding limb in individuals with unilateral CAI, no significant differences were found. This suggests that there may either be a preexisting condition or changes in the central organization of the nervous system resulting from immobilization (86). These findings suggest that the impaired control of inversion movement and reduced activity in the peroneus longus muscle may contribute to ankle instability. Additionally, the lack of differences in muscle strength measurements between the affected and unaffected limbs in individuals with unilateral CAI suggests that factors other than muscle weakness may

be involved in the development of ankle instability, such as neural adaptations or preexisting conditions.

Using body correction mechanism, a quick inversion movement of the ankle causes flexion on the same side knee and hip and adduction action on the same side hip. These movements lead to a decrease in the angle of ankle inversion, as is the effect of the vertical ground reaction force (94). As a result, hip and knee muscular strength is critical for ankle injuries and instability. In persons with CAI, a hip-strengthening exercise program has been proven to decrease symptoms and protect against recurrent sprains (96). Another study found that female athletes with stronger hip external rotator muscles had superior dynamic control during the landing portion of the jump (95).

2.3.2. Assessment

The active, passive, and resistive ROM of the ankle must be taken into account while evaluating an acute ankle sprain. Since pain or limited mobility may be a sign of injury to the ATFL or other ankle-movement-related structures, active plantarflexion and dorsiflexion may help identify potential ligamentous lesions. Passive dorsiflexion and plantarflexion can also show the health of ligaments, tendons, and joint capsules. Pain or excessive laxity during passive motion may suggest ligamentous or joint capsule damage. Resisted ROM assessment helps identify potential muscle or tendon injuries, such as tears or strains. Weakness or pain during resisted motion may indicate muscle or tendon involvement. Observation and palpation of the ankle are also important in the evaluation process. Localized discomfort, bruising, deformity, and swelling may signify fractures, sprained ligaments, or other traumas. Tests such as the anterior drawer test and talar tilt test are utilized to assess the stability of the ankle joint, particularly in situations where there may be concerns about potential instability or ligament damage. These stress tests involve applying specific forces to the ankle joint in order to observe any abnormal movements or laxity, which can indicate instability or injury. The results of these tests provide valuable information to healthcare professionals, helping them make an accurate diagnosis and develop an appropriate treatment plan for patients with ankle-related issues. These examinations aid in evaluating ligament health and determining the stability of the joint. Additional diagnostic procedures, such as imaging examinations (X-rays, MRI), may be necessary in addition to ROM evaluations to determine the severity of the injury and find any underlying structural damage (97).

During clinical examinations, healthcare professionals routinely employ the anterior drawer sign and conduct talar tilt tests as part of a comprehensive evaluation to assess the stability of the ankle joint. The anterior drawer test serves as a valuable diagnostic maneuver used to assess the extent of anterior translation or forward movement of the talus in relation to the tibia. The presence of increased anterior drawer motion during the test indicates potential elongation or rupture of the ATFL, which is a critical ligament responsible for providing stability to the ankle joint. Conversely, the talar tilt test focuses on evaluating the movement of the talus within the ankle mortise during inversion, involving the inward rolling of the foot. Observation of higher inversion compared to the contralateral healthy ankle suggests possible injuries, such as elongation or tear of the CFL, or even a combination of ATFL and CFL injuries. These diagnostic tests play an essential role in the identification and characterization of ankle instability, providing invaluable insights into the condition and integrity of the ligaments involved (98). This is because the initial inflammatory response and swelling that occur immediately after an injury can affect the joint's stability and limit the accuracy of these tests. By waiting until day five, some of the acute symptoms and swelling may have subsided, allowing for a more accurate assessment of ligamentous integrity. It is crucial to remember that the timing of these tests might change based on the precise damage and each person's unique situation, so it is always better to speak with a healthcare provider to determine the best course of action. (97). Additionally, the anterior drawer test, localized discomfort assessment, and hematoma evaluation together have a sensitivity of 96% and specificity of 84%. (32).

An inversion stress test can be carried out to evaluate the ATFL and CFL by inverting the back foot in both dorsiflexion and plantarflexion. Evaluation of the peroneal muscles and tendons is crucial to rule out any additional associated pathologies. Eversion stress testing is used to assess deltoid ligament and medial instability (47).

The Ottawa Ankle Guidelines (OARs) are a clinical tool for determining the need For the diagnosis of acute ankle injury or midfoot, radiography is recommended. Stress radiography is not considered a reliable diagnostic tool for detecting acute ligament injury following ankle sprain (97). Magnetic resonance imaging (MRI) after an acute injury is a valid and reliable approach to detect ruptures of the ATFL and CFL. Diagnostic ultrasound is employed as a method to identify damage, although its reliability and sensitivity are lower when compared to MRI. Compared with MRI and CT, the diagnostic

accuracy of arthrography and tenography is less accurate, especially 48 hours after lateral ligament injury (97,98).

2.3.3. Treatment and Prevention

As CAI is a multifactorial disorder, rehabilitation must address the many deficiencies that may be found in CAI patients. Therefore, patient monitoring and evaluation is the foundation of effective rehabilitation. Traditional treatment approaches primarily focus on improving ROM, strength, neuromuscular control, and postural control (99). While following rehabilitation programs, improvements in proprioception and neuromuscular control can be considered to prevent relapses, research has shown that effective rehabilitation protocols are still required to reduce relapse frequency and manage CAI symptoms.

Altered joint mobility is commonly observed in individuals with chronic ankle sprains. These changes typically include heightened laxity in the reduced posterior talar shift, anterior joint and limited ROM in dorsiflexion. The inversion mechanism, which results in an anterior position, can lead to misalignment of the talofibular ligament talus in the anterior direction. These positional abnormalities are often associated with issues in the arthrokinematic movement of the joint. Joint mobilization techniques have been shown to address these problems by enhancing the arthrokinematic movements, particularly by improving dorsiflexion. (100).

Through the use of accessory motions, the manual therapy approach tries to restore joint ROM (DFROM) by stretching the joint capsule and related ligaments. Increased extensibility of non-contractile tissues and lengthening of these structures are also benefits of this approach (5,101). According to the findings from Johanson's study in 2008, DFROM seems to be more closely related to the subtalar joint than muscle tension. While the tension of the gastrocnemius and soleus muscles is considered a contributing factor, the results suggest that the mobility and function of the subtalar joint plays a more important role in determining DFROM (102). Numerous manual therapy methods that concentrate on talocrural joint mobility have shown successful in promoting arthrokinematic movement and DFROM (dorsiflexion range of motion). These techniques involve applying specific stimuli to the talocrural joint to promote improved joint mobility and restore normal joint function. Research has shown positive outcomes in terms of increasing DFROM and enhancing the overall movement of the ankle joint

through the application of these manual therapy techniques. (101-104). It has been discovered that joint mobilization treatments are helpful in lowering pain, enhancing muscle tone, and boosting DFROM (dorsiflexion ROM). There is a belief that the improvement in DFROM, which is considered a risk factor for re-injury, is associated with changes in the posterior glide of the talus. Several studies (104-106) suggest a connection between these two factors. It is theorized that by promoting a more normal posterior glide of the talus during ankle movement, there can be an improvement in DFROM and a reduction in the risk of re-injury. These findings highlight the potential importance of addressing the posterior talar glide as a part of ankle rehabilitation protocols to optimize functional outcomes and minimize the likelihood of future injuries. Joint mobilizations, through the application of tissue traction, activate gamma motor neurons and result in articular stretching. This stretching of the joint capsule and ligaments increases the sensory output of mechanoreceptors present in these structures. As a result, there is an improvement in postural control. The increased sensory input from the mechanoreceptors helps to enhance proprioception, which is the body's ability to sense its position and movements in space. Improved proprioception contributes to better postural control and stability, reducing the risk of falls or instability-related injuries. (107).

Regaining bilateral strength is regarded as clinical practice and is crucial for avoiding ligamentous injuries to the ankle (108). Strength training can help to enhance muscle spindle function and the capacity to detect motion and force in the joint, which can assist in making up for the mechanoreceptor inadequacies in the lateral ankle ligament fibers. Due to better muscle function, including increased joint position perception, people with CAI may be able to recognize and correct incorrect ankle posture (110). Exercises should focus on strengthening the peroneal muscles because CAI and repeated injury have been associated to weakness in this muscle group (108).

Training in balance has long been a part of CAI patient therapy. The activation of mechanoreceptors, which improves sensory output by activating gamma motor neurons while stimulating the ankle capsule and ligaments, is hypothesized to be successfully increased by balance training (111). Balance training is frequently initiated in a controlled environment on a stable surface and advanced by adding various disturbances in order to promote the utilization of diverse sensorimotor systems. To gradually enhance single-leg balance, balance training typically means introducing interruptions, such as taking away

visual information, changing the surface, or adding goals, such as throwing a ball or completing tasks (109). All of this requires that the person develop a balance strategy.

A comprehensive rehabilitation program that incorporates ankle taping may be more beneficial than ankle tape and bracing alone in preventing recurrent ankle instability. Ankle taping's preventative impact is thought to be related to sensory feedback. According to Robbins et al. (78), the attachment of the skin of the leg to the plantar surface of the foot has been suggested as a method to enhance sensory input to the plantar surface. This improved sensory input can facilitate more accurate foot placement and reduce the risk of excessive strain on the ligaments. Similarly, Karlsson and Andreasson (76) propose that interventions such as taping or wearing a lace-up brace can provide benefits for individuals with unstable ankles. These interventions aim to increase proprioceptive feedback and enhance cutaneous sensory input to the central nervous system. By augmenting sensory information, individuals may experience improved ankle stability and reduced susceptibility to injury. Even after continuous activity, ankle taping still offers some level of constraint against excessive ankle motion, even if it may eventually lose some of its early resistance. However, it is not well known how ankle support specifically affects joint kinetics, kinematics during dynamic activities like cutting motions, and numerous sensory metrics. Examining the function of external ankle bracing in these contexts should be the primary goal of future study.

2.4. Neuro-vestibular-ocular Exercises Training

To enhance sensory control and functional stability, neuromuscular training applies biomechanical and neuromuscular principles. Neuromuscular training emphasizes joint control and movement quality in all three biomechanics/planes of motion, in contrast to conventional strength training (112). Soccer players must contend with uncontrollable outside variables including ball possession and opponents' and teammates' placements.(113). Examining attentional and peripheral aspects of neuromuscular activation is crucial for addressing ankle instability. Integration of sensory, visual, and motor skills must be prioritized throughout the recovery process. Reaction time, information processing, focus of attention, visual-motor control, and the interaction between difficult tasks and the environment are some of these skills. This is particularly crucial during the last stages of therapy. The potential sensory reweighting of visual feedback in motor control can be effectively addressed by incorporating neuromuscular

training with neurocognitive or visual processes, such as ball tracking or interaction with the players in the team, as well as tasks of varying complexity (including response and decision making), predictive elements, and cognitive load (such as dual-task activities). (113). By concentrating on visual attention, especially in high-intensity, dynamic, and complex contexts, sport-specific factors that may affect athletes' situational awareness may be researched. A widespread startle response can be brought on by unexpected events in the central nervous system (115). This causes a brief, unconscious change in neuromuscular activity. Athletes who rely significantly on visual information may have brief episodes of "careless blindness" in which they fail to anticipate crucial visual cues and miss them.

The functional instability experienced after ankle injuries is likely an outcome of the combined effects of diminished mechanical support and compromised proprioception and kinesthesia. According to certain studies, a neuromuscular rehabilitation program improves postural control, increases eccentric evtor muscle strength, and contributes to greater functional capacity to retain strength (116). The goal of neuromuscular training is to increase neuromuscular control, which will help to achieve functional joint stability and prevent injury. These training routines all include elements of strength, stretching, plyometrics, and balance (100). A study looked at the effectiveness of neuromuscular training in young soccer players. Dynamic stretching activities, agility drills, leaping exercises, balance training, and eccentric strength workouts were all part of the training regimen. The control group, used a normal warm-up regimen that included static and dynamic stretches, aerobic components, and a home stretching program. According to the study's findings, implementing a neuromuscular training program was successful in preventing injuries among young soccer players. (117) In one study, the effects of an eight-week combined jumping protocol consisting of balance and strength were compared. 36 male professional football players were split up into three groups: control, jumping, and balance plus strength. It was concluded that the balance and strength protocol was more effective and had a faster recovery and greater effect for footballers with CAI (118). Rehabilitation programs that include neuromuscular training such as perturbation training, agility training, vision training and sport-specific skills training play a crucial role in improving function and preventing ankle injuries.

The vestibulo-ocular reflex is an important component that is often overlooked in published ankle rehabilitation protocols (119). A well-known exercise program called vestibular rehabilitation (VRT) was created to address balance issues brought on by

problems with the peripheral vestibular system (120). VRT promotes vestibular healing processes and vestibular adaptation through head eye movement, visual substitution, somatosensory cues, and postural techniques. The goal of VRT is to improve gaze stabilization, postural stability, and activities of daily life. VRT exercises include head-eye motions, various upper extremity tasks, general flexibility and strengthening exercises, as well as maintaining balance while doing various head and body postures and activities (121). Positive effects of vestibular rehabilitation on postural stability have been demonstrated in previous research (122).

Visual skills in sports include skills from ball tracking to the ability to predict what the opponent will do in the next move and are important in almost all sports. Improving visual skills can help improve sports performance. In football, which is a dynamic game, there are reactive movements such as sudden changes of direction, deception, stopping, perception, etc. Although various techniques have been developed to enhance factors such as balance and dynamic visual acuity in sports, there is a relative scarcity of studies investigating the effects of ocular workouts on athletes. However, a recent study aimed to address this gap by implementing a four-week oculomotor exercise program involving 30 club elite female basketball players. The results of this study demonstrated that oculomotor training yielded improvements in both balance and dynamic visual acuity among the basketball players and potentially other athletes engaged in dynamic sports. These findings suggest that incorporating oculomotor exercises into training regimens holds promise for enhancing visual-motor skills and overall performance in dynamic sports (123).

2.5 Myofascial Release “Hands-on” Therapy

According to Schleip and Baker (2015) and Schleip and Müller (2013), fascia is an anatomical structure that surrounds the body like a taut mesh and contains all the connective tissues (bone, joint, blood, muscle, and nerve) with fibrous collagen. From the skin to the periosteum, fascia is made up of interwoven, separate layers with variable depths. All muscles and organs are wrapped in fascia, which has three layers: Superficial, deep, and subserous (124). The subcutaneous layer of adipose connective tissue is the topmost layer. It provides mobility assistance and sublayer mechanical protection for the structures underneath. The deep fascia, which contains the muscles, comprises dense fibrous sheaths and bands. It enables synergistic muscle actions because of its structure.

Internal organs, blood arteries, nerve fibers, and bodily cavities are all surrounded by the subserous layer (125). The fascial layers are made up of elastic fibers, collagen, and ground substance and are interwoven. The deep layer, in particular, is surrounded by dense neuronal networks and contains a variety of receptors (126).

Carol Manheim, Anthony Chila, and John Peckham originally employed myofascial release, one of the most effective physical treatments on the fascia, in a course at the University of Michigan in 1981. Barnes (141) propagated it to physiotherapy and manual therapy circles and it has since been employed for numerous orthopedic disorders. It is also called as “myofascial stretching” nowadays. Myofascial release is a gradual stretch administered by a therapist to the soft tissues, adjusting the angle, force, and duration of application based on input from the individual to whom it is applied, and used to address soft tissue limits (22). During this procedure, the patient remains passive, and the muscles are kept relaxed throughout the application. This technique can also be utilized in certain types of myofascial release. In contrast, other soft tissue procedures may involve active participation, such as contract-and-release techniques.

Fascia is known to form abnormal cross-links as a result of inactivity or injury, changing its structure from a gel-like to a solid consistency, reducing its pliability and potentially disrupting muscle force production, transmission, and distribution. Fibrous adhesions reduce muscle power, endurance, and motor coordination throughout the normal range of motion (ROM).

When it comes to myofascial release, there are three categories to consider: indirect myofascial release, direct myofascial release, and self-myofascial release (22). The practitioner uses a loads to reach the constricted fascia with the knuckles, elbows, ulnar edge of the forearm, fist, or other assistive instruments in the direct kind. The goal here is to create elongation, stretching, and movement between myofascial fascial layers. The technique moves slowly and deeply through the fascia layers.

In the indirect method, this time a few grams of force are applied and a slight pressure is applied when the hand is placed on the fascia. This pressure is then maintained for three to five minutes before release. In between, the fascia can be extended in all directions by placing the hands in a crossed position over the tissue (141).

In self-administered myofascial release (SMR), the user places their body weight on a semi-soft object (such as a tennis ball, sponge rollers or knurled poles) and moves slowly along or over the muscle area of interest. This equipment is made in a variety of ways.

A four-week intervention was used in a research by Ruben et al. (128) on 36 male soccer players. The participants were placed into two groups at random: the experimental group experienced eccentric exercise, myofascial release, and neuromuscular taping; the control group did not. Soccer players with recurrent ankle sprains who combined fascial therapy with eccentric strength training experienced improvements in their ankle mobility, strength, and stability (128). In the literature, myofascial release is usually applied to athletes with foam rollers or instrument-assisted, and studies on foam rollers are inconsistent in the literature. According to Castiglione (2010), pre-exercise self-administered foam rolling can improve participants' balance, flexibility and ROM through myofascial release, leading to greater mobility and neuromuscular activity. According to Halperin (2014), self-administered myofascial release had no acute effect on static and dynamic balance. There is a few research examining the effect of manual myofascial release on performance and proprioception in soccer players, while other studies have mostly focused on jump performance (129).

3. MATERIALS AND METHODS

This study was conducted at Asim Kara Sports Facilities and Kartalspor Facilities between September 2022 and April 2023 to investigate the effects of two different training protocols on performance and proprioception parameters in soccer players with CAI.

Ethics committee approval of the study was obtained from Marmara University. The clinical study number of the study is NCT05799885.

3.1. Subjects

To determine the sample size for this study, power analysis was done with Gpower 3.1.9.7. In power analysis, effect size was 0.76, Type I error was 0.05, allocation ratio was 1 and the statistical power of power in detecting mean differences of 0.05. The result of the analysis is given below:

t tests – Means: Wilcoxon–Mann–Whitney test (two groups)

Options: A.R.E. method

Analysis: A priori: Compute required sample size

Input: Tail(s) = Two

Parent distribution = Normal

Effect size d = 0.757913

α err prob = 0.05

Power (1 – β err prob) = 0.8

Allocation ratio N2/N1 = 1

Output: Noncentrality parameter δ = 2.8684724

Critical t = 2.0038039

Df = 55.2957795

Sample size group 1 = 30

Sample size group 2 = 30

Total sample size = 60

Actual power = 0.8046545

According to this result the minimum total sample size is 60 (30 for NVOEG group and 30 for MFHOG group). Based on this information A total of 63 male players between the ages of 18-30 were included in the study. However, 2 players were transferred to another club and 1 player could not continue working because of injury during training. Participants voluntarily chose to participate in the study and gave their consent by signing the informed consent form. A clear explanation of the purpose and procedures of the study was given before consent was given. Participants were randomly divided into 2 groups by computer-based randomization method.

3.1.1. Inclusion Criteria

Subjects were included;

- Be between 18-30 years of age.
- Having a history of first ankle sprain more than 1 year ago.
- At least 2 episodes of "giving way" in the last 6 months
- No other injuries to the lower limbs.
- A score of ≤ 27 on the Cumberland ankle instability scale (CAIT).

3.1.2. Exclusion Criteria

Exclusion criteria included

- Bilateral ankle instability
- History of musculoskeletal surgery and/or fractures in the lower extremities;
- A history of acute injury to the musculoskeletal structures of other lower extremity joints in the last three months, affecting joint integrity and function and causing interruption of the desired physical activity for at least one day;
- Having a history of balance and vestibular disorders.

3.1.3. Flow of Research

The Marmara University Non-Interventional Ethics Committee provided their protocol number 200 the required ethics committee approval for this study. All subjects who decided to participate in the study did so voluntarily, and a formal informed consent form was received from each of them (Appendix 1,2)

The study started with 63 patients and a total of 60 patients completed the treatment program. The flow chart of the patients included in the study is shown in Figure 3.1.

The first group NVOE received neuro-vestibular-ocular training with a physiotherapist twice a week for 8 weeks. In the second group MFR, myofascial release was applied by a physiotherapist twice a week for 8 weeks.

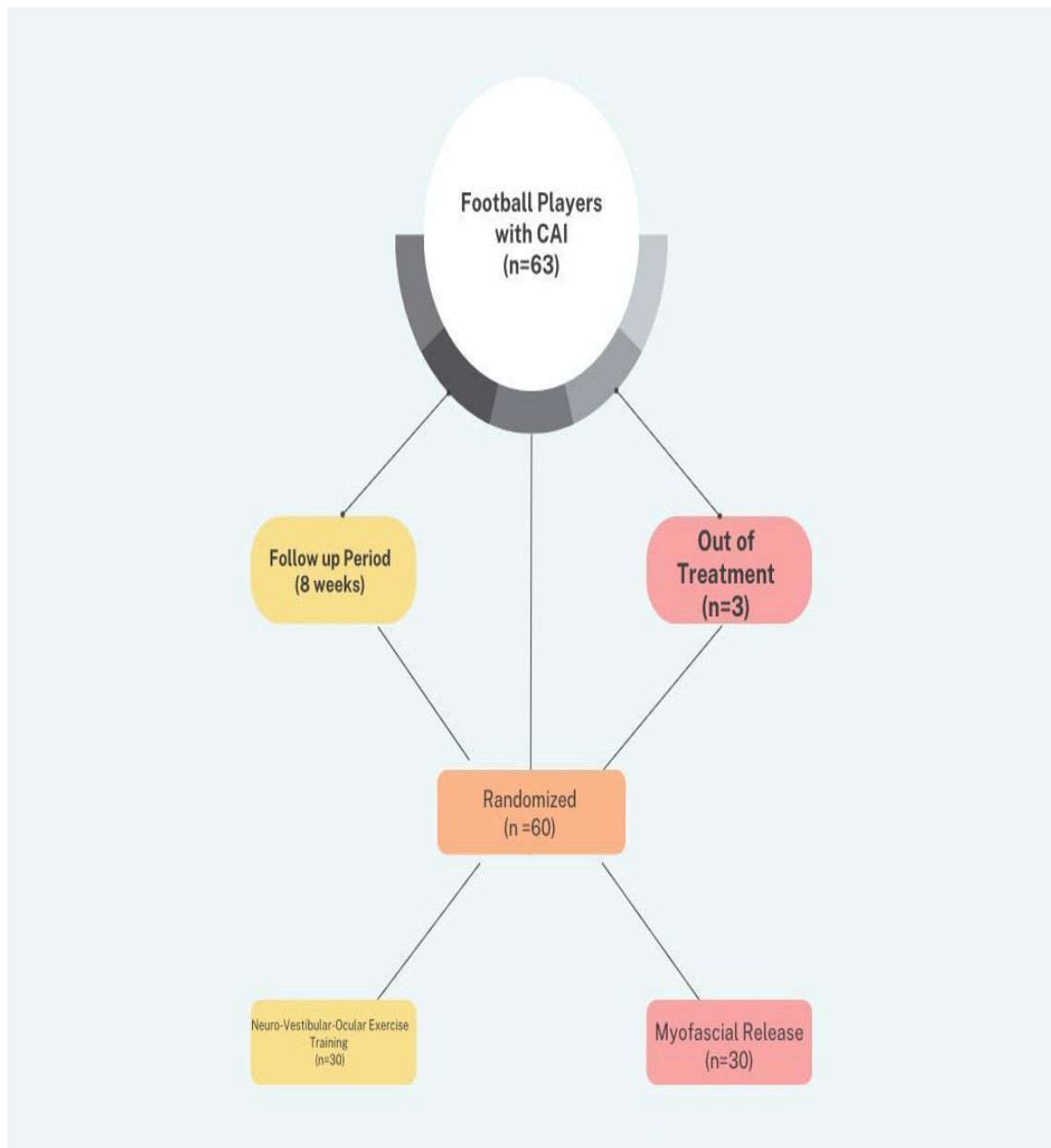


Figure 3. 1. Flowchart diagram

3.1.4. Study Protocol and Design

All subjects received an explanation of the study's objectives and the specifics of the exercise training regimen, as per the participant consent form. All participants were required to complete informed permission forms with their demographic information in order to participate in the study and in compliance with the research criteria. The same physiotherapist led the neuro-vestibular-ocular exercise program for an hour, twice weekly, for the individuals in the NVOE group after the examination. Myofascial release was applied to the plantar fascia, gastro-soleus, and hamstring muscle groups for 8 weeks

by the physiotherapist in the subjects in the MFR group. In the MFR group, the sessions lasted approximately 1 hour. Participants in the neuro-vestibular-ocular group tried to maintain their balance with eye and head movements with hop stabilization exercises aimed at providing neuromuscular control, strength, balance and static and dynamic balance on different surfaces.

3.2. Evaluation

3.2.1. Demographic Information Form

Age, gender, education level, sociodemographic characteristics, diseases, pre-existing chronic diseases, training frequency, training duration, position played, surgical conditions, injuries and treatments are the questionnaires created by the researcher (Appendix 1).

3.2.2. Cumberland Ankle Instability Tool (CAIT)

Participants will be recruited according to the CAIT questionnaire and participants who score 27 points or less on this questionnaire will be included. The Cumberland Ankle Instability Tool (CAIT) was developed by Hiller and others and has proven to have high content validity and reliability. The CAIT is a reliable and valid questionnaire consisting of nine items on a 30-point scale. It is used in clinical settings to assess functional impairment, determine severity, monitor progress and evaluate treatment outcomes. Given the variety of response possibilities, the instrument's sensitivity is raised. Both the left and right ankles can be tested using the CAIT, allowing for the assessment of both ankles (130) (Appendix 2). The CAIT can also be used to determine the degree of instability using a numerical value.

3.2.3. Proprioception Assessment

Proprioception is the ability to perceive how various body parts move and arrange themselves in relation to their surroundings. Clinically, its measurements are typically based on an evaluation of how the joint feels. A goniometer is used to gauge the proprioceptive sense of the ankle joint. With their eyes closed, subjects are positioned in the beginning posture. The goniometer is adjusted to zero and the ankle subtalar joint is in neutral position (STJN) (131). Passively applying 20 degrees of inversion and 10

degrees of eversion to the ankle, then returning it to neutral (132). A goniometer is used to measure deviations from the targeted angle after three repeated of the measurements (131).



Figure 3. 2. Assessment of ankle proprioception using a goniometer

3.2.4. Performance Assessment

3.2.4.1. Landing Error Scoring System (LESS)

The Landing Error Scoring System (LESS) is an inexpensive clinical tool for assessing jump landing biomechanics. It contains 17 questions scored on a scale. LESS is particularly useful for people who frequently perform jumping and landing activities. It is utilized to evaluate the possibility of athletes being exposed to non-contact injuries (133). The athlete is presented with a demonstration before their assessment. A 30 cm high box with a non-slippery floor was prepared for the splash. Each participant was asked to jump the distance at least half their height.

The jumping process was given to the participants by the researchers shown one by one, and three jump attempts by the participants is allowed to do. Cameras were fixed to the front of the jump area and to the side of the leg under test (camera-enabled smartphones) and video recordings were taken during the jumps. The distance of the cameras from the jump area is 345 cm and the distance of the camera lens from the ground is 122 cm. No commands were given during the application, the participants were expected to make a free landing on the ground with a jump and then to make a vertical jump immediately after. According to the jump protocol, each person repeated the described jump three times in succession. A free video-based image analysis program was used to examine the jump images captured during the jump testing.

In this system, a low total score indicates that the technique of landing after jumping is good, while a high score indicates that the technique is weak and the risk of injury is high. Padua et al. the risk limit; It is recommended as a score of 6 and above. He determined ≤ 4 points for perfect landing, $4 >$ and ≤ 5 points for good landing, $5 >$ and ≤ 6 points for middle landing (134) (Appendix 3).



Figure 3. 3. Assessment of LES

3.2.4.2. 30-Meter Sprint Test

Players performed maximum effort 30-meter sprints three times on the field. Between each of the 30-meter sprints a rest period of 3 minutes was given. Data analysis will consider the shortest time recorded to cover the 30-meter distance during the sprint test. Before each sprint test, players participated in a 10-minute running session at 60-70% of their maximum heart rate, followed by 5 minutes of exercises that included short jumps of 5 to 10 meters, walking and a 2-minute rest period. Timings were recorded with a stopwatch and a video recording system with phone support. (135)

3.2.4.3. The Zig-Zag Agility Test

Players' agility was assessed by a zigzag agility test with and without the ball. On a field of synthetic turf, players underwent the zigzag agility test three times, with a two-minute rest interval in between each trial. The time recorded for the shortest performance in the zigzag agility tests, both with and without the ball, was noted. In the test, 4 cones were placed at the corners and 1 cone was placed in the center of the track. The long side of the track is 4.05 meter (16 feet), the short side is 3 meter (10 feet) (1foot=0.3 meter)

Mirkow et al. (136) found that the coefficient of variation for agility tests was 21.12%. The intraclass correlation coefficient was 0.81 for the zigzag agility test and 0.84 for the non-zigzag agility test. In addition, the typical measurement error was 0.21 for the zigzag test and 0.098 for the non-zigzag test (136)

There are no specific guidelines or requirements regarding the number of ball contacts in the zigzag agility test. Time was measured using a stopwatch.



Figure 3. 4. Assessment of zig-zag agility test

3.2.4.4. Kick Speed Performance

Soccer kicking performance was evaluated based on the shot's ball speed. Cones were positioned one and two meters distant from the ball's starting position. In accordance with Federation Internationale de Football Association (FIFA) regulations, a ball of standard size and sufficient pressure was utilized for this measurement. Each participant ran three unbalanced side trials, and the times from these trials were averaged. Between each trial, there was a 20-second rest time. They were told not to slow down to improve shot precision (135). For statistical analysis, each participant engaged in three trials using each leg. The measurements were made with the video analysis method in the "speed gun" application.





Figure 3. 5. Assessment of kick speed performance

3.3. Intervention

Before both treatment protocols, the participants participated in the training of their teams. After the training, the players were treated. In both treatment protocols, the same strength program was applied as 3 sets of 12 repetitions.

Group NVOE, combined neuro-vestibular-ocular exercise program and strength program, Group MFR consisted of a myofascial release and strengthening program.

3.3.1. Neuro-vestibular-ocular Exercises Training Group

Jumping and Stabilization: For jumping and stabilization three repetitions are done with eyes open. They will be told to focus on a particular spot on the wall while slowly turning their heads to the right and left. The original metronome pace was 60 beats per minute, and it would increase by 20 beats per minute every two weeks after that. The participants will carry out 5 leaps in each direction for a predetermined distance after the subject has stabilized and returned to the starting position after 10 seconds of head movement. The four were: anteromedial/posterolateral, medial/lateral, and anterior/posterior/posteromedial. They moved their heads left and right for 10 seconds at the metronome speed after leaping onto the target and maintaining equilibrium. After 10 seconds of head movement, the individual went back to the beginning position.

1-Arms in cross position on the chest, 30 seconds on Thera-Band Stability Trainer, Hopping 45.7-cm while hands on the hips

2- Arms in cross position on the chest, 60 seconds on Thera-Band Stability Trainer, Hopping 68.6-cm while hands on the hips

3- Arms in cross position on the chest, 60 seconds on BOSU ball, Hopping 91.4-cm while, hands on the hips

4- Arms in cross position on the chest, 60 seconds on Balance Disc, Hopping 91.4-cm while hands free



Figure 3. 6. Jumping and stabilization

Sport Specific and Unanticipated Hop to Stabilization: 9 marker plates were placed on the floor of the test area with a distance of 45.7 cm between them and the experiment was conducted by explaining it to all participants. For each session, the color and sequence are chosen randomly. Participants jumped from the starting point to the target point by performing one-leg jumps and one-leg squat jumps. After jumping on the target and balancing, they jumped in the other direction they chose by moving their heads left and right at metronome speed for 10 seconds. The initial metronome rate was 60 beats per minute, and the rate was increased by 20 beats per minute each week (every three sessions).

1. Each move has a time limit of 5 seconds.
2. Each move has a time limit of 3 seconds
3. Each move has a time limit of 1 seconds





Figure 3. 7. Sport specific and unanticipated hop to stabilization

Strength:

- 4-way ankle theraband exercises
- Foot intrinsic strengthening (toe curl, doming)
- Heel raises exercise (3 sets × 12 reps)
- Squat, Lunge, Plank



Figure 3. 8. Strength exercises

3.3.2. Myofascial Release “Hands-on” Group Rehabilitation Protocol

The treatment protocol used for all athletes in the myofascial release (MFR) group consisted of the following steps(137,138,):

Plantar myofascial MFR:

Athletes’ position: Prone position with feet away from end of table for simple dorsiflexion.

Technique: The soft tissue is passed slightly in front of the calcaneus with the knuckles. A tension line is created in front. From the side of the athlete, finger flexion and extension are worked towards the sole of the foot and deeper layers.



Figure 3. 9. Plantar myofascial MFR

Gastrocnemius MFR:

Athlete position: Lying prone with feet off the end of the table to allow easy dorsiflexion.

Technique 1: Performed on the patient with the tendon in contact with the achilles at 90 degrees elbow flexion, focusing on relaxation of the muscle and tendon with the patient's passive dorsiflexion slowly creating a tension line in the superior direction.

Technique 2: Includes pressing the gastrocnemius tendons with the index and middle fingers of both hands. Pressure is applied to the popliteal fossa, gradually creating and maintaining a line of tension. This is done while passively dorsiflexing the athlete's foot, targeting the upper region of the fibrous part of the muscle.

Technique 3: The athlete was applied with the middle, index and ring fingers of both hands touching the lateral and medial edges of the calcaneus.

While the athlete's foot was passively dorsiflexed, a gradual downward tension was applied starting from the upper region.



Figure 3. 10. Gastrocnemius MFR

Soleus, MFR: The athlete lies face down on a support that will cause 10-15 degrees of flexion of the knee and prevent stretching of the gastrocnemius. In the technique, the elbow was used to make contact with the athlete's Achilles tendon. Pressure was gradually applied along the tendon and fascia layer between the soleus and gastrocnemius muscles, creating an upward line of tension. This was done while the patient's foot was passively dorsiflexed.



Figure 3. 11. Soleus, MFR

Hamstrings MFR: The muscle spasm can be calmed and relieved by gently grabbing and shaking the affected area (The athlete should lie prone with the knee flexed to promote muscle relaxation.). Pressure should be applied above or on the muscle spasm as the athlete flexes their knee. Hold the pressure whether the knee is extended actively or passively. Work down the muscular belly while shifting your hand's position (thumb, elbow, or forearm), then repeat. Stretch out gently to finish.



Figure 3. 12. Hamstrings MFR

Strength:

Strength exercises are the same as the NVOE group.

- 4-way ankle theraband exercises
- Foot intrinsic strengthening (toe curl, doming)
- Heel raises exercise (3 sets × 12 reps)
- Squat, Lunge, Plank

Table 3. 1. Training Protocol for Neuro-vestibular-ocular group (4-Phase Progression)

Neuro-vestibular-ocular Training	Phase 1 Week 1-2	Phase 2 Week 3-4	Phase 3 Week 5-6	Phase 4 Week 7-8
Jumping and Stabilization Focus	Arms in cross position on the chest, 30 seconds on Thera-Band Stability Trainer, Hopping 45.7-cm while hands on the hips	Arms in cross position on the chest, 60 seconds on Thera-Band Stability Trainer, Hopping 68.6-cm while hands on the hips	Arms in cross position on the chest, 60 seconds on BOSU ball, Hopping 91.4-cm while hands on the hips	Arms in cross position on the chest, 60 seconds on Balance Disc, Hopping 91.4-cm while hands free
Sport Specific and Unanticipated Hop to Stabilization Focus	One Leg Jumps and Each move has a time limit of 5 seconds	One Leg Jumps and Each move has a time limit of 3 seconds	One Leg Squat Jumps and Each move has a time limit of 3 seconds	One Leg Squat Jumps and Each move has a time limit of 1 seconds
Strength Focus	4 way ankle theraband Exercises (3 sets × 12reps) Foot intrinsic strengthening (toe curl, doming) Double leg heel raises: (3 sets × 12reps)	4 way ankle theraband exercises (3 sets × 12reps) Foot intrinsic strengthening (toe curl, doming) Double leg heel raises: (3 sets × 12reps)	4 way ankle theraband exercises (3 sets × 12reps) Foot intrinsic strengthening (toe curl, doming) Squat (2sets × 10reps) Lunge (2 sets × 10reps) Plank (2 sets x 10 reps)	4 way ankle theraband exercises (3 sets × 12reps) Foot intrinsic strengthening (toe curl, doming) Single leg heel raises: (3 sets × 12reps) Squat (2 sets × 10reps) Lunge (2 sets × 10reps) Plank (2 sets x 10 reps)

Table 3. 2. Training protocol for myofascial release hands-on group(4-phase progression)

Myofascial Release Hands-On Training	Phase 1 Week 1-2	Phase 2 Week 3-4	Phase 3 Week 5-6	Phase Week 7-8
	Plantar Facia MFR Gastrocnemius MFR Soleus MFR Hamstring MFR 2 Repetitions	Plantar Facia MFR Gastrocnemius MFR Soleus MFR Hamstring MFR 3 Repetitions	Plantar Facia MFR Gastrocnemius MFR Soleus MFR Hamstring MFR 4 Repetitions	Plantar Facia MFR Gastrocnemius MFR Soleus MFR Hamstring MFR 5 Repetitions
Strength Focus	4 way ankle theraband exercises(3 sets × 12reps) Foot intrinsic strengthening (toe curl, doming) Double leg heel raises: (3 sets × 12reps)	4 way ankle theraband exercises (3 sets × 12reps) Foot intrinsic strengthening (toe curl, doming) Double leg heel raises: (3 sets × 12reps)	4 way ankle theraband exercises(3 sets × 12reps) Foot intrinsic strengthening (toe curl, doming) Squat (2sets × 10reps) Lunge (2 sets × 10reps) Plank (2 sets x 10 reps)	4 way ankle theraband exercises(3 sets × 12reps) Foot intrinsic strengthening (toe curl, doming) Single leg heel raises: (3 sets × 12reps) Squat (2 sets × 10reps) Lunge (2 sets × 10reps) Plank (2 sets x 10 reps)

3.4. Data Analysis

The data were evaluated in the statistical package program of IBM SPSS Statistics 26. Descriptive statistics were given as unit count (*n*), percentage (%), mean ± standard deviation (*Mean*±*SD*), median (*M*), minimum (*min*) and maximum (*max*) values. Normal distribution of numerical variables controlled with Skewness and Kurtosis values. Parametric tests were used since numerical descriptive features and variables showed normal distribution. Chi-square tests (Pearson chi-square/Fisher exact test) were used for the comparison of the categorical descriptive features while One-way ANOVA was used for the comparison numerical descriptive features between the groups. One-way ANOVA and Paired Sample t-test were used for in-group and between-group comparisons of clinical indices, and Bonferroni correction was used to compare main effects in the analyses. A value of $p < 0.05$ was considered statistically significant.

4. RESULTS

Table 4. 1. Comparison of descriptive characteristics of patients according to groups

	Group		Test Statics	
	NVOEG <i>n</i> =30	MRHOG <i>n</i> =30	Test Value	<i>p</i>
Age, (year)				
<i>Mean</i> ± <i>SD</i>	24.47±2.33	24.33±2.60	0.21 †	0.835
<i>M (min-max)</i>	25 (20-28)	25 (19-28)		
Height, (cm)				
<i>Mean</i> ± <i>SD</i>	177.97±4.55	181.63±2.62	-0.82 †	0.113
<i>M (min-max)</i>	177 (166-188)	182 (175-186)		
Weight, (kg)				
<i>Mean</i> ± <i>SD</i>	71.93±4.25	76.60±2.65	-1.11 †	0.107
<i>M (min-max)</i>	71.50 (62-80)	76.50 (71-82)		
BMI, (kg/m²)				
<i>Mean</i> ± <i>SD</i>	22.69±0.41	23.20±0.26	0.73 †	0.096
<i>M (min-max)</i>	22.55 (22-23.40)	23.20 (22.60-23.70)		
Playing time, (year)				
<i>Mean</i> ± <i>SD</i>	10.70±0.84	10.27±0.91	1.92 †	0.059
<i>M (min-max)</i>	10 (10-12)	10 (9-12)		
Dominant side, <i>n</i> (%)				
Right	25 (83.3%)	27 (90%)	0.71 ‡	0.353
Left	5 (16.7%)	3 (10%)		
Unstable ankle, <i>n</i> (%)				
Right	16 (53.3%)	18 (60%)	0.80 ‡	0.397
Left	14 (46.7%)	12 (40%)		

†: Independent Samples t-test (t); ‡: Chi-Square Test (χ^2); Summary statistics are given as *mean ± standard deviation* and Median (*minimum, maximum*) for numerical data and Number (*Percentage*) for categorical data. The parts determined in bold are statistically significant ($p<0.05$).

According to Table 1, a total of 60 patients, 30 in the NVOEG group and in the MRHOG group were included in the study. The median age of the patients was 25 for both NVOEG and MRHOG groups. The differences between the ages of the patients in the groups were not statistically significant ($p>0.05$). The BMI for NVOEG group was 22.69 ± 0.41 and MRHOG group was 23.20 ± 0.26 . There was no significant difference between the groups according to BMI ($p>0.05$). The median playing time of the patients was 10 years for both groups. The differences between the playing times of the patients in the groups were not statistically significant ($p>0.05$). The results for age, BMI and playing time is given in Figure 4.1.

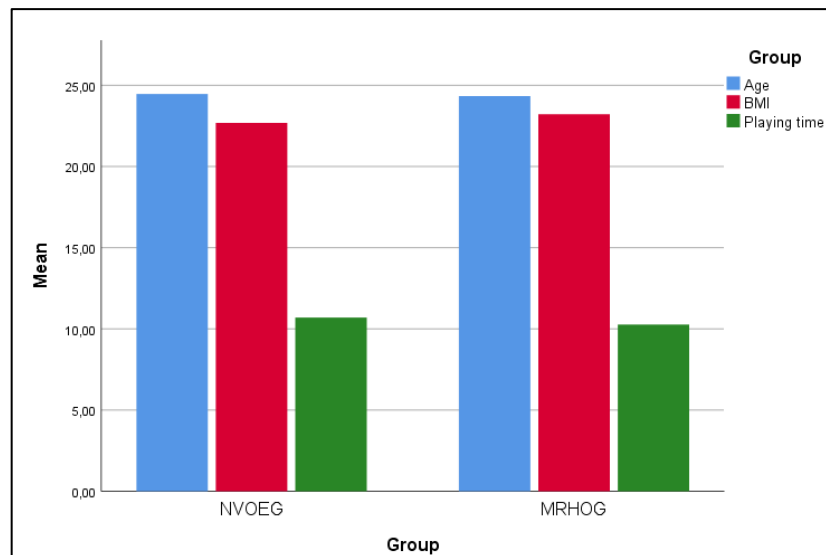


Figure 4. 1. Comparison chart of age, BMI and playing time of patients according to groups

The dominant side for the 83.3% of the patients in NVOEG group was right while 90% in MRHOG group. There was no significant difference between the groups in terms of dominant side ($p>0.05$). On the other hand, unstable ankle for the 53.3% of patients in NVOEG group was right while 60% in MRHOG group. There was no significant difference between the groups in terms of unstable ankle ($p>0.05$). The results for dominant side and unstable ankle is given in Figure 4.2.

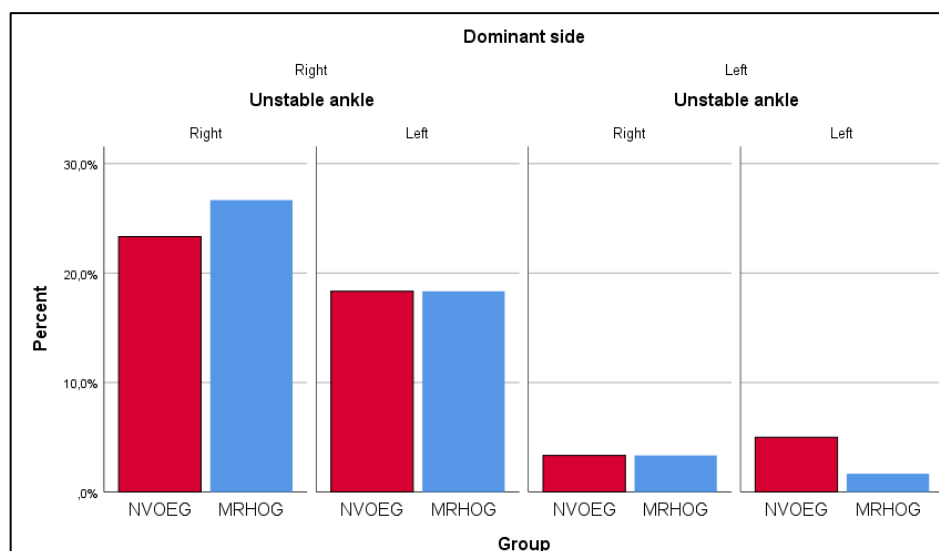


Figure 4. 2. Comparison chart of dominant side and unstable ankle of patients according to groups

According to Figure 4.2, 87.5% of the patients in NVOEG group with right unstable ankle has right dominant side. In the same group 78.6% of the patients with left unstable ankle has right dominant side. On the other hand, 88.9% of the patients in MRHOG group with right unstable ankle has right dominant side. In the same group 91.7% of the patients with left unstable ankle has right dominant side.

Table 4. 2. Comparison of pre-test scores between groups

	Group		Test statistics [†]	
	NVOEG <i>n=30</i>	MRHOG <i>n=30</i>	<i>t</i>	<i>p</i>
LESS Test	6.94±0.53	6.90±0.55	0.185	0.854
CAIT unstable	24.00±0.87	24.37±1.00	-1.52	0.135
CAIT stable	29.07±0.67	29.23±0.68	-0.94	0.350
Kicking speed unstable	19.56±2.68	19.85±2.47	-0.44	0.661
Kicking speed stable	24.87±2.96	24.78±2.52	0.12	0.903
Zigzag without ball	8.18±0.84	8.25±0.38	-0.40	0.692
Zigzag with ball	10.55±1.02	10.59±0.92	-0.15	0.885
Number of ankle sprain	5.20±0.55	4.93±0.52	1.93	0.059
Inversion unstable ankle	4.53±0.68	4.57±0.68	-0.19	0.850
Inversion stable ankle	2.67±0.74	2.53±0.73	-1.41	0.165
Eversion unstable ankle	3.63±0.72	3.70±0.75	-0.35	0.706
Eversion stable ankle	1.83±0.70	1.50±0.73	1.81	0.076
30 m sprint test	6.75±0.57	6.57±0.51	1.27	0.210

[†] Independent Samples t-test; Descriptive statistics were given as *mean ± standard deviation*. The parts determined in bold are statistically significant ($p<0.05$).

According to Table 4.2, the pre-test scores of NVOEG and MRHOG groups were not statistically significant for all test results ($p>0.05$). The graphed image of the tests of the groups is presented in Figure 4.3.

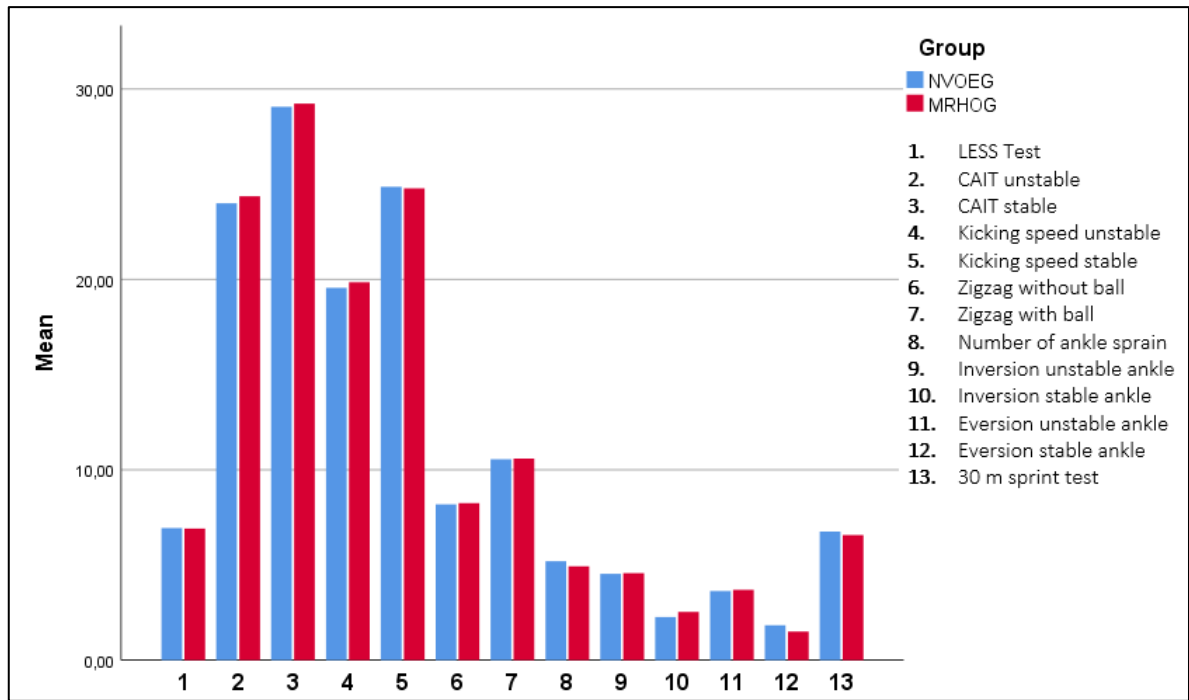


Figure 4. 3. Comparison chart of pre-test means for all tests between groups

All pre-test means for 13 tests are given in Figure 4.3 as NVOEG and MRHOG groups. It was seen that pre-test means for groups are very close.

Table 4. 3. Comparison of post-test scores between groups

	Group		Test statistics [†]	
	NVOEG <i>n=30</i>	MRHOG <i>n=30</i>	<i>t</i>	<i>p</i>
LESS Test	4.53±0.35	5.20±0.42	-6.80	0.000
CAIT unstable	26.33±0.66	25.73±0.83	3.10	0.003
CAIT stable	29.83±0.38	29.40±0.56	3.50	0.001
Kicking speed unstable	24.23±3.00	23.60±2.41	0.90	0.301
Kicking speed stable	27.72±3.04	26.68±2.64	1.44	0.155
Zigzag without ball	5.80±0.60	5.85±0.27	-0.50	0.620
Zigzag with ball	6.85±0.59	7.30±0.64	-2.89	0.005
Inversion unstable ankle	2.57±0.50	3.47±0.68	-5.86	0.000
Inversion stable ankle	1.83±0.38	1.93±0.60	-0.77	0.443
Eversion unstable ankle	2.13±0.35	2.90±0.66	-5.62	0.000
Eversion stable ankle	1.27±0.28	1.23±0.34	0.41	0.684
30 m sprint test	4.48±0.28	5.28±0.28	-11.15	0.000

[†] Independent Samples t-test; Descriptive statistics were given as *mean ± standard deviation*. The parts determined in bold are statistically significant ($p < 0.05$).

According to Table 4.3, the post-test means for LESS Test, CAIT score for unstable ankle, CAIT score for stable ankle, zigzag agility with ball, inversion for unstable ankle, eversion for unstable ankle and 30 m sprint test significantly different between NVOEG and MRHOG groups ($p<0.05$). The graphed image of the tests of the groups is presented in Figure 4.4.

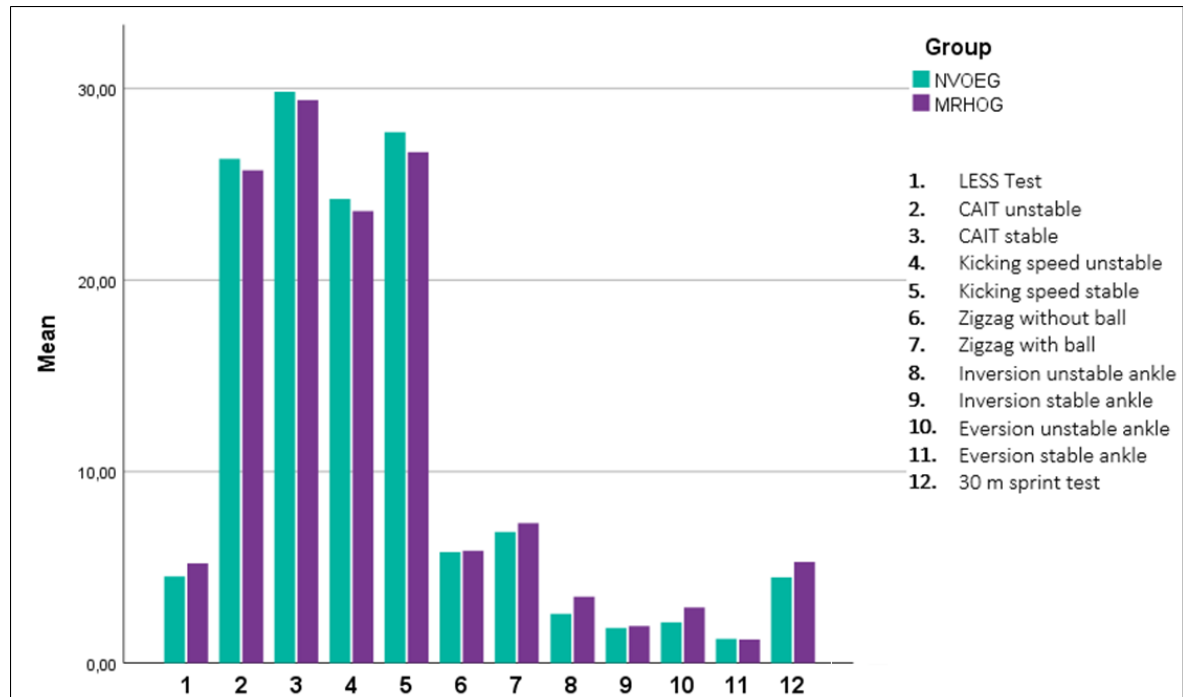


Figure 4. 4. Comparison chart of pre-test means for all tests between groups

LESS Test score, zigzag agility with ball, inversion for unstable ankle, eversion for unstable ankle and 30 m sprint test means of post-tests was significantly higher in MRHOG group ($p<0.05$). On the other hand, CAIT for unstable side and CAIT for stable side means of post-tests was significantly higher in NVOEG group ($p<0.05$).

Table 4. 4. Comparison of pre-test and post-test scores in groups

		NVOEG <i>n</i> =30			MRHOG <i>n</i> =30		
		<i>Mean</i> ± <i>SD</i>	<i>t</i> [‡]	<i>p</i> [‡]	<i>Mean</i> ± <i>SD</i>	<i>t</i> ^{&}	<i>p</i> ^{&}
LESS Test	Pre-test	6.94±0.53	71.14	0.000	6.90±0.55	68.56	0.000
	Post-test	4.53±0.35			5.20±0.42		
CAIT unstable	Pre-test	24.00±0.87	-21.07	0.000	24.37±1.00	-15.27	0.000
	Post-test	26.33±0.66			25.73±0.83		
CAIT stable	Pre-test	29.07±0.67	-8.33	0.000	29.23±0.68	-2.41	0.023
	Post-test	29.83±0.38			29.40±0.56		
Kicking speed unstable	Pre-test	19.56±2.68	-19.33	0.000	19.85±2.47	-16.18	0.000
	Post-test	24.23±3.00			23.60±2.41		
Kicking speed stable	Pre-test	24.87±2.96	-65.04	0.000	24.78±2.52	-33.62	0.000
	Post-test	27.72±3.04			26.68±2.64		
Zigzag without ball	Pre-test	8.18±0.84	32.18	0.000	8.25±0.38	117.82	0.000
	Post-test	5.80±0.60			5.85±0.27		
Zigzag with ball	Pre-test	10.55±1.02	46.71	0.000	10.59±0.92	62.81	0.000
	Post-test	6.85±0.59			7.30±0.64		
Inversion unstable ankle	Pre-test	4.53±0.68	26.03	0.000	4.57±0.68	19.75	0.000
	Post-test	2.57±0.50			3.47±0.68		
Inversion stable ankle	Pre-test	2.67±0.74	4.71	0.000	2.53±0.73	9.20	0.000
	Post-test	1.83±0.38			1.93±0.60		
Eversion unstable ankle	Pre-test	3.63±0.72	16.16	0.000	3.70±0.75	10.77	0.000
	Post-test	2.13±0.35			2.90±0.66		
Eversion stable ankle	Pre-test	1.83±0.70	6.30	0.000	1.50±0.73	3.12	0.004
	Post-test	1.27±0.28			1.23±0.34		
30 m sprint test	Pre-test	6.75±0.57	38.32	0.000	6.57±0.51	19.85	0.000
	Post-test	4.48±0.28			5.28±0.28		

[‡] Paired Samples t-test statistics for NVOEG, & Paired Samples t-test statistics for MRHOG. Descriptive statistics were given as mean ± standard deviation. The parts determined in bold are statistically significant ($p<0.05$).

According to Table 4.4, there was significantly difference between pre-test and post test results for both groups in terms of 13 different tests ($p<0.05$). CAIT for unstable ankle, CAIT for stable ankle, kicking speed for unstable side and kicking speed for stable side scores significantly increased for both NVOEG and MRHOG groups ($p<0.05$). On the other hand LESS Test, zigzag agility with and without ball, inversion and eversion for both unstable and stable ankles, and 30 m sprint test significantly decreased for both NVOEG and MRHOG groups ($p<0.05$).

Table 4. 5. Comparison of post-test and pre-test difference between groups

	Group		Test statistics [†]	
	NVOEG <i>n</i> =30	MRHOG <i>n</i> =30	<i>t</i>	<i>p</i>
LESS Test	-2.41±0.19	-1.71±0.14	-16.67	0.000
CAIT unstable	2.33±0.61	1.37±0.49	6.79	0.000
CAIT stable	0.77±0.50	0.17±0.38	5.21	0.000
Kicking speed unstable	4.67±1.32	3.75±1.27	2.77	0.008
Kicking speed stable	2.85±0.24	1.90±0.31	13.39	0.000
Zigzag without ball	-2.39±0.41	-2.39±0.11	0.09	0.926
Zigzag with ball	-3.70±0.43	-3.28±0.29	-4.44	0.000
Inversion unstable ankle	-1.77±0.91	-1.10±0.31	9.23	0.000
Inversion stable ankle	-0.43±0.50	-0.60±0.36	1.48	0.145
Eversion unstable ankle	-1.50±0.51	-0.48±0.41	-5.89	0.000
Eversion stable ankle	-0.57±0.49	-0.27±0.47	-2.42	0.019
30 m sprint test	-2.27±0.32	-1.29±0.36	-11.17	0.000

[†] Independent Samples t-test; Descriptive statistics were given as *mean ± standard deviation*. The parts determined in bold are statistically significant ($p<0.05$).

According to Table 4.5, the difference between post-test and pre-test means was significantly different between NVOEG and MRHOG groups for LESS Test, CAIT for unstable and stable ankles, kicking speed for unstable and stable ankles, zigzag agility without ball, inversion for unstable ankle, eversion for unstable and stable ankles, and 30 m sprint test between groups ($p<0.05$). The graphed image of the tests of the groups is presented in Figure 4.5.

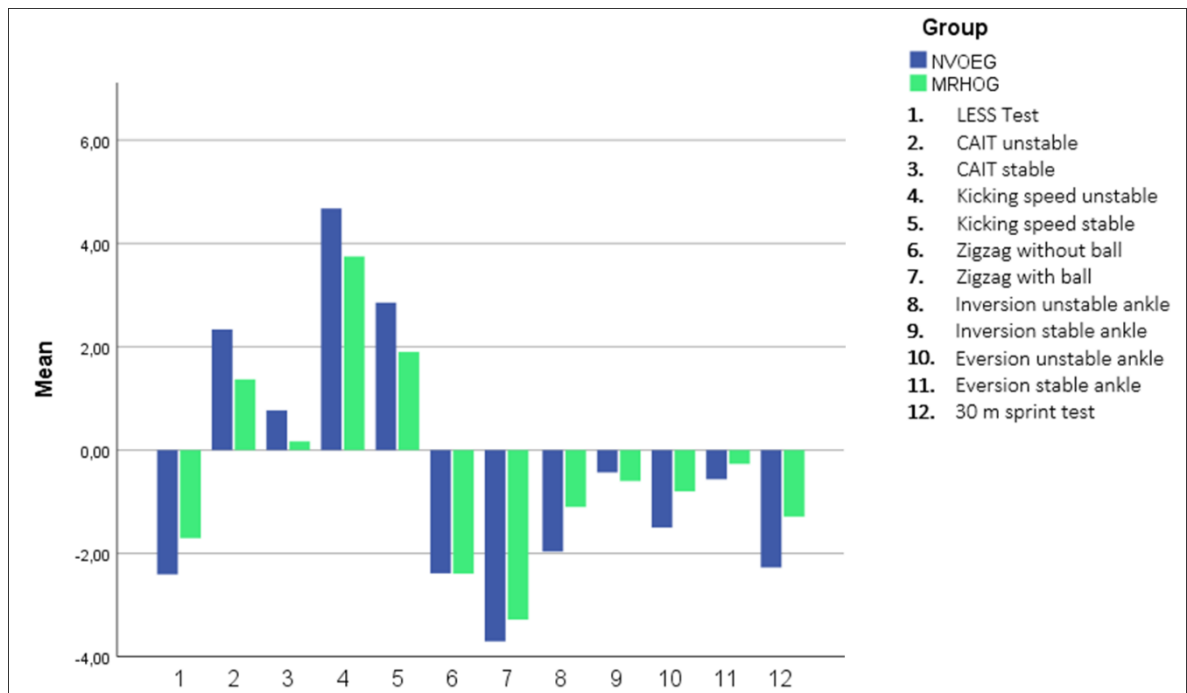


Figure 4. 5. Comparison chart of post-test and pre-test difference for all tests between groups

The difference between post-test and pre-test means was significantly higher in NVOEG group for LESS Test, CAIT for unstable and stable ankles, kicking speed for unstable and stable ankles, zigzag agility without ball, inversion for unstable ankle, eversion for unstable and stable ankles, and 30 m sprint test ($p < 0.05$).

5. DISCUSSION

CAI is characterized by a recurrent sense of “giving way” with pain and functional impairment, often triggered by a history of ankle sprain (137). Recurrent ankle sprains can occur in up to 73% of athletes, and 59% of those report CAI (7). The current study aimed to explore the effects of combining myofascial release therapy with neuro-vestibular-ocular exercises on proprioception and performance in football players who suffer from chronic ankle instability. Chronic ankle instability is a prevalent condition among football players and can have a significant impact on their performance and proprioceptive abilities. The study focused on neuro-vestibular-ocular exercises, which incorporate both neuromuscular training and vestibular-ocular training techniques. These exercises have not been extensively researched in the context of chronic ankle instability, and the superiority of training programs that combine myofascial release and neuro-vestibular-ocular exercises has not been examined. Additionally, there is a lack of studies investigating the effectiveness of combined neuromuscular and vestibular-ocular exercises specifically within the football player population. Therefore, this study aimed to fill these knowledge gaps and provide valuable insights into the potential advantages of these treatment approaches. The study was carried out over a period of eight weeks with football players aged between 18 and 30, and the results revealed significant improvements in proprioception and performance in both groups. However, the neuro-vestibular-ocular exercise group exhibited superior outcomes compared to the myofascial release group. These findings emphasize the importance of incorporating neuro-vestibular-ocular exercises and myofascial release into the treatment regimen for chronic ankle instability in football players.

Proficiency in football relies on various skill parameters, and chronic ankle instability can have a significant impact on these abilities. In sports like football, basketball, and volleyball, where quick and precise movements are vital, the integration of multiple sensory inputs becomes crucial. Multisensory integration allows athletes to anticipate ground forces, perceive external sensations, and maintain awareness of their body's position, all of which contribute to high levels of strength and performance (140). Key movements such as vertical jumping, landing, sprinting, and cutting heavily depend on multisensory integration, with vision playing a central role in accurately positioning the body in space. However, chronic ankle instability can disrupt this integration, leading to compromised proprioception and reduced leg stability, which negatively affect football

performance (141, 143). The ability to generate kick speed is another crucial aspect of football performance, as it impacts accuracy and power. Proprioception and overall leg stability significantly influence kick speed, underscoring the importance of a stable and functional ankle joint (143). Agility, defined as the capacity to rapidly change direction in response to stimuli, is a fundamental skill in football. It requires swift shifts in direction and coordinated movements of the entire body (144). Chronic ankle instability can hinder agility due to compromised proprioception and reduced stability, making it difficult for football players to execute quick changes of direction effectively. Consequently, addressing chronic ankle instability becomes essential to optimize these skill parameters and enhance overall football performance.

The typical rehabilitation protocols for addressing chronic ankle instability in football players involve a comprehensive combination of exercises targeting strength, stability, balance, proprioception, and functional movements. A comprehensive rehabilitation program often includes the following exercises: exercises to improve range of motion, exercises to strengthen the ankle and surrounding muscles, training for balance and proprioception, plyometric exercises, functional training exercises, and exercises focused on neuromuscular control.

Neuromuscular training has emerged as a viable approach for managing and preventing ankle instability. The primary objectives of neuromuscular training encompass enhancing neuromuscular control, augmenting joint stability, and mitigating the risk of injury. These training regimens typically encompass a repertoire of exercises, such as strengthening exercises, stretching routines, plyometric activities, and balance exercises (26). By utilizing afferent impulses and the brain systems in charge of dynamic joint control, neuromuscular training's fundamental goal is to improve subconscious motor capabilities. According to certain studies, a neuromuscular rehabilitation program improves postural control, increases eccentric evor muscle strength, and contributes to greater functional capacity to retain strength (116). In a randomized controlled trial, 67 athletes diagnosed with chronic ankle instability (CAI) were assigned to one of three groups: an 8-week neuromuscular training group (involving static and dynamic exercises), a strength training group (employing resistance band exercises), or a control group that received no training. The participants' outcomes were evaluated at baseline and after 8 weeks using measures such as self-reported instability sensation (CAIT), dynamic balance (SEBT), ankle dorsiflexion range of motion (WBLT), and functional status (FAAM and FAAM-SPORT). The results indicated that both the neuromuscular

training group and the strength training group demonstrated significant improvements in ankle dorsiflexion, sensation of instability, functional status, and dynamic balance after the 8-week intervention (159). In their study, Faizullin and Faizullina (117) examined the effectiveness of neuromuscular training in young soccer players. A variety of workouts including dynamic stretches, agility drills, leaping drills, balancing training, and eccentric strength training were included in the training program. According to the study's findings, implementing a neuromuscular training program was successful in preventing injuries among young soccer players. They concluded that various approaches to balance training yield comparable results in the rehabilitation of unstable ankles and demonstrate the effectiveness of balance training for this purpose(117). In another study, the effects of an eight-week jumping protocol and a combined protocol consisting of balance and strength were compared. Thirty-six male professional footballers were divided into three groups as control group, jumping group and balance plus strength group. It was concluded that the balance and strength protocol was more effective and had a faster recovery and greater effect for footballers with recurrent ankle sprains (118).In a study examining the effects of balance exercises and combined exercises (neuromuscular and stabilization exercises) on pain, function, and range of motion in female athletes with chronic ankle instability, a total of 30 participants were divided into three groups: balance exercises (n=10), combined exercises (n=10), and a control group (n=10). Both exercise groups underwent their respective training programs for 6 weeks, with three sessions lasting 60 minutes per week. The comparison between the two exercise programs revealed that the combined exercises had a greater impact on reducing pain, improving function, and increasing dorsiflexion range of motion in the subjects(165).A study of 18 individuals with chronic ankle instability (CAI) was conducted to evaluate the effect of the progressive hop to stabilization balance (PHSB) program on self-reported function, dynamic postural control, and sense of joint position (JPS). Participants were divided into two groups: the PHSB group and the Single Leg Balance (SLB) group. Both groups followed their own 4-week schedule, with three sessions per week. The SLB group did a series of single-leg balance exercises, while the PHSB group did a series of exercises focused on single-leg stabilization. The findings showed that both the PHSB and SLB programs provided similar improvements, suggesting that both programs could be used in athletes with CAI (166). A study examined changes in neuromuscular and athletic performance among young soccer players who underwent core strength training on unstable surfaces (CSTU) compared to stable surfaces (CSTS). Thirty-nine elite male soccer players participated in

the study, receiving training for a period of 9 weeks, 2-3 times per week, in addition to their regular in-season soccer training. The participants were divided into two groups and followed a progressive basic strength training program. The CSTS group performed basic exercises on stable surfaces such as the floor or bench, while the CSTU group performed the same exercises on unstable surfaces using tools like the Thera-Band Stability Trainer or Swiss ball. Measurements were taken, including tests to assess trunk muscle strength and activation, countermotion jump height, sprint time, agility time, and kick performance. The results showed that trunk muscle strength, sprint performance, and kick performance improved in both the CSTU and CSTS groups when combined with regular soccer training. Agility is a fast, coordinated movement using the entire body that is characterized by changes in speed or direction in reaction to a stimulus, according to Sheppard and Young (22). For soccer athletes, possessing good agility offers numerous benefits such as the ability to execute challenging movements with ease, reduced risk of falling or sustaining injuries, and enhanced support for various techniques, particularly dribbling skills. The effectiveness of agility training relies on the performance of the neuromuscular system, which is dependent on the nerve response and reactivity of this system. The central nervous system plays a crucial role in rapidly and forcefully transmitting impulses to the muscle fibers involved in executing agility exercises, thereby determining the level of muscle contraction. Consequently, the intensity of training significantly impacts the improvement of agility (163). Agility is an important aspect of soccer performance, characterized by the ability to swiftly change directions by initiating and stopping motion rapidly (164). In a study involving elite football players, researchers investigated the impact of a 6-week neuromuscular training program on agility performance. The participants in the neuromuscular training group followed engaged in dynamic stability, balance, and core strength exercises in the gym, while on-field activities included agility drills, cutting maneuvers, and plyometric exercises. The neuromuscular training group underwent two sessions per week, with each session lasting 30 minutes. The study demonstrated that this 6-week neuromuscular training program led to a significant improvement in return performance (180°) among elite football players (144). Although it is seen that speed is needed for agility, which has a complex structure, coordination, balance and the ability to react to a change in the environment also plays an important role (145). This skill, which includes cognitive processes such as visual scanning, perceptual and decision-making, is one of the most important indicators of successful performance in most sports (161). Vestibular-ocular exercises in the neuro-

vestibular-ocular exercise group may also have been effective in increasing agility. Reduced agility contributes to the occurrence of injuries among athletes, while enhanced flexibility can enhance agility and support the maintenance of physical fitness (146).

Vestibular exercise training helps the person to adapt and improve balance through targeted exercises and therapies (28). If sensory and balance information is not correct, the athlete may experience a delay in reaction time, unable to sustain symptoms such as dizziness, disorientation, or a sensation. Instability may be seen in people who have balance problems or have difficulty in recovery after changing direction (30). This reflex, which synchronizes eye movements with head movements, is very important to maintain balance and visual stability during dynamic activities. Including VOR training or retraining in ankle rehabilitation can help increase the integration of sensory information and improve overall balance and stability. Sports such as football, basketball, and volleyball require the integration of multiple sensory inputs, including external sensations, proprioception, and vestibular cues, due to their time-sensitive nature and the uncertainties inherent in these competitions (140). Multisensory integration in sports plays a crucial role in developing high levels of strength and allows athletes to predict the timing, direction, and magnitude of ground reaction forces acting on the lower extremities (141). Performance movements such as vertical jumping, landing, sprinting, and cutting rely heavily on multi-sensory integration, with the visual system playing an important role in positioning the body in space (142). There is no similar study in the literature on football players, and there is no training in football that combines neuromuscular and vestibulo-ocular techniques. Ishigaki and colleagues found that athletes engaged in high-speed ball sports exhibited higher dynamic visual acuity than non-athletes (166). This superior visual acuity is attributed to the constant changes in positions that occur in fast ball sports. Such sports require reanalysis of visual information obtained from each new position, while also maintaining balance and control over posture (167). On the other hand, one study investigated the effect of including visual stimuli in soccer training on reaction time (RT), cognitive function, and physical fitness. A total of 38 male soccer players aged 10-15 years were randomly assigned to either the intervention or control group. Following the initial assessment, the intervention group engaged in the regular soccer training program along with the visual stimulus program, while the control group solely continued with the regular soccer training program for a period of 6 months. To evaluate speed, agility, and coordination, two parallel lines were marked 5 meters apart, each measuring 1.2 meters. The athletes were instructed to sprint as quickly as possible

between the lines and repeat this task five times. At the conclusion of the 6-month study, the intervention group displayed a statistically significant improvement of 13.36% ($p < 0.001$) in repeated sprinting ability (172). It was observed that athletes with a faster visual information processing system exhibited faster reaction times (173).

In our study, we looked at the effectiveness of Neuro-vestibular-ocular therapy on proprioception and performance parameters (LESS, kick speed, zig-zag agility with and without the ball, 30-meter sprint) in football players after 8 weeks. The demographic profiles of both NVOEG and MRHOG were quite consistent and provided parity for comparisons in the study ($p > 0.05$) (Table 4.4). The median age of patients in the NVOEG group was 25 years. BMI for the NVOEG group was 22.69 ± 0.41 . The mean playing time of the patients was 10 years. Dominant side and unstable ankle side were also investigated as part of demographic profiling. The majority of the participants were right-sided dominant in 83.3% on NVOEG and 53.3% in NVOEG, the unstable ankle side was predominantly right-sided. Pretest scores of NVOEG and MRHOG groups were not statistically significant for all test results ($p > 0.05$). Post-test LESS scores of NVOEG group were found to be significantly lower than pre-test scores ($p < 0.05$). Post-intervention scores for both stable and unstable ankles improved significantly compared to the pre-intervention CAIT scores of the NVOEG group ($p < 0.05$). Post-intervention measurements showed a significant improvement, ie an increase, in the kick speed of the NVOEG group compared to the pre-intervention ($p < 0.05$). Post-intervention ball and collective zigzag agility test scores showed significant improvements in the 30-meter sprint time NVOEG group (ie, a decrease in scores reflecting faster completion times) ($p < 0.05$). After intervention for both inversion and eversion of the stable and unstable ankle, the NVOEG group showed a significant reduction in inversion and eversion for both the stable and unstable ankle ($p < 0.05$) (Table 4.3).

Myofascial release, a form of manual therapy, can be a valuable element in the rehabilitation program for football players with chronic ankle instability. This hands-on technique specifically targets the fascial system to alleviate restrictions, enhance tissue mobility, and improve overall function. When applied to the ankle area, myofascial release can help address muscular imbalances, reduce pain, and restore optimal movement patterns. A four-week intervention was used in a study by Ruben et al. (128) on 36 male soccer players. The participants were placed into two groups at random: the experimental group experienced eccentric exercise, myofascial release, and neuromuscular taping; the control group did not. In soccer players with recurrent ankle

sprains, the combination of fascial treatment and eccentric strength training improved ankle mobility, strength, and stability (128). In the literature, myofascial release is usually applied to athletes with foam rollers or instrument-assisted, and studies are inconsistent in the literature. In a study involving 40 participants with chronic ankle injuries, the effectiveness of deep tissue massage and myofascial release was examined. The results indicated that both deep tissue massage and soft tissue release massage were effective in reducing pain and significantly improving ankle function. However, there was no significant difference observed between the two approaches (152). According to Wilke et al. (138), the interaction between connective and muscle tissues and fascia tissue has a mechanical effect that helps smooth joint transitions by providing support during activation. They suggested that understanding the functioning of the fascia could improve performance, balance and reduce the risk of injury by promoting appropriate biomechanical patterns. The effect of applying fascial tissue equipment to the lower extremity posterior group muscles on athletic performance differs in the literature (139). While there is little research examining the effect of myofascial release on performance and proprioception in football players, other studies have mostly focused on jumping performance and myofascial release using assistive devices. Considering the conflicting findings in the available literature, we conducted a study using hands-on technical myofascial release as an intervention. Moreover, the myofascia, a connective tissue, contains numerous sensory nerves that are associated with receptors responsible for sensing body position and mechanical stimuli, such as Golgi receptors and Pacini receptors (149). Consequently, when pressure is applied during a therapeutic technique called MFR intervention, these mechanical receptors are stimulated, leading to an enhancement in the integration of proprioceptive information by the central nervous system. This, in turn, helps in regulating the activation level of motor units(150).One study conducted by Schaefer and Sandrey (151) investigated the effects of a 4-week dynamic balance program combined with low back and whole body myofascial release (LBWM) in individuals with a history of CAI. The study included 36 participants with ankle instability who were randomly assigned to three groups: balance training with LBWM, balance training with sham myofascial release, and balance training only. Dynamic stability was assessed using the star excursion balance test. The results showed improvements in all groups, with no significant differences between them. In another study the impact of chronic ankle instability on muscle strength, proprioceptive sensation, dynamic balance, and joint range of motion through the application of the myofascial

deformation model treatment were investigated. The findings revealed significant improvements in maximum isometric strength, proprioception, dynamic balance, and maximum joint angle following the application of the fascia distortion model treatment (168). This suggests that myofascial release techniques may have a positive impact on stability beyond the immediate treatment area. Although myofascial release therapy has been found to improve flexibility and potentially joint control (148) A single-blind, randomized controlled trial was conducted to assess the effects of Fascial Manipulation on clinical outcomes in semi-professional soccer players with chronic ankle instability (CAI). The study aimed to determine if this approach could modify the natural progression of the condition. The results demonstrated that Fascial Manipulation led to improved range of motion (ROM) in semi-professional athletes affected by CAI. The findings suggested that Fascial Manipulation is a valid method for symptom improvement and indicated that participation in the study group enhanced performance levels (160). Research has demonstrated the tightly fused nature of the connective tissue surrounding adjacent compartment muscles in the lower extremities (161, 162). Given the close morphological relationship between muscles and the surrounding connective tissues, changes in local stiffness and muscle strength may affect both the affected tissue and the surrounding areas. This manipulation of force transmission can impact movement and power output by facilitating or limiting them. Initial evidence indicates that even small forces can initiate mechanical interactions between compartment muscles. The myofascial continuum, which involves the mechanical transmission of force through musculoskeletal connections, has been suggested by some therapists as a potential explanation for the development of musculoskeletal pain conditions as well as improved sports performance during multi-joint movements. (161, 162). Thus, in our study, the application of myofascial release may have contributed to an increase in the kick speed of the football players. In addition, there is no other study in the literature looking at the kick speed of manual myofascial release. Techniques aimed at muscle relaxation, such as myofascial release therapy, are known to break down adhesions, enhance blood flow and lymphatic drainage, improve soft tissue extensibility, and enhance range of motion and muscle strength. These effects are believed to arise from changes in the thickness of the intracellular substance, transitioning it from a more solid gel state. This transformation is thought to influence the elastic and viscoelastic properties of connective tissue (169). Consequently, the myofascial release technique can be employed to release constricted fascial structures and attain an optimal muscle length for effective muscle contraction.

Previous research has provided evidence of changes in muscles following manual therapeutic interventions, which include the inhibition of taut bands, alterations in interstitial fluid, pain reduction, and reduced muscle contracture (170). Compared to other studies such as Peacock et al. (153), Healey et al. (147), Linderorth (154), Fama and Buetti (155), Malin et al. (156), Behara and Jacobson (157) and Li (158), self-myofascial release (SMR) was found to be more effective than dynamic warm-up in improving vertical jump, standing long jump, agility, repetition maximum bench press and sprint performance. In a crossover study involving college male and female soccer players, a bio foam roller and a rigid roller were utilized. The participants (20 individuals, 10 males and 10 females) were randomly assigned to a control group (CON). During each trial, the subjects underwent various assessments, including a functional movement screen (FMS), vertical jump (VJ), proactivity test (PA), and 30-meter sprint (30M). Prior to performing the anaerobic tests over a period of 7 days, the participants applied rotational pressure to each lower extremity muscle for three sets of 30 seconds using the myofascial roller. The study's findings indicated that there was no significant improvement in any of the anaerobic sports performance tests between the control group and the myofascial roller group (171). It should be noted that in our study, we manually applied myofascial release.

The BMI for MRHOG group was 23.20 ± 0.26 . The median playing time for participants across MRHOG group was 10 years. Dominant side and side of unstable ankle were also investigated as part of the demographic profiling. A majority of participants were right-side dominant 90% in MRHOG, and the side of the unstable ankle was also predominantly on the right 60% in MRHOG. (Table 4.4) Furthermore, it was observed that post-test LESS scores MRHOG group were significantly lower than the pre-test scores ($p < 0.05$). The post-intervention scores for both stable and unstable ankles were significantly improved compared to the pre-intervention CAIT scores in both the MRHOG group ($p < 0.05$). Post-intervention measurements revealed a significant improvement in kicking speed in MRHOG group for both unstable and stable ankles ($p < 0.05$). Zigzag agility test scores without a ball & with ball, 30 meter sprint times post-intervention results showed significant improvements (i.e., decreased scores, reflecting faster completion times) in the MRHOG group ($p < 0.05$). Post-intervention, in the MRHOG group demonstrated a significant reduction in inversion and eversion for both unstable and stable ankles ($p < 0.05$) (Table 4.3).

In this study, while there was no significant difference between NVOEG and MRHOG groups in pre-test measurements ($p > 0.05$), significant improvements were

observed in both groups in post-test measurements ($p < 0.05$). However, the improvement was significantly higher in the NVOEG group than in the MRHOG group ($p < 0.05$) (Table 4.5).

Due to the lack of research on the inclusion of neuro-vestibular-ocular reflex training in CAI treatment protocols, we found it difficult to compare the findings of our study with those of others. Therefore, we compared it with neuromuscular training and the limited number of vestibular-ocular training. This study is the third study in literature to include the vestibular-ocular reflex (VOR). It is the second study that combines neuromuscular training techniques with vestibular-ocular training. This is the first study in a specific group of soccer players. Unlike other studies, we applied a broader training protocol specific to the sport of soccer and evaluated soccer-specific parameters. There were no related studies in the literature in some of our performance tests of myofascial therapy. These are kick speed and LESS. In general, studies have been done on vertical jump and flexibility for athletes. Although there were no limitations in this study and the desired sample size was achieved in power analysis, the study should be developed more comprehensively. Further studies are needed to determine the long-term effects of neuro-vestibular-ocular training on performance and proprioception CAI.

6. CONCLUSION

This study provides comprehensive evidence supporting the efficacy of combined neuro-vestibular-ocular exercises (NVOEG) and myofascial release therapy (MRHOG) in improving proprioception and performance in football players with CAI. Our findings consistently show significant improvements in several measures, including LESS scores, CAIT scores, kick speed, agility, 30m sprint test scores, and proprioception (JPST). Interestingly, these improvements were more pronounced in the NVOEG group, indicating a potential superiority of the combined neuro-vestibular-ocular approach in managing CAI.

These results significantly contribute to the growing body of evidence advocating for comprehensive and multifaceted rehabilitation strategies in the management of CAI. The value of neuro-vestibular-ocular exercises, as evidenced in this study, could herald a new standard in sports rehabilitation, augmenting traditional physiotherapy approaches such as myofascial release therapy.

From an application standpoint, our findings hold several implications. Primarily, sports rehabilitation professionals and physiotherapists could leverage the advantage of NVOEG in enhancing recovery and athletic performance in individuals with CAI. This study could serve as a catalyst for incorporating more holistic approaches that go beyond conventional physiotherapy in sports rehabilitation regimens.

Furthermore, these findings may prompt football coaches and trainers to incorporate neuro-vestibular-ocular exercises into routine training to potentially mitigate the risk of ankle instability, enhance performance, and increase the longevity of players' careers. This could lead to a healthier, more resilient team and a lower risk of injuries that often accompany this highly competitive sport.

Nonetheless, it is crucial to continue expanding this research to larger and more diverse athletic populations to substantiate these findings further. In addition, studies exploring the specific mechanisms underlying the benefits of neuro-vestibular-ocular exercises would provide valuable insights and refine intervention strategies for individuals with CAI.

In conclusion, our study suggests a promising path towards more effective management strategies for CAI, potentially reshaping sports rehabilitation practices, improving athletic performance, and contributing to a safer, healthier sporting environment.

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8. APPENDICES

8.1. Informed Written Consent

ARAŞTIRMAYA KATILIM ONAM FORMU

Bu çalışma Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Spor Fizyoterapisi Bölümü tarafından yürütülen “Kronik ayak bileği instabilitesi olan futbolcularda kombine nöro-vestibular- oküler egzersizler ve myofasyal gevşetmenin propriyosepsiyon ve performans üzerindeki etkileri” başlıklı araştırma kapsamında planlanmıştır. Çalışma süresi haftada iki gün ve toplam 8 haftadır. Çalışmamıza katılmayı kabul eden gönüllü bireylerin; yaşı, cinsiyeti, sosyo-demografik koşulları, var olan kronik hastalıkları, geçirilen cerrahi durumları, yaralanmaları ve antrenman davranışlarına dair bilgiye ulaşılarak, tedavi planına dahil edilecektir. İlk gruba katılacak olan bireyler 8 hafta süreyle egzersiz eğitimi alacaktır. Diğer gruba katılan oyunculara ise fizyoterapist tarafından fasya gevşetme uygulanacaktır. Bu amaçla kullanılan değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmalarda kullanılacaktır.

Araştırma ile ilgili sizden doldurmanızı istediğimiz formları doğru bir şekilde doldurmanızı ve herhangi bir şikayetiniz ya da rahatsızlığınız olduğunda bize bildirmeniz gerekmektedir. İstedığınız zaman çalışma dışına çıkma hakkınız olduğunu bilmenizi isteriz. Bu araştırma kapsamında uygulanacak olan uygulamalarda herhangi bir risk bulunmamakta ve yapılacak hiçbir uygulama size zarar vermeyecektir. Bu araştırma dahilinde sizden herhangi bir ücret talep edilmemektedir. Bu çalışmada yer almanız nedeniyle size hiçbir ödeme yapılmayacaktır. Kişisel bilgileriniz herhangi bir amaçla, kurum yöneticileri veya üçüncü kişilerle paylaşılmayacaktır.

Katılımınız için teşekkür ederiz.

Sorumlu araştırmacı: Dr.Öğr.Üyesi Elif Tuğçe Çil

Yardımcı Araştırmacı: Fzt. Büşra Kocakılıç

“Kronik ayak bileği instabilitesi olan futbolcularda kombine nöro-vestibular- oküler egzersizler ve myofasyal gevşetmenin propriyosepsiyon ve performans üzerindeki etkileri” isimli çalışmada katılımcıya/gönüllüye verilmesi gereken bilgileri okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. Çalışma hakkında yazılı ve sözlü açıklama adı belirtilen araştırmacı tarafından yapıldı. Bu çalışmayı istediğim zaman ve herhangi bir neden belirtmek zorunda kalmadan bırakabileceğimi ve bıraktığım takdirde herhangi bir olumsuzluk ile karşılaşmayacağımı anladım. Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum.

Gönüllünün Adı /Soyadı /İmzası /Tarih

Açıklama Yapan Kişinin Adı /Soyadı /İmzası /Tarih

8.2. Ethical Approval



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

PROJENİN ADI	: “Kronik Ayak Bileği İnstabilitesi Olan Futbolcularda Kombine Nöro-Vestibular-Oküler Egzersizler Ve Myofasyal Gevşetmenin Propriyosepsiyon ve Performans Üzerindeki Etkileri”
PROJENİN YÜRÜTÜCÜSÜ	: Dr. Öğr. Üyesi Elif Tuğçe ÇİL
PROJEDEKİ ARAŞTIRICILAR	: Büşra KOCAKILIÇ
ONAY TARİHİ VE SAYISI	: 29.12.2022/200

Sayın: Dr. Öğr. Üyesi Elif Tuğçe ÇİL

“200” protokol numaralı “Kronik Ayak Bileği İnstabilitesi Olan Futbolcularda Kombine Nöro-Vestibular-Oküler Egzersizler Ve Myofasyal Gevşetmenin Propersiyon ve Performans Üzerindeki Etkileri” isimli projeniz Fakültemiz Etik Kurulu tarafından incelenmiş oy birliği ile etik yönden uygun olduğuna karar verilmiştir.





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8.3. Demographic Information Form

- 1) Sporcunun Adı Soyadı: Telefonu:
- 2) Doğum Tarihi:
- 4) Boy uzunluğu (cm):
- 5) Vücut ağırlığı (kg) :
- 6)Oynadığı Takım :
- 7)Oynadığı Statü : () Amatör () Profesyonel
- 8)Oynadığı Mevki :
- 9)Antrenman Yaşı :
- 10)Dominant taraf: El () sağ () sol Ayak () sağ () sol
- 11)Herhangi bir sürekli hastalığınız var mı? Varsa hangileri?
() Sürekli bir hastalığım yok () Romatizma () Nörolojik problemler () Travma () Diğer.....
- 12) Herhangi bir yaralanma(sakatlık,ameliyat) geçirdiniz mi? Aşağıya yazınız.
Yaralanma Ne Zaman Oldu Ne Kadar Sürdü
1.
2.
3.
4.
5.
- 13) Antrenman sıklığınız? ()Haftada 1 kez ()Haftada 2-3kez ()Haftada 4-5 kez ()Her gün
- 14) Yaptığınız antrenman her seferinde kaç dakika sürüyor?
()30 – 60 dk ()60 – 90 dk ()90 – 120 dk
- 15) Daha önce ayak bileğiniz burkuldu mu? () Evet () Hayır
- 16) Evet ise, kaç defa?
- 17) Daha önce ayak bileği instabilitesi için herhangi bir tedavi gördünüz mü?
() Evet () Hayır
- 18) Kronik ayak bileği instabilitesi ile ilgili egzersiz programı yapıyor musunuz?
() Evet () Hayır
- 19) Yapıyorsanız ne süredir yapmaktasınız?.....
- 20) Yapıyorsanız ne tarz egzersizler yapıyorsunuz?Açıklayınız.

8.4. CAIT

1) Ayak bileğim ağrıyor.		SAĞ	SOL	
	Hiçbir zaman			5
	Spor sırasında			4
	Düz olmayan zeminde koşarken			3
	Düz zeminde koşarken			2
	Düz olmayan zeminde yürürken			1
	Düz zeminde yürürken			0
2) Ayak bileğimde güvensizlik hissediyorum		SAĞ	SOL	
	Hiçbir zaman			4
	Spor sırasında ara sıra			3
	Spor sırasında sık sık			2
	Günlük aktiviteler sırasında ara ara			1
	Günlük aktiviteler sırasında sık sık			0
3) Keskin dönüşler sırasında ayak bileğimi Güvensiz hissediyorum.		SAĞ	SOL	
	Hiçbir zaman			3
	Koşarken ara sıra			2
	Koşarken sıklıkla			1
	Yürüdüğümde			0
4) Merdiven inerken ayak bileğimi güvensiz hissediyorum		SAĞ	SOL	
	Hiçbir zaman			3
	Hızlı indiğimde			2
	Bazı durumlarda			1
	Her zaman			0
5) Tek ayak üzerinde durduğumda ayak bileğimi güvensiz hissediyorum		SAĞ	SOL	
	Hiçbir zaman			2
	Parmak ucunda			1
	Normal basarken			0
6) Ayak bileğimi güvensiz hissediyorum		SAĞ	SOL	
	Hiçbir zaman			3
	Yana sıçradığım zaman			2
	İleriye sıçradığım zaman			1
	Zıplayıp yere düştüğüm zaman			0
7) Ayak bileğimi güvensiz hissediyorum		SAĞ	SOL	
	Hiçbir zaman			4
	Düz olmayan zeminde koşarken			3
	Düz olmayan zeminde jog koşusu sırasında			2
	Düz olmayan zeminde yürürken			1
	Düz zeminde yürürken			0
8) Ayak bileğim burkulur gibi olduğunda onu engelleyebiliyorum.		SAĞ	SOL	
	Hemen			4
	Çoğu zaman			3
	Bazen			2
	Hiçbir zaman			1
	Hiç böyle bir his yaşamadım			0
9) Ayak bileğim burkulur gibi olduktan sonra , ayak bileğim normale döner.		SAĞ	SOL	
	Neredeyse hemen			4
	1 günden kısa sürede			3
	1-2 gün içinde			2
	2 günden fazla sürede			1
	Hiç böyle bir his yaşamadım			0

İniş Hatası Puanlama Sistemi Başlığı	Operasyonel Tanım	Kamera Görünümü	Hata Durumu	Puan
1 İlk temasta diz fleksiyon açısı	Test edilen ekstremite ilk temas 30 dereceden fazla diz fleksiyonu ile yapıyor ise EVET. Diz fleksiyon açısı 30 dereceden az ise HAYIR.	Yandan	Hayır	EVET: 0 HAYIR: 1
2 İlk temas kalça fleksiyon açısı	İlk temas sırasında test edilen ekstremitenin uyluğu gövde ile aynı çizgide, yani kalça fleksiyonu yok ise HAYIR. Eğer kalça fleksiyonu var ise EVET.	Yandan	Hayır	EVET: 0 HAYIR: 1
3 İlk temasta gövde fleksiyon açısı	İlk temas sırasında gövde vertikal veya ekstansiyonda ise HAYIR. Gövde fleksiyonda ise EVET.	Yandan	Hayır	EVET: 0 HAYIR: 1
4 İlk temas ayak bileği plantar fleksiyon açısı	İlk temas sırasında sırayla önce parmaklar sonra topuk yerle temas ediyorsa EVET. Önce topuk sonra parmaklar temas ediyor ya da taban düz bir şekilde yeriniyorsa HAYIR.	Yandan	Hayır	EVET: 0 HAYIR: 1
5 İlk temasta diz valgus açısı	İlk temas sırasında, patella merkezinden aşağı düz bir çizgi çizilir. Çizgi orta ayak üzerinden geçiyor ise, HAYIR. Çizilen hat orta ayagın medialinden geçiyor ise, EVET.	Önden	Evet	EVET: 1 HAYIR: 0
6 İlk temas lateral gövde fleksiyon açısı	İlk temasta gövde orta hatтан sola veya sağa fleksiyonda ise, EVET. Gövde vücudun sol veya sağ tarafına fleksiyonda değil ise, HAYIR.	Önden	Evet	EVET: 1 HAYIR: 0
7 Destek yüzeyi Geniş	Tüm ayagın yerle temasından sonra omuz ucundan aşağı bir çizgi çizilir. Test edilen ekstremitede ayak bu çizginin dışında kalıyor ise, EVET. Eğer ayak iç veya dış rotasyonda ise puanlama topuk referans alınarak yapılır.	Önden	Evet	EVET: 1 HAYIR: 0

8.5. LESS

İniş Hatası Puanlama Sistemi Başlığı		Operasyonel Tanım	Kamera Görünümü	Hata Durumu	Puan
8	Destek yüzeyi Dar	Tüm ayağın yere temasından sonra omuz ucundan aşağı bir çizgi çizilir. Test edilen ekstremitede ayak bu çizginin dışında kalıyor ise, EVET. Eğer ayak iç veya dış rotasyonda ise puanlama topuk referans alınarak yapılır.	Önden	Evet	EVET: 1 HAYIR: 0
9	Ayak pozisyonu – ayak ucu içeri	Test edilen ekstremitede ilk temas ve maksimum diz fleksiyonu arasında ayak 30 dereceden fazla iç rotasyonda ise, EVET. Test edilen ekstremitede ilk temas ve maksimum diz fleksiyonu arasında ayak 30 dereceden daha az iç rotasyonda ise, HAYIR.	Önden	Evet	EVET: 1 HAYIR: 0
10	Ayak pozisyonu – ayak ucu dışarı	Test edilen ekstremitede ilk temas ve maksimum diz fleksiyonu arasında ayak 30 dereceden fazla dış rotasyonda ise, EVET. Test edilen ekstremitede ilk temas ve maksimum diz fleksiyonu arasında ayak 30 dereceden daha az dış rotasyonda ise, HAYIR.	Önden	Evet	EVET: 1 HAYIR: 0
11	Simetrik ilk ayak teması	Eğer bir ayak diğerinden önce yerle temas ediyor veya bir ayak topuk-burun diğeri burun topuk şeklinde iniyor ise, HAYIR. Yerle temas simetrik ise, EVET.	Önden	Hayır	EVET: 0 HAYIR: 1
12	Diz fleksiyonundaki değişim	Test edilen ekstremitenin dizli ilk temastan maksimum diz fleksiyonuna kadar 45 dereceden fazla fleksiyon açısında ise, EVET. Test edilen ekstremitenin dizli 45 dereceden daha az fleksiyon açısında ise, HAYIR.	Yandan	Hayır	EVET: 0 HAYIR: 1

8.6. Permission of Institution

14/12/2022

ÇALIŞMANIN YÜRÜTÜLECEĞİ KURUM
Asım Kara Spor Tesisleri

Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Spor Fizyoterapistliği Yüksek Lisans Programı'nda kayıtlı olan Fzt.Büşra Kocakılıç'ın " Kronik Ayak Bileği İnstabilitesi olan futbolcularda kombine nöro-vestibular-oküler egzersizler ve myofasyal gevşetmenin propriyosepsiyon ve performans üzerindeki etkileri " konulu çalışmayı Ocak 2023-Mart 2023 tarihleri arasında kurumumuzda yapması tarafımızca uygundur.

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55040 Maltepe/İstanbul

Adı-Soyadı : Mehmet Berk
İmza : GÜNGÖR