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DEPARTMENT OF SPORTS PHYSIOTHERAPY

EVALUATION OF MUSCLE TONE AND BALANCE IN YOUNG COLLEGIATE ATHLETES WITH ANKLE INSTABILITY

MASTER THESIS

ELİF VARAN, PT.

İSTANBUL, 2023

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ADVISER

ASST.PROF. DR. FEYZA ŞULE BADILLI

ISTANBUL, 2023

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	Title, Name-Surname (Institution)	Signature
Chair of the Jury:	Assist. Prof. Şule Badıllı Yeditepe University	
Supervisor:	Assist. Prof. Şule Badıllı Yeditepe University	
Member/Examiner:	Assist. Prof. Şule Badıllı Yeditepe University	
Member/Examiner:	Assist. Prof. Ayça AKLAR Fernerbahçe University	
Member/Examiner:	Assist. Prof. Elif ÜSTÜN DEVELİ Yeditepe University	

APPROVAL

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

Prof. Dr. Bayram YILMAZ

Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is entirely original work of mine, with the exception of passages where proper attribution has been made in the text, and that it does not, to the best of my knowledge and belief, contain any material that has been published or written by someone else and has been approved for the award of any other degree.

16.10.2023

ELİF VARAN

DEDICATION

I would like to dedicate my thesis to my family, my friends, and to the people who lost their lives in the earthquakes in Turkey on February 6, 2023.

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First of all, I would like to express my respects and gratitude to my thesis advisor Assist. Prof. Dr. Şule Badıllı, who is more than just an advisor and helps me in every stage of my thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

AI	**Ankle Instability**
ATFL	**Anterior Talofibular Ligament**
BL	**Bifurcate Ligament**
CAI	**Chronic Ankle Instability**
CAIT	**Cumberland Ankle Instability Tool**
CFL	**Calcaneofibular Ligament**
CG	**Control Group**
FI	**Functional Instability**
FTCL	**Fibulo Talocalcaneal Ligament**
IAC	**International Ankle Consortium**
IER	**Inferior Extensor Retinacula**
LAS	**Lateral Ankle Sprain**
LG	**Lateral Gastrocnemius**
LTCL	**Lateral Talocalcaneal Ligament**
MG	**Medial Gastrocnemius**
MYO	**Myotonometric**
PL	**Peroneus Longus**
PTFL	**Posterior Talofibular Ligament**
ROM	**Range of Motion**
SD	**Standart Deviation**
TA	**Tibialis Anterior**

ABSTRACT

Varan, E. (2023) Evaluation Of Muscle Tone And Balance In Young Collegiate Athletes With Ankle Instability. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, MSc thesis. Istanbul

The aim of this study is to evaluate muscle tone and balance in young collegiate athletes with ankle instability. 19 (12F, 7M) volunteer athletes who enrolled as team member at Yeditepe University's Directorate of Culture and Sports between 2022-2023 were included in the study. 12 volunteer were with a CAI record (8F, 4; 21.16 ± 2.44 years) and 7 volunteer athletes were healthy (3F, 4M; 21.57 ± 2.76years). All participants will be placed in the Chronic Ankle Instability Group (CAI) after completing an assessment form that proposes about their demographic and clinical characteristics, if their Cumberland Ankle Instability Tool (CAIT) score is 24 or less, and if they receive a Foot and Ankle Ability Measure (FAAM) questionnaire score of 90% for Daily subscale and 80% for Sports subscale. Healthy participants constituted the control group (CG).

After participants were divided into groups, MyotonPRO® was used for myotonometry for assessing muscle biomechanical properties. For static and dynamic balance tests, the ProKin (TecnoBody, Dalmine, Italy) device was utilized. Myotonometry measurements targeted the superficial muscles around the ankle peroneus longus, tibialis anterior, lateral and medial gastrocnemius (PL, TA, LG and MG). Balance measurements were conducted with eyes open and closed, including both static and dynamic balance while standing on one leg. The data from the two groups were compared at the study's conclusion, and any differences were examined. Using the SPSS program, the data were statistically analyzed. Due to the limited sample size, significant differences between the biomechanical properties of muscles and balance parameters could not be observed. However, correlations were found between muscle tone and balance values.

Key Words: ankle, joint instability, chronic ankle instability, muscle tone, balance

ÖZET (Turkish)

Varan, E. (2023) Ayakbileği İnstabilitesi Olan Üniversiteli Genç Sporcularda Kas Tonusunun ve Dengenin Değerlendirilmesi. Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Bölümü, Yüksek Lisans Tezi, İstanbul.

Bu çalışmanın amacı, ayak bileği instabilitesi olan genç üniversiteli sporcuların kas tonusunu ve dengelerini değerlendirmektir. Çalışma, 2022-2023 döneminde Yeditepe Üniversitesi Kültür ve Spor Dairesi'ne takım oyuncusu olarak kayıt yaptıran 19 gönüllü sporcuyu içermiştir (12 kadın, 7 erkek). Bu sporculardan 12'si kronik ayak bileği instabilitesi öyküsüne sahiptir (8 kadın, 4 erkek; yaş ortalaması 21.16 ± 2.44) ve 7 gönüllü sporcu sağlıklıdır (4 kadın, 3 erkek; yaş ortalaması 21.57 ± 2.76). Tüm katılımcılar, demografik ve klinik özellikleri içeren bir değerlendirme formunu doldurduktan sonra, Ayak ve Ayakbileği Kullanılabilirlik Ölçütü (FAAM) anketinde günlük yaşam aktiviteleri için %90' dan az ve spor aktiviteleri için %80'den az puan alırlarsa ve Cumberland Ayak Bileği Instabilite Anketi (CAIT) puanları 24 veya daha düşükse, Kronik Ayak Bileği İnstabilitesi Grubu'na (CAI) kategorize edilmiştir. Sağlıklı katılımcılar kontrol grubunu oluşturmuştur (CG). Katılımcılar gruplara ayrıldıktan sonra, kasın biyomekanik özelliklerini değerlendirmek için MyotonPRO® (Myoton AS, Tallinn, Estonya) cihazı kullanılmıştır. Statik ve dinamik denge testleri için ise ProKin (TecnoBody, Dalmine, İtalya) cihazı kullanılmıştır. Myotonometri ölçümleri, ayak bileği çevresindeki yüzeyel kasları; peroneus longus, tibialis anterior, lateral ve medial gastrocnemius (PL, TA, LG ve MG) hedeflemiştir. Denge ölçümleri gözler açık ve kapalı durumdayken, tek bacak üzerinde durarak statik ve dinamik dengeyi için yapılmıştır. Çalışmanın sonunda, iki grup verileri karşılaştırılmış ve farklar analiz edilmiştir. Verilerin istatistiksel analizi SPSS yazılımı kullanılarak gerçekleştirilmiştir. Sınırlı örnek sayısı nedeniyle kasların biyomekanik özellikleri ve denge parametreleri arasında anlamlı farklar gözlenememiştir. Ancak kas tonu ve denge değerleri arasında korelasyonlar bulunmuştur.

Anahtar Kelimeler: ayak bileği, instabilite, kronik ayak bileği instabilitesi, kas tonusu, denge

1. INTRODUCTION AND PURPOSE

One of the most frequent sports injuries is a lateral ankle sprain (LAS), which has the potential to lead to chronic ankle instability (CAI) [1]. CAI is a phrase used to describe circumstances in which people continue to suffer symptoms of instability and a feeling of the ankle 'giving way' persisting for 1 year after the initial sprained ankle history.[2]

Inversion, internal rotation, and plantar flexion of the foot and ankle are common causes of lateral ankle sprain (LAS), which is then followed by the protective and reflexive actions of the peroneus longus (PL) and tibialis anterior (TA) muscles.[1 3]. These actions may result in eccentric strain injuries[4] , which then change the mechanical characteristics of the muscles around the ankle joint.[5] In a prior investigation, measurements were made using myotonometry, a simple, sensitive, and reliable technique for determining the mechanical characteristics of muscles. [6,7] Their findings indicated increased muscle tone and stiffness in individuals who had experienced previous LAS incidents, suggesting that myotonometry could potentially be employed to evaluate impairments in muscle function resulting from LAS in individuals engaging in physical activities.

This information, once confirmed through myotonometry in athletes diagnosed with chronic ankle instability (CAI), could help fill the existing gap in global literature on this subject. Additionally, it could have therapeutic implications, such as the possible use of myotonometry to diagnose muscle patho-mechanics and choose certain rehab and training techniques.[1]

Determining the mechanical characteristics of ankle muscles in athletes who met the criteria established by the International Ankle Consortium (IAC) was one of a main goal of this study. One of our hypothesis was that athletes diagnosed with chronic ankle instability (CAI) would show increased muscle tone and stiffness while displaying reduced elasticity in the muscles that responsible for the ankle joint.

In sports, cutting movements, particularly side cutting movements, tend to be very prevalent, especially in sports like volleyball and basketball. Injuries typically happen during actions like jumping, forward propulsion, or cutting maneuvers.[8] Following acute ankle sprains, chronic ankle instability (CAI) can develop in approximately 20%- 40% of patients when appropriate treatments with well-supported strategies like bracing and neuromuscular training are not administered.[9,10]

Additionally, since the ankle plays a significant role in posture and body movements, balance disturbances are often among the values referred to under the umbrella of functional impairment in individuals with CAI.[11,12]

We planned our study to assess the balance disturbances and changes in muscle biomechanical properties observed in individuals with CAI, similar to the findings in the mentioned studies. In this study, our aim was to assess both balance and muscle tone in individuals with CAI.

Two hypotheses identified for this study:

Hypothesis 1: Young collegiate athletes with chronic ankle instability have increased ankle muscle tone compared to those without instability, and their balance values are negatively affected.

Hypothesis 0: There is no difference in ankle muscle tone and balance values between young collegiate athletes with and without chronic ankle instability.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Anatomy and Biocmechanics of the Ankle and Foot

Foot and ankle are composed of twenty-six separate foot bones, long bones of lower limb, resulting in a total of thirty-three joints. Although often called the 'ankle joint,' foot motion involves multiple joints.[13]

There are three joints in the ankle: the sub-talar joint, the talo-crural joint, and the distal tibio-fibular joint. That components cooperate to make the back of the foot work in harmony. [14]

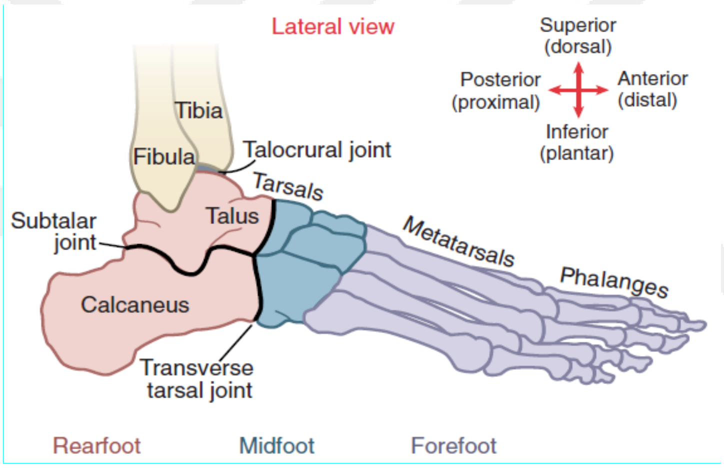

Figure 1.1 Lateral view of regions of the foot, rearfoot bones and ankle complex joints [15]

Hindfoot movements are defined as plantarflexion-dorsiflexion in the sagittal plane, inversion-eversion in the frontal plane, and internal rotation-external rotation in the transverse plane.[14] Actually, hindfoot movement does not show up separately from other joints. The other joints that make up the ankle move together to ensure smooth movement of the hind foot.[14]

Rear foot movement does not only occur in a single plane; the rear foot has its own axis of movement. Coordinated motion of this part of foot is most accurately referred to as pronation and supination. Pronation includes dorsiflexion, eversion, and external rotation in the open kinetic chain, whereas supination requires plantar flexion, inversion, and internal rotation.[14] In the closed kinetic chain, pronation involves plantar flexion, eversion, and external rotation, whereas supination entails dorsiflexion, inversion, and internal rotation. [14]

Stability of ankle joints relies on three primary factors: the alignment of the joint surfaces when under load, the passive ligament limitations, the muscles and the tendons, that is responsible for active control of the joints. All these structures provide stabilization of the ankle in daily life activities.[14]

2.1.1. Talocrural Joint Anatomy

The proximal surface of the talus, the distal extremities of the tibia and fibula, and the distal tibial joint surface make up the talocrural joint.

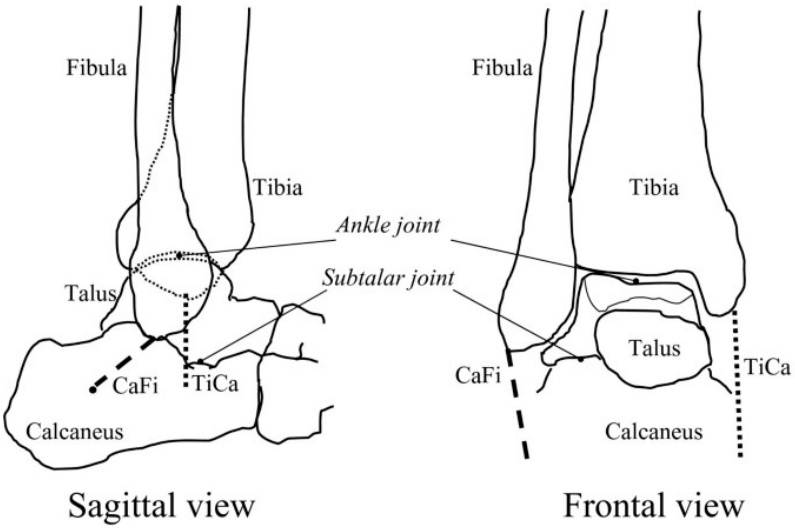

Figure 1.2 Sagittal and frontal view of ankle joint.[14]

The talocrural joint's architectural design enables the moment created in other parts of the body to be transferred towards the foot properly. In the literature, this joint is often called a mortise joint, due to its similarity in shape. [14]

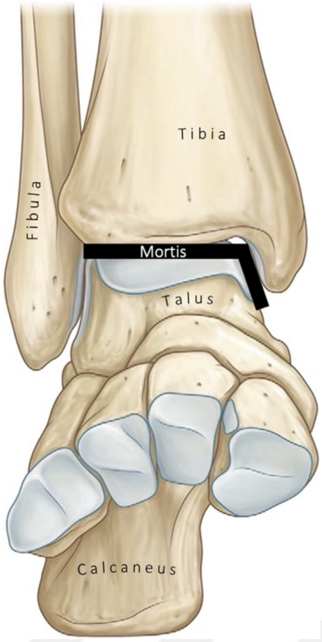

Figure 1.3 Talocrural joint has been referred to as mortise due to the congruence. [16]

The alignment of both malleoli forms the joint's axis of motion. This axis remains slightly in front of the tibial plane and slightly behind the fibular plane. Although movements of the ankle joint occur mostly in the sagittal plane, a small movement also occurs in the horizontal and coronal planes.[17]

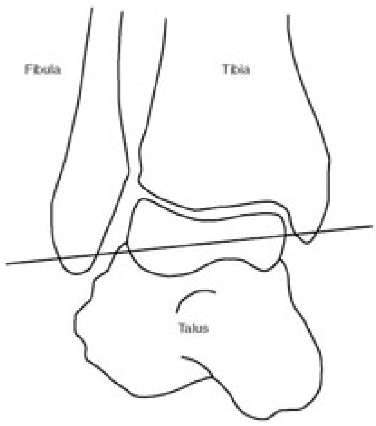

Figure 1.4 Axis of talocrural joint [14]

In a previous study, they examined the loading on the ankle, 30° of plantar flexion has occured 28° in plantar flexion, 1° in the internal rotation, and 4° in the inversion.[18] In comparison, thirty degree of dorsiflexion in the closed kinetic chain consisted of twenty-three degree in dorsiflexion, nine degree in external rotation, and two degree in eversion.[18] In closed kinetic movements, dorsiflexion occurs when the tibia slides forward. This three-plane motion system is vital in ankle stabilization (Figure 1.4).

In cases where full weight is placed on the ankle, the main structure that resists abnormal talar rotation and sliding movement is the joint surfaces.[19] Nevertheless, the importance of ligaments in talocrural stability is also crucial. Ligaments play a very important role in ankle instability. These are the anterior talo-fibular ligament (ATFL), posterior talo-fibular ligament (PTFL), calcaneo-fibular ligament (CFL), and deltoid. Within the capsule of the joint, while the deltoid ligament provides medial support, the others provide lateral support.[14]

Anterior talofibular ligament is situated on the dorsal-lateral side and extends to the lateral malleol in an anterior-medial direction, forming an angle of roughly 45° with the coronal plane. The anterior talofibular ligament usually has 24 mm long and 7 mm wide. Studies have found that ATFL restricts forward shifting and excessive rotation of the talus. During movements in sagittal plane, loads on ATFL increase. The anterior talofibular ligament exhibits lower maximum load and energy to failure values when subjected to tensile stress, in comparison to the posterior talofibular ligament (PTFL), calcaneofibular ligament (CFL), anterior inferior tibio-fibular ligament, and deltoid ligament. This could potentially account for the higher frequency of injuries observed in the ATFL among the lateral ligaments.

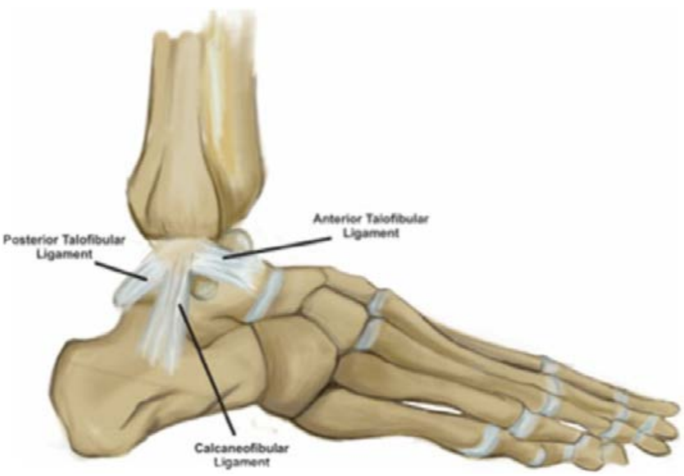

Figure 1.5 Ligamental structures of lateral ankle; PTFL, ATFL, CFL [20]

CFL originates from the lateral malleol in a posteriorly and downward route to the lateral part of the calcaneus. The CFL plays a role in limiting abnormal supination in talo-crural and talo-calcaneal joints. Studies have shown that the CFL ligament is at its tightest in the dorsiflexion position and prevents abnormal inversion and internal rotation.[14,19] At the same time, this ligament prevents abnormal inversion and internal rotation of the rearfoot when the joint is in dorsiflexion position. [21]

PTFL extends from the posterior distal part of fibula towards the posterior and lateral aspect of talar bone. This ligament has wide attachments to both the talus and fibula and has an impact on restraining inversion and internal rotation when ankle is underload.[14] Considering the ankle ligaments, this ligament has the least injury rate among them.[21]

2.1.2. Subtalar Joint Anatomy

Talus and calcaneal bone make up the subtalar joint. Just like the ankle joint, it is involved in transferring the moments occurring in the body to the foot. This joint contains two surfaces and enables pronation and supination movements. These two joint surfaces are located anterior and posterior. [14]

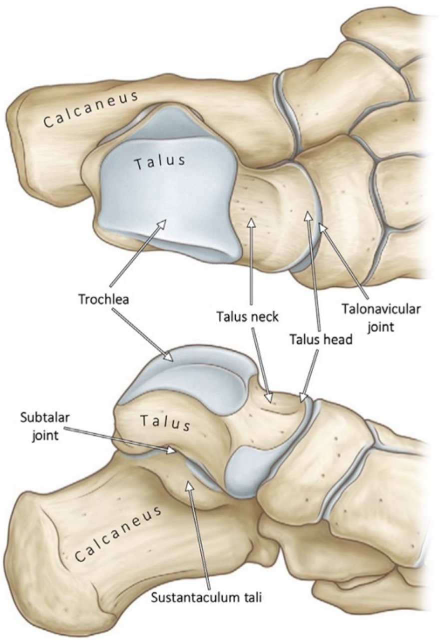

Figure 1.6 Superior and lateral image of talocalcaneal joint [16]

The forward of side talocalcaneal or talo-calcaneo-navicular joint is established through the interaction of talar head, the two surfaces, the sustentaculum tali, and proximal facet of navicula. The talus head functions as the ball in this articulation, while the anterior calcaneal and proximal navicular facets, together with the plantar calcaneonavicular ligament, make up the socket.

The facets of talocalcaneal joints are equipped with distinct ligamentous joint capsules and are divided by the sinus tarsi and canalis tarsi. The anterior joint surface is positioned more medially than the posterior, and the axis of movement is also higher.[22]

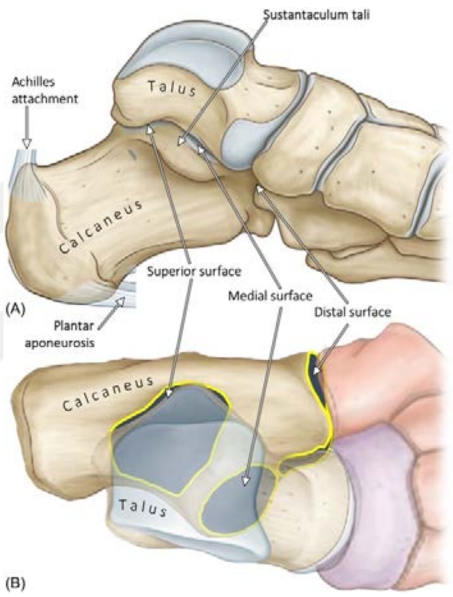

Figure 1.7 Facets of talocalcaneal joint [16]

This difference leads to an oblique axis of rotation for the talocalcaneal joint, characterized by an average upward tilt of 42° and a medial angulation of 23° in relation to the vertical axis of the feet. (Figure 1.8)

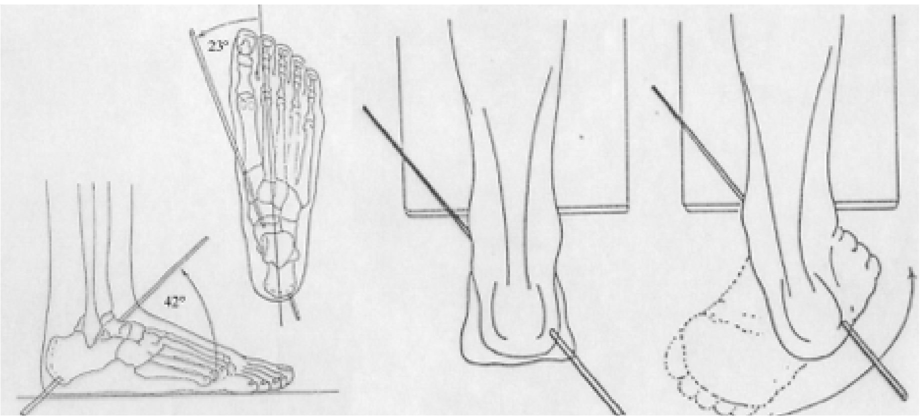

Figure 1.8 Talocalcaneal axis enables triplanar movements of foot.[14]

Ligamentous components have an crucial role for the stabilisation of talocalcaneal joint, still not fully comprehended. There are significant variations in the reports upon the nomenclature of specific ligaments and their respective functions. The lateral ligamentous components can be broadly divided into three types: interosseous ligament, peripheral cervical ligaments, and deep fibers of extensor retinaculum (Figure 1.9). [14]

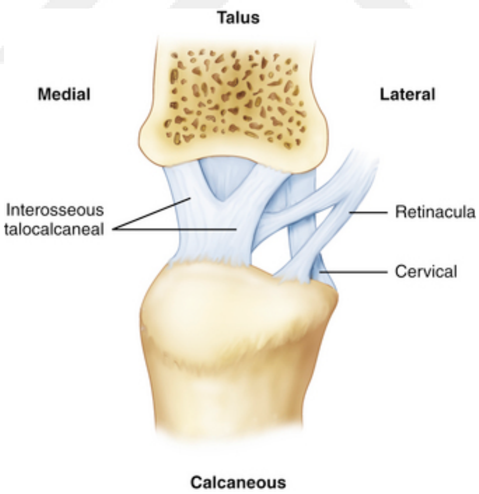

Figure 1.9 The intrinsic subtalar ligaments [14]

While deep joint ligaments provide stabilization of the talocalcaneal joint shown in the Figure 1.9, they separate the capsule as anterior and posterior. They are often named to as the "cruciate ligaments of the talocalcaneal joint" because they passing the canal tarsi in an oblique route. The cervical ligament is situated anteriorly and laterally to the interosseous ligament and runs anteriorly and medially across the calcaneus toward the talus. The two talocalcaneal surfaces are supported by this ligament, which is located inside the canalis tarsi. Studies have found that this bond is the strongest ligament in the area. It’s function is to provide resistance against supination movement.

The interosseous ligament is situated posterior to the cervical ligament and follows a medial path. It originates on the calcaneus, slightly in front of the posterior talocalcaneal capsule, and ascends in a superior and the route medially directed until it comes to talar neck. Due to the angular and diagonal alignment of the fibers forming the ligament, the interosseous ligament is in a tense position during subtalar joint movements.[14,22] This ligament is occasionally referred to as the ligament of sinus tarsi.[14]

Fibers from the inferior extensor retinacula (IER) suggested as potential contributors to the support of the lateral part of the talocalcaneal joint. Within the canalis tarsi, three origins of the IER have been identified: lateral, intermediate, and medial. Notably, it has been demonstrated that only the lateral origin of the IER significantly impacts subtalar joint stability.[22] Nonetheless, it has been proposed that injury to any of these roots can have an effect on sinus tarsi syndrome.[14]

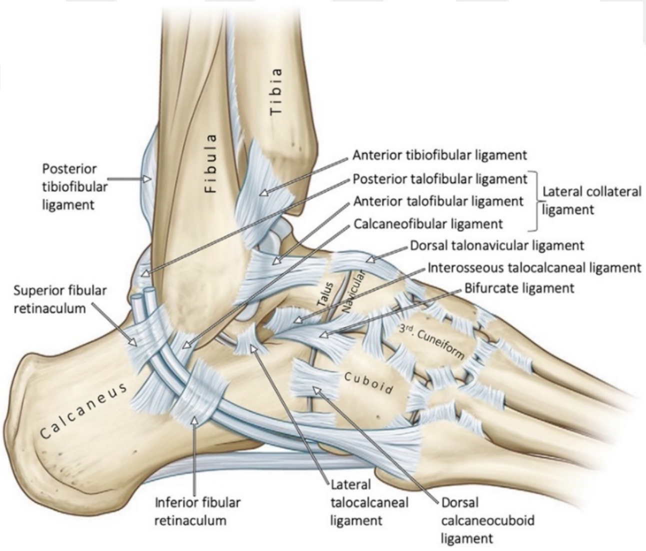

Figure 1.10 Ligamentous structures of midtarsal joints[16]

The surrounding ligamentous structures of the talocalcaneal joint includes calcaneofibular ligament (CFL), lateral talo-calcaneal (LTCL) ligament, and fibulo-talocalcaneal (FTCL) ligament. CFL plays a crucial role in limiting abnormal inversion and internal rotation for calcaneus over talus.[14]

Primarily the posterior talocalcaneal joint is covered by the LTCL ligament, which travels in the same direction and frontal to the calcaneofibular ligament (see Figure 4). Although the lateral talo-calcaneal ligament has small size and less robust compared to the CFL, it contributes to preventing excessive supination of the talocalcaneal joint.[14,22] Different configurations of the lateral talocalcaneal (LTCL) ligament have been documented, and at times, its filaments are contiguous among the ones of the calcaneofibular ligament. The fibulotalocalcaneal ligament, extends from the posterior side of the distal fibula to the posterior side of the talus and further to the posterior side of calcaneus. It is positioned distinctly behind the CFL and aids in showing resistance abnormal supination.[14]

The bifurcate ligament (BL) is another noteworthy passive stabilizer of ankle for lateral support. It has two parts that first part is the calcaneocuboid and the second part is the calcaneonavicular branch. Since BL acts to restrict abnormal supination movement, it may be affected by injury mechanisms involving this movement.[14]

2.1.3. Distal Tibio-fibular Joint Anatomy

This joint is another joint that forms the ankle. It includes a ligament structure that extends like a curtain along a vertical line among the shin bones, and a ligamentous structure that supports the anterior and posterior ankle and mortise structure with the anterior inferior fibulotibial ligament (AIFTL) and posterior inferior fibiotibial ligament (PIFTL) ligaments located on the distal side.[14]

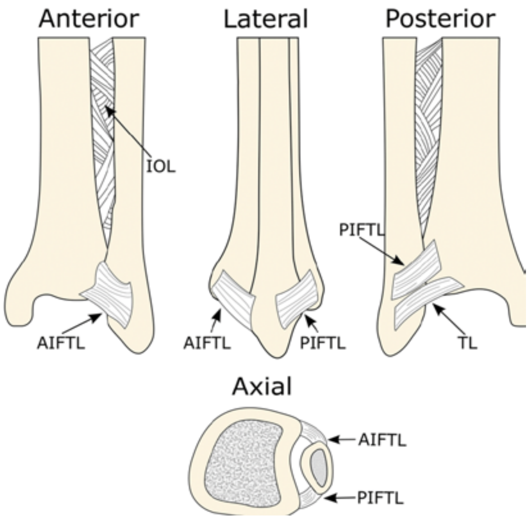

Figure 1.11 Ligamentous strtuctures of distal tibio-fibular joint (AIFTL and PIFTL) [23]

AIFTL, is injured by eversion type strains. These injuries generally named as high ankle sprains.[14]

2.1.4. Muscles and Tendons

Foot and ankle are dynamically controlled by several muscles. These units in these region are responsible for controlling the precise movements of the joints. Additionally, these muscles are responsible in creating stability, propulsion, and impact mitigation necessary for walking. The movement of this area is carried out by more than ten muscles. These muscles are investigated in four compartments (see Figure 1.12).

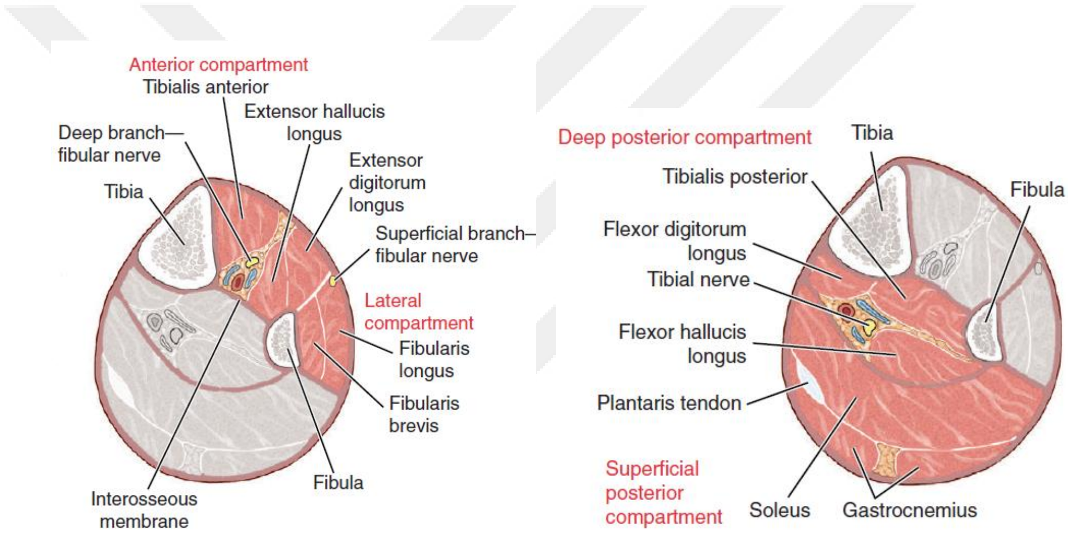

Figure 1.12 Compartments of the lower leg [15]

The tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus terteus muscles are located in the anterior compartment. The muscles peroneus longus and brevis are located in the lateral compartment. The gastrocnemius, soleus, and plantaris muscles are located in the posterior compartment. The tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles are located in the deep compartment. These muscle groups are responsible for motion on all three planes of ankle. (see Figure 1.13)[15]

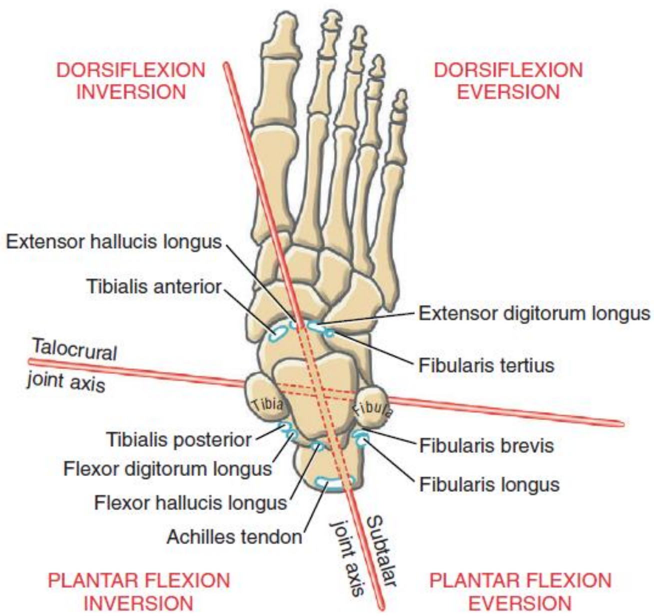

Figure 1.13 The movements of muscle groups in illustrated according to their positioning relative to the pivot points of the joints [15]

Ligaments, capsules and other joint structures provide passive stabilization of the joint. The muscle groups are in charge of the active stabilization for the ankle. They provide this stabilization effect by the accumulation of forces on the joint that they create when muscles contract. When muscles contract in isolation, they generally create concentric force. However, the eccentric properties of these muscles should be taken into account when providing stabilization during complex joint movements. In this context, the peroneal muscles of the region, have an important effect in stabilization.[24]

With the peroneal muscles, the muscle groups in the anterior compartment play a role in the dynamic stabilisation of the lateral ankle with engaging in eccentric contractions. Additionally, anterior compartment muscles over the ankle also contribute significantly to joint stabilization by producing eccentric force. Thus, these muscles provide dynamic stabilization against excessive inversion and this can be very important in ankle sprain prevention.[14]

2.1.5. Innervation

The ankle and surrounding tissues have innervations by the sacral and lumbar nerves originating from the spine. The tibial and peroneal nerves deliver motor signals to these muscles. The sural and saphenous nerves supply sensory transmission. In addition, it is known that the joint capsule and lateral ligaments have a proprioception mechanism rich in mechanoreceptors.[14]

2.1.6. Kinematics of Ankle Joint

The rotation of the hindfoot over the tibia in three axes: the anteroposterior (x), mediolateral (y), and inferosuperior (z) direction defines ankle motion. Rotations of the ankle involve dorsal flexion and plantar flexion in the Y-axis, inversion and eversion in the X-axis, rotations in the Z-axis. However, it should not be forgotten that normal ankle mobility does not occur only in a single axis. Nearly all movements occur in more than one plane. [25] There is more than one center of motion due to both the bony structure of the ankle and soft tissue restrictions.[25,26] As a result of isolated movements of the talocrural and talocalcaneal joints, plantar flexion, dorsal flexion, inversion and eversion movements happen. Due to the integrated movement of these joints, internal and external rotation movements may also occur.[25] To be detailed, inversion and internally rotation movements are in slight plantar flexion; Eversion and externally rotation movements occur during subtle dorsal flexion. These movements often occur simultaneously. [25,27] Specific angle of rotation can vary and has been reported to be between 5° to 18° in different studies.[26,28]

During plantarflexion, talus moves to the posterior and it simultaneously slides towards forward, resulting in approximately 5-6 degrees of internal rotation. Conversely, throughout dorsal flexion, talus shifts to the anterior on the tibia while sliding towards posterior, resulting in approximately 5-6 degrees of external rotation.[15,26,28] When talocrural joint is bearing the weight of the body, rotational movement on this joint around a horizontal plane without flexion is typically linked to tibial internal rotation and talar external rotation.[18,28] With this multiplanar organization, the talus exhibits a combination of rolling and gliding, involving the movements in saggital axis. The talus rotates around the anterior-posterior and transverse axes while the tibia is still, pronating during dorsal flexion and supinating during plantar flexion. Conversely, while talus stable, tibia rotates externally during plantar flexion and internal rotation during dorsal flexion. The amount of all these movements may vary depending on anatomical structure differences. [26,28]

Talocrural joint has dorsal flexion and plantar flexion movements in the horizontal axis have a total range of approximately 70 degrees. Most of this is achieved with plantar flexion. [29] This can vary, between approximately 20° to 60°. For activities like walking, it typically involves around 30° of motion. When ascending stairs, it can be approximately 37°, and when descending stairs, it can extend to around 56° of motion.[26,29] The dorsiflexion angle required for running has been stated as 10 degrees in studies while the plantar flexion need was 14°. [29] Reaction loads on the ankle during walking can reach up to 7 times the body weight. During daily activities, the ankle can be under a load of up to 4/5 of the body weight. Muscles, tendons, ligaments and joint structures play an important role in absorbing this load.[26]

The dorsal flexion and eversion of the talocalcaneal joint are the positions in which the ankle is the most firm. This is typically achieved during activities like climbing or squatting when there is maximal congruity on articular structures. On the contrary, the plantar flexion position carries a greater possibility of injury or sprains.[26]

2.2. Ankle Injuries In Sports

Ankle joint injuries, like other orthopedic injuries, affect both professional and recreational athletes. General rehabilitation principles can be applied in the treatment of these injuries. In this context, many approaches such as rest, ice applications and exercise treatments are used together. Appropriate modalities are selected according to the phase of the treatment and the athlete is given a treatment appropriate to his capacity. Timing is often a crucial factor in sports-related interventions, emphasizing the importance of early diagnosis and treatment for athletes. Various factors, both internal and external, can make athletes more susceptible to specific injuries. Various tissues in this area can be acutely injured. Ankle sprains, tendon injuries, fractures and dislocations are very common injuries. The main purpose of the treatment of these injuries is to ensure that the athlete returns to his/her former physical capacity and to minimize the risk of reoccurring these injuries.[30]

The majority of sports, particularly those that include activities like running, jumping, and kicking, tend to experience injuries primarily in the lower limbs[31] In a comprehensive assessment of injuries managed at a multidisciplinary sports facility, roughly 25% of the documented 12,681 injuries, across a spectrum of 19 distinct sports, involved the lower extremity, specifically the foot and ankle.[32,33] It is also known that approximately 30% of the time lost due to injuries in sports related to running and jumping is connected to injuries to the foot and ankle. [32,34]

Ligament injuries are quite frequent in athletes also in the general population fort the foot and ankle. After a sprain, signs of inflammation are often seen in the area. These are; redness, swelling, sensitivity to touch, pain when carrying weight, and decreased range of motion. In the treatment, preventive approaches are applied first, and later various physiotherapy approaches are applied. These include exercise, electrotherapy, kinesiotaping, and various manual therapy methods. The aim of conservative treatment is to ensure that the patient returns to his previous activity level in the healthiest way possible. However, in cases where the desired results cannot be obtained from conservative treatment, various surgical procedures can be applied.[17]

It is known that approximately 15% of athlete injuries are ankle injuries. While it can be seen very frequently, it can also be seen in many sports branches. The incidence is highest in sports such as volleyball, football, basketball or running.

The most commonly injured of ligaments is the ATFL. High ankle sprains may occur in sports where the ankle is kept immobile as a requirement of the sport. These are also called syndesmosis injuries.[31] Furthermore to the significant accompanying medical costs, the loss of sports or job time has financial repercussions.[33] Ankle injuries often respond positively to conservative treatment, but in some cases, symptoms may persist and chronic instability of the ankle may occur. This condition is called chronic ankle instability (CAI) in the literature. [35,36]

2.2.1. Lateral Ankle Sprains

Eighty percent of players who had an ankle sprain said that it happened again. After ligament injuries, neuromuscular and proprioceptive problems occur, leading to functional instability (FI). This functional instability is thought to be the main reason why sprains occur again. [37–39]

To date, various criteria for the evaluation of functional instability have been established in the literature. These are balance evaluation, body's response to perturbation, muscle reaction time, joint position sense, strength evaluation and nerve function tests.[40]

Ankle sprains are often not isolated ligament injuries. With the trauma, damage to the surrounding tissues may also occur. Muscles, tendons and nerves are some of the structures that may be affected. As a result of this interaction, negative effects may be observed on some of the body's abilities. The systems most affected by this are balance and proprioception. Neuromuscular effects are not limited to this. After such injuries, the responses of the muscles to sudden mechanism, speed of nerve transmission, muscle weakness and loss of joint range of motion may occur. [40]

2.2.1.1. Pathomechanics

Ankle sprains basically happen when the foot is forced into excessive inversion. Activities where this is frequent are jumping, walking and especially landing on one leg. The moment of first contact with the ground is very important in injury mechanics. If we examine it anatomically, generally at the moment of contact the hind foot is in internal rotation and the proximal segments are in external rotation. This creates extreme stress on the ligaments. If the impact intensity is high, injury may occur. It should not be forgotten that having the ankle in plantar flexion may also make the ankle more susceptible to sprain.[41]

When an ankle sprain occurs, the first structure affected is usually the ATFL. Studies have shown that after ATFL rupture, an increase in the mobility of other planes is also observed. This increased mobility can also put more load on other structures. The laxity that will occur in this case should not be ignored clinically. Injuries to the ligaments around the subtalar joint and the joint capsule may also occur with ankle sprains. [14]

2.2.1.2. Risk Factors

An insufficient understanding of the underlying causes of injuries may limit the capacity to establish and improve injury risk reduction initiatives. Many researchers have created a detailed injury causation model to explain how internal and extrinsic risk variables interact to cause antecedent harm. This model draws inspiration from both the biomechanical and the epidemiological model. [42–44]

An athlete is vulnerable to harm even before an injury-triggering event takes place because intrinsic and extrinsic causes for injury interact. This is what the epidemiologic model of injury seeks to capture. According to this theory, each athlete (i.e., the predisposed athlete) has an individual combination of intrinsic risk factors that raise their likelihood of becoming injured.[45]

Intrinsic risk factors are categorized into various factors including height, weight, age, gender, body mass index (BMI), muscle strength, previous injury history, anatomical alignment, aerobic capacity, dominant limb, flexibility, proprioception, and postural stability.[46]

Extrinsic factors, which are frequently seen in sports injuries, cover a broad spectrum of things. These elements include the athlete's actions and attitudes, as well as their level of talent, equipment, coaching techniques, interactions with other athletes, and the surrounding environment in which the sport is played. Evaluating extrinsic risk factors requires an understanding of the specific activities that lead to injuries (such as landing from a jump), the interactions between competing players (including contact mechanisms in team sports), and the biomechanics of the injury event (such as inversion and internal rotation of the foot and ankle). [45]

2.2.1.3. Sign and Symptoms

When an ankle "rolls" or "gives way" when doing exercises like jogging or landing awkwardly after a jump, athletes regularly report being injured. The degree of acute disability brought on by these injuries might range from mild ankle pain that doesn't interfere with sports participation to total disability that prevents weight-bearing and walking. Acute lateral ankle sprains are frequently indicated by clinical symptoms such localized ecchymosis and swelling around the lateral malleolus. Particular painful spots can reveal information about the precise ligament damage, thus they should be carefully noted during the diagnostic process. Peroneal nerve injury has been noted in the most severe cases of lateral sprainsof ankle; it often manifests as a neuropraxia that gets better over time. [17]

2.2.1.4. Assessment- Evaluation

It's crucial to check the ankle's alignment during the physical examination because chronic ankle instability (CAI) can be exacerbated by malaligned feet and a varus tibia. [47,48] The patient's hindfoot alignment is normally evaluated from the back while they are standing. The hindfoot often deviates slightly from the body's midline, or at an angle between 5 and 10 degrees of valgus. This examination helps identify any anomalies or misalignments in the hindfoot that can cause problems with the ankle. [47]

It's critical to evaluate the patient's neurovascular condition, especially when analyzing ankle injuries. Because severe inversion injuries, which are frequent in lateral ankle sprains, can induce traction damage to the superficial branch of common fibular nerve, clinicians should evaluate. The superficial fibular nerve may be subjected to more stress and excursion as a result of an ATFL injury because of the increased ankle range of motion. This strain has the potential to impair proper nerve function and impair the protective reflexes of the ankle. Consequently, it is critical to evaluate the neurovascular status, especially the condition of the superficial peroneal nerve, while evaluating ankle injuries.[49]

It's crucial to feel the lateral ankle ligaments during a physical examination of the ankle for any signs of discomfort. The ligaments' laxity, or looseness, should also be evaluated and contrasted with the unharmed other side of limb for referencing. The anterior drawer test (ADT) is one of the tests used to measure ATFL laxity. It is possible to increase the ADT's precision in determining ligament laxity by performing it with palpation and comparing the results to the unharmed contralateral ankle. This is a typical clinical examination.[50]

The calcaneofibular ligament (CFL) in the ankle is evaluated largely by the talar tilt (TT) test. Hindfoot is inverted after the foot is in dorsiflexion during this test.[14] Since individuals with CAI do not always have laxity, it is not appropriate to perform the ADT test alone, such as the talar tilt test.[51] The findings of the ADT and TT tests can vary depending on the examiner's expertise and experience, and both tests' interobserver reliability can be unpredictable.[52]

Muscle strenght test for the peroneal muscles should be evaluated for weakening. An additional test that crucial for the balance is single leg balance test, this test is benefical for detecting potential ankle sprain, especially for patients who have active lifestyle. The patient must perform this test on effected or potential leg with eyes open and eyes closed. This test is thought to be successful if the patient feels unbalanced at any point, which suggests a possible risk for future ankle sprains. [53]

Loaded ankle radiographs on both sides should be taken because they allow for easy side-by-side comparisons.[54] This is very useful when there are only minor alignment difficulties.[47]

Commonly used imaging methods in CAI are ultrasonography (US) and magnetic resonance (MRI). A previous meta-analysis comparing imaging modalities on CAI reported that US was more sensitive than MRI and other modalities for visualizing ATFL and CFL injuries.[55]

These findings show that diagnosing CAI purely based on imaging is insufficient. Nevertheless, when a patient has recurrent ankle pain while receiving conservative treatment, MRI is useful for assessing possible talar or tibial osteochondral injury.[56]

2.2.1.5. Classification

The severity of ligament injury and associated morbidity is usually described by examining the lateral ligaments of the ankle in 3 subgrading methods.[57] In grade I, which is the first and mildest stage, some fibers of the ATFL are stretched and some fibers are torn, but the ligament does not disrupt completely. Clinically, those who suffer from a grade I sprain often have slightly swollen ankle and no or slight hematoma (bruising), local tenderness at the area of ligamentous structure of distal fibula , and little or no active range of motion restriction.[58]

Some patients with grade I sprains might find it difficult to bear their entire weight, but an examination will not reveal any obvious laxity. Patients who receive the right care often suffer no severe functional loss and can resume their sport activities within 7 to 10 days.[57] A moderate injury, also called grade II describes complete torn ATFL and a partially torn CFL. The joint has a limited range of motion anterolaterally, as well as localized edema, ecchymosis, bleeding, and discomfort. On inspection, there can be minimal or no aberrant laxity. More serious functional loss affects patients with grade II injuries, such as the inability to hop or do toe rises on the affected foot. It can occasionally be difficult to tell a grade II or III injury in the acute phase due to edema and functional loss.[58]

The condition, which may include ATFL and CFL complete tears and capsular rupture, is evaluated as grade III and sometimes this condition may be accompanied by a PTFL tear. On clinical examination, the capsule, ATFL and CFL are generally tender, with widespread edema and ecchymosis at the lateral ankle and towards the heel. Although mild to serious laxity is frequently detected on ADT or TT tests, edema and muscular spasm may prevent it from being easily seen during inspection.[58]

Table 2.1. Classification of acute ankle sprain [59]

Grade	Ligament Injury	Clinical Findings
I **Mild**	A few ligament fibers in the ATFL have been ruptured and the ATFL is strained. There isn't a total disruption of the ligaments.	Slight swelling, no laxity, difficulty with full weight bearing.
II **Moderate**	A complete tornATFL, a partially torn CFL are both symptoms of moderate damage to the lateral ligamentous complex.	Anterolateral ankle edema, ecchymosis, bleeding, and discomfort in a localized area. modest or non-existent abnormal laxity.
III **Severe**	Complete rupture of the ATFL, PTFL and CFL.	On the lateralis of ankle and heel, there is swelling and ecchymosis.

2.3. Chronic Ankle Instability

According to International Ankle Consortium, CAI is a condition in which the ankle is still sprained despite having been standing for at least 1 year after the initial injury, and is accompanied by complaints such as pain, weakness, decreased functionality, limited joint movement, feeling of insecurity and recurrent feeling of collapse, which are characteristic of this condition. These listed conditions have established diagnostic standards for CAI.[1]

In the case of CAI, new reasons have been put forward over time. Consequences such as sensory-motor impairments due to resulting instability, decreased muscle strength, reduced joint range of motion, impaired balance, disturbances in proprioception, disruptions in peripheral nerve conduction, and delayed peroneal muscle reactions have been elucidated in a comprehensive study.[40] After a couple years, they unveiled an more detailed version for their model that included a Venn diagram with two crossing circles to represent potential mechanical and functional (sensorimotor) aspects that could contribute to CAI.[14] They named it CAI to address uncertainties about whether functional instability was a cause or a potential contributing factor for this condition (see Figure 2.1). In addition, in this model, instead of defining patients separately as mechanically or functionally unstable, the disorders are determined mechanically and functionally and suggested making personalized choices.[14]

According to the updated new model, laxity, restriction of movements in the joints, degenerative changes and synovial fluid changes are included under the heading of mechanical problems. Under the heading of functional problems, there are increased muscle strength, balance disorders, neuromuscular control disorders, and proprioceptive disorders. [14] The two heading of these disorders were identified, described, and studied using this model (see Figure 2.2), which also provided an illustration of the connections within and between these interrelated causes. It was suggested that customized treatments may be created to meet any insufficiencies that were clinically found in particular individuals.[14]

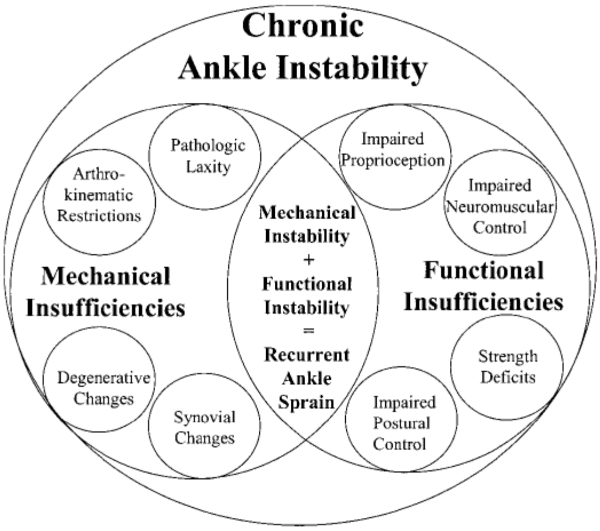

Figure 2.1 Diagram illustrating the mechanic and functional impairments for CAI.[14]

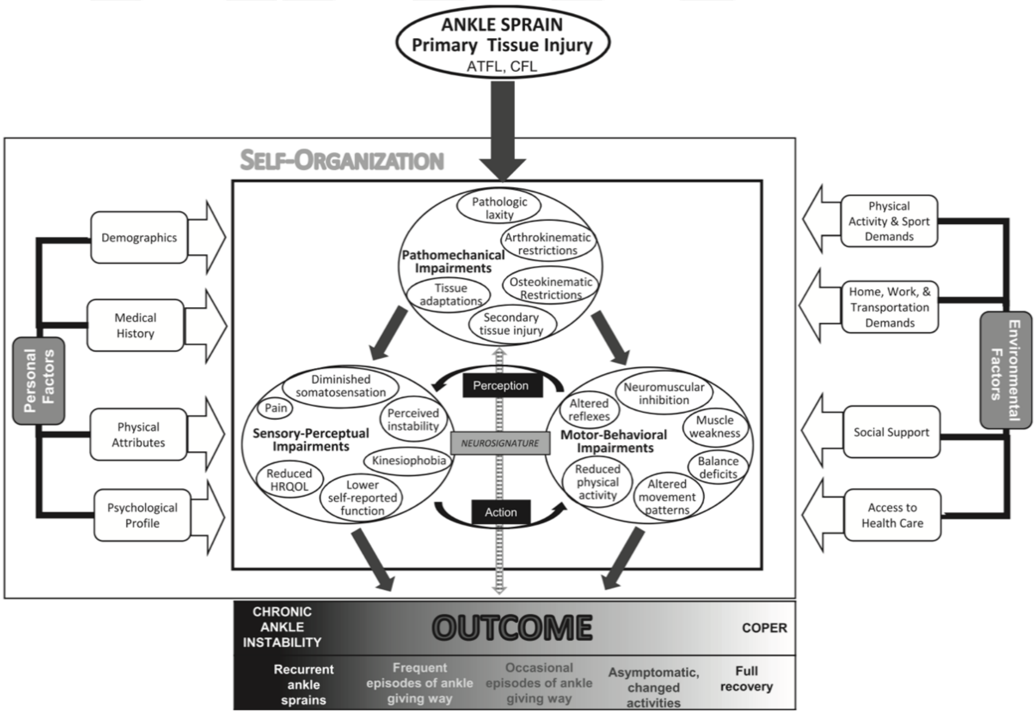

Figure 2.2 The updated model of CAI.[2]

2.3.1. Primary Tissue Injury

After ankle sprains, collagen fiber damage due to stretching and tearing in the lateral ligaments causes symptoms such as pain, edema and inflammation. In addition to the damage and inflammation in these tissues, the patient's psychological and emotional changes related to the injury can affect the person's recovery periods, and with the decrease in tissue quality efficiency, this can lead to CAI.[2]

2.3.2. Pathomechanical Impairments

Pathomechanical limitations, which result from an initial LAS, are specifically described as structural anomalies in the ankle. These anomalies have a role on emergence of CAI and play a part in ankle dysfunction. The biopsychosocial model's biological component includes these deficiencies.[2]

2.3.2.1. Pathologic Laxity

The lateral ankle ligaments' lack of structural integrity causes aberrant looseness in joints of rearfoot. In older models of CAI, this looseness was referred to as mechanical instability. According to several recent research[60,61] there is initially an increase in joint laxity following a sprain, which progressively decreases over the following few weeks and months to its pre-injury level. It's crucial to remember, nevertheless, nearly all patients who undergo a sprain are going to have some residual laxity.

2.3.2.2. Arthrokinematic Restrictions

After a LAS or in situations of CAI, some extra joint movements may become restricted. For instance, persons who suffer from lateral ankle instability frequently experience limitations in the talus' capacity to travel from the anterior to the posterior of the tibia. These restrictions may lead to a decreased ROM in the ankle dorsiflexion.[62–64] Additionally, a slight forward shift of the talus on the tibia may contribute to limits in talus glide.[65] Additionally, many patients' distal fibulas have moved anteriorly in relation to their tibias, which has limited the distal fibula's ability to travel anteriorly to posteriorly.[66,67]

2.3.2.3. Osteokinematic Restrictions

Limitations in dorsiflexion range of motion are frequently seen in patients who are recovering from LAS or CAI. Numerous factors, including the talus's limited anterior and posterior movement and the triceps surae's soft tissue constraints, might contribute to this restriction. Myofascial restrictions, neuromuscular spasms controlled by the motor-neuron system, rigidity in the musculotendinous tissues, or a combination of these factors may all contribute to these soft tissue limitations.[63] As osteoarthritis in the ankle complex develops, patients with chronic ankle instability may have limits in their range of motion in both the feet and ankles.[68,69]

2.3.2.4. Secondary Tissue Injury

The extreme inversion-internal rotation that frequently causes ankle sprains or less severe cases of the ankle giving way may cause extra injury to the anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL). The ankle complex's supplementary tissues might potentially undergo injury. Injury to the synovial membrane of the talocrural and subtalar joints, the peroneus longus and brevis tendons, the talus and tibia's osteochondral surfaces, and the ligaments of neighboring joints on the medial side of the ankle are all of special concern.[70]

2.3.2.5. Tissue Adaptations

Damaged tissues will adapt to the pressures placed on them over time and may go through changes that are hard to detect during a routine physical examination. For instance, studies have shown that, compared to healthy individuals who have never experienced a lateral ankle sprain, both CAI and non-CAI groups might experience considerable thickening of the anterior talofibular ligament (ATFL).[71]

2.3.3. Sensory-Perceptual Impairments

Conditions that a patient senses or feels in relation to their body, injuries, or self are referred to as sensory-perceptual deficits. These deficits include physiological elements like somatosensation (the biopsychosocial model's "bio" element), psychophysiological elements like pain (the biopsychosocial model's "biopsycho" element), and psychosocial elements like kinesiophobia. The latter two criteria take into account the patient's perceptions of the injury and how it has impacted their general wellbeing. Intentionally, this category consists of disabilities that impact both conscious and unconscious emotions and perceptions.[2]

2.3.3.1 Diminished Somatosensation

Chronic ankle instability patients are found to have impairments in a number of somatosensation-related domains. These deficiencies are thought to be the result of nerve loss after ligament injuries, as well as damage to ligament and joint proprioceptors after the initial injury. There has been evidence of impairment in both the active and passive perception of joint location during frontal-plane and sagittal-plane ankle motions, with CAI patients showing a greater frequency of proprioceptive errors.[72,73] The inability of persons with CAI to accurately assess the position of their ankle joint prior to their foot striking the ground while walking or landing has been suggested as a factor that increases the chance of recurring ankle sprains. This is due to the fact that during the first phase of weight bearing, the foot is more likely to make contact with the ground, which makes it more probable that the ankle will supinate as opposed to pronate.[74]

2.3.3.2 Pain

In the vast majority of chronic musculoskeletal illnesses, pain is a prominent symptom. It's interesting to note that the literature on CAI hasn't really addressed how to measure and assess pain. [10] Despite the fact that clinical experience demonstrates that persons with CAI frequently seek medical care because they are in pain. In situations of chronic pain, sensory input that is created by injury, inflammation, or damage at the exact location of symptoms is not the only cause of pain, according to the neuromatrix hypothesis of pain. Instead, it is created by the neuromatrix, a vast network of neurons that spans the whole brain. Chronic mental and physical stress can also make it harder for a patient to function in everyday life and cause them to lose interest in it.[75] Although these links are currently poorly understood, the effect of pain on other frequently seen deficits in people with CAI is likely to be of major clinical consequence.[2]

2.3.3.3. Perceived Instability

When performing daily tasks, people with CAI frequently express anxiety that their ankle feels shaky or is prone to giving way. Although excessive ankle inversion does not always occur frequently for these patients, their impression of instability is a notable and clinically relevant deficit.[76] Both the Cumberland Ankle Instability Tool (CAIT) and the Identification of Functional Ankle Instability (IdFAI) questionnaire have seen widespread usage as CAI evaluation instruments. On both survey measures, people must self-report how many and where they feel their episodes of instability have occurred.[2]

2.3.3.4. Kinesiophobia

Concerns about mobility and the chance of re-injury during functional activities have been seen in patients with chronic ankle instability (CAI). A significant barrier that has to be overcome is the worry that moving the damaged ankle can be detrimental. This worry goes opposed to the emphasis on therapeutic activities as a fundamental management approach for CAI. [2,77]

2.3.3.5. Self-Reported Function

Patients with persistent ankle instability regularly report having fewer functional skills. To assess these deficiencies, a specially designed questionnaire called the Foot and Ankle Ability Measure (FAAM) is frequently employed. The specific tasks and activities that CAI patients are capable of undertaking are revealed by self-reported function tests.[2,77]

2.3.3.6. Health-Related Quality of Life

The number of CAI patients has decreased, according to measures of health-related quality of life (HRQOL). Global or generic HRQOL tests encompass more aspects of well-being than region-specific function scores do, such as mood, vitality, and social interactions, which are less strongly tied to ankle function. [77,78]

2.3.4. Motor-Behavioral Impairments

Motor-behavioral problems include, for example, effects and changes in movement patterns, muscular contractility, and physical activities that persons with CAI choose to engage in or avoid. These deficiencies have an impact on sensorimotor function's motor component. With the exception of reduced physical activity disorder, which combines a biological component related to the physiological effects of exercise and physical activity with a psychosocial component expressing intentional behavior, all disorders in this category are a part of the biological (bio) aspect of the bio-psycho-social model.[2]

2.3.4.1. Altered Reflexes

Numerous studies have looked at how muscles react to ankle inversion perturbations in terms of timing and intensity. The most frequently used measurements include electromyographic recordings, force readings, and observations of joint motion in response to abrupt ankle inversion.[79]

Changes in somatosensation, adjustments to nerve conduction velocity, or adjustments to the brain processes of the deep tendon reflex could all explain motor response delaying seen in these investigations. Regardless of the precise physiological cause, the peroneal muscles' delayed contraction causes an electromechanical delay in their capacity to provide eversion force, which is required to counterbalance the ankle's quick inversion.[79]

2.3.4.2. Neuromuscular Inhibition

In those with persistently unstable ankles, arthrogenic muscle inhibition—the term for the decreased muscle activity linked to joint pathology—has been widely reported. It is common to explore this phenomena by particularly looking at the H-reflex reaction of the peroneus longus. The monosynaptic stretch reflex is represented by the H-reflex, which was created artificially. It sheds light on spinal motor control. In these research, motor nerves are electrically stimulated through the skin of participants, and surface electromyography is used to assess the H-reflex activity that results on the muscle under investigation.[2,80]

2.3.4.3. Muscle Weakness

Performing manual muscle tests to gauge strength is the mainstay of the clinical assessment of muscular function in CAI patients. A study [81] comparing the muscle strength of CAI patients with healthy ones using a hand dynamometer found that there was no significant difference in dorsiflexion strength between the two groups, but decreased muscle strength in eversion inversion and plantar flexion.

Additionally, isokinetic dynamometry has been extensively used to study ankle strength in CAI patients. Consistent meta-analyses have revealed concentric eversion strength deficiencies in CAI patients. Additionally, eccentric strength in eversion, inversion, plantar flexion, and dorsiflexion, as well as concentric inversion and plantar flexion strength deficiencies, have all been noted.[2]

2.3.4.4. Balance Deficits

Initial research found a link between ankle instability and balance difficulties.[2] Numerous researches have identified postural control or balance deficiencies in CAI patients during the ensuing decades. Maintaining a firm one-legged stance while performing balance tasks that measure static balance are the most often reported tasks in the literature. [82]Dynamic balancing is another typical exercise where participants must balance on one leg while extending their reach in a predetermined direction. Patients with CAI may exhibit balance issues due to motor function issues, somatosensory perception issues, or a mix of both.[2]

The standard method for assessing static balance is to have a person complete trials with their eyes open and then closed. Numerous techniques that fall under the categories of low, medium, and high technology can be used to evaluate static equilibrium.[2]

One of the high-tech common balance regime procedures measures three-dimensional forces and oscillations, details about the rates of coming together in one leg on a plate.[82] Despite the fact that a variety of force plate measurements have been used in CAI research, the consistent conclusion is that patients with CAI consistently show balance issues. These measurements frequently evaluate variables including the intensity, speed, or variability of postural sway.[2]

2.3.4.5. Altered Movement Patterns

Compared to control participants, different compensatory mechanisms were observed in those with CAI during maneuvers such as walking, jumping, running or changing direction, and these have been regulated and performed many times by biomechanical evaluation methods.[2]

People with CAI frequently exhibit particular biomechanical characteristics when walking. Some of characteristics include a tendency to show more plantar flexion and inversion of the foot in respect to the tibia, a center of pressure that deviates more to the side of the foot during the stance phase, and peroneal muscle activation patterns that differ noticeably from one another.[83] The biomechanical changes that occur while jogging and running usually match those that occur during walking in people with CAI.. According to conflicting data, these modifications may include decreased peroneus longus activation in some investigations and enhanced peroneal activation in others. Additionally, patients with CAI have been seen to have greater gluteus maximus muscle activation prior to initial ground contact.[2]

2.3.4.6. Reduced Physical Activity

More scientific study is required to determine the long-term repercussions of a person with CAI refraining from physical activity owing to the unsettling sensation in the ankle. Additionally, it's feasible that these people will choose various forms of exercise that won't worsen their health or lead to instability.[2]

2.3.5. Personal Factors

Depending on their individual traits, patients may react to traumas in different ways. The International Classification of Functioning model refers to these traits as personal variables. In the new model created for CAI[2] conditions such as an individual's health history, physical and mental state, and demographic information can affect the patient's response to injury or the situation he is in. It's important to keep in mind, too, that other individual circumstances could also have an impact on how a patient responds to an injury.

Age, body mass index (BMI), and gender are among demographic variables that can have a substantial biological impact on how an injury heals and other physiological features. How a patient reacts to a new injury or a recurring one can be influenced by their medical history, which includes the existence of comorbidities, structural problems brought on by prior injuries, and their history of healing from earlier medical conditions and accidents. Physical characteristics may also influence how a person reacts to and recovers from an injury. Last but not least, a person's psychological makeup, which consists of characteristics like self-efficacy and anxiety, is very important for how they react to an injury.[2]

2.3.5. Environmental Factors

Environmental factors are those things that are not part of the patient's own organism but can affect how they react to injury in the International Classification of Functioning model. These variables cover a range of elements related to a person's environment and situation. The individual's perceptions of societal expectations about physical exercise and sports involvement, as well as expectations about their roles in activities connected to the home, family, work, and transportation, are examples of environmental influences. The availability of social support networks, such as close friends and family who can offer help and comfort, is also essential for how a person reacts to and recovers from an injury.[2]

The type and frequency of healthcare that a patient receives can also be significantly impacted by their access to healthcare professionals and facilities. This accessibility to quality medical care can have a significant impact on the treatment and recovery from illnesses and accidents.[2]

2.4. Treatment and Prevention

The majority of medical professionals advise non-surgical care for lateral ankle sprains, with physical therapy and activity restriction being the usual first steps.[84] Conservative treatment is the initial option for medical care of sprains. In nonoperative way, a personalized rehabilitation program for at least three months is essential since it meets each patient's specific exercise needs. [84,85]

The functional and preventative components of the CAI rehabilitation approach are both included.[84] With a focus on proprioceptive development, peroneal strengthening, and athletic-definitive training, the patient performs a range of strengthening exercises.[84,85]

All exercises and activities must be pain- and symptom-free during the first functional phase, and they must incorporate weight-bearing and multidirectional motions. Again, multidirectional motions and training for strenght of the ankle periarticular muscles are stressed during the preventative phase. Exercises involving plantar flexion also inversion should receive special attention, with the joint's tension being gradually increased to fulfill the necessary demands. It's vital to remember that no amount of tape or bracing can guarantee that no other injuries won't occur, even though ankle taping or bracing may play a part in the preventive recovery phase. [84]

Early mobilization combined with external assistance, such as bracing, is a component of functional management. It also includes some time spent resting, applying ice, compressing, and elevating (RICE). After initial care, the treatment program should proceed with a method that includes muscle strengthening, increasing joint movement, improving proprioceptive sense and functional training. Proprioceptive exercises involves a series of progressive workouts employing apparatus like wobble boards and trampolines for regaining postural and balance management. External supports aid in the rehabilitation process by providing proprioceptive feedback in addition to mechanical stability. [86]

Lower extremity musculoskeletal injuries can be avoided and pain and dysfunction can be treated more quickly using injury prevention techniques that emphasize musculoskeletal strengthening, balance, proprioception, and improved biomechanics, especially in certain groups.[87]

MATERIAL AND METHOD

3.1. Subjects

The sample of the study consists of athletes with chronic ankle instability (CAI) at least 6 months and in team sports including either basketball, volleyball or handball at Yeditepe University. Using the GPower software the sample size for the study was found to be 22 for each group.

The study included 19 athlete ;12 (8F,4M) athletes with self reported CAI and 7 (3F, 4M) healthy athletes. The inclusion of the control group in our study served to mitigate potential biases. The athletes with self reported chronic ankle instability who met inclusion criteria are involved in instability group (CAI) and the healthy athletes with no CAI involved in control group (CG). In our study, the control group (CG) was included to remove bias.

3.1.1. Inclusion criteria

The experimental groups were chosen from among sportsmen which filled the precise inclusion requirements defined by the IAC for chronic ankle instability.

- Significant record of LAS at least 1 year before participation in the study,
- Age between 18-30,
- Participating in one of the team sports such as basketball, volleyball, or handball,
- Experiencing ≥ 2 ankle sprains in the last 6 months and
- The CAIT score was 24 or lower,
- Scoring less than 90% in daily life activities and less than 80% in sports activities for FAAM questionnaire.

3.1.2. Exclusion Criteria

These criterias set by the International Ankle Consortium for Chronic Ankle Instability (CAI).

- Include any lower extremity fractures or surgeries for the last 4 months or record of musculoskeletal injuries or vestibular disorders.

The study's objectives and approach were explained to the athletes and each of them willingly agreed to participate in the study and provided written informed permission in (Appendix 1). The Medipol University Ethical Committee accepted the study protocol on May 25, 2023, with issue number E-10840098-772.02-3263 (Appendix 2).

3.1.3. Flow of Research

Our study included university sports team athletes aged between 18 and 30. The participants will be given an explanation of the study's goals and methodology. Athletes, after filling out an assessment form that includes demographic and clinical characteristics, will be categorized into the Chronic Ankle Instability Group (CAI) if they score <90% for daily subscale and <80% for sports subscale on the FAAM questionnaire, if their CAIT is 24 or lower. Participants who score higher than these thresholds will be included in the Control Group (CG). After including 12 CAI athlete CAI who met the criterias for including and 7 healthy athlete's ankle we conducted our measurements.

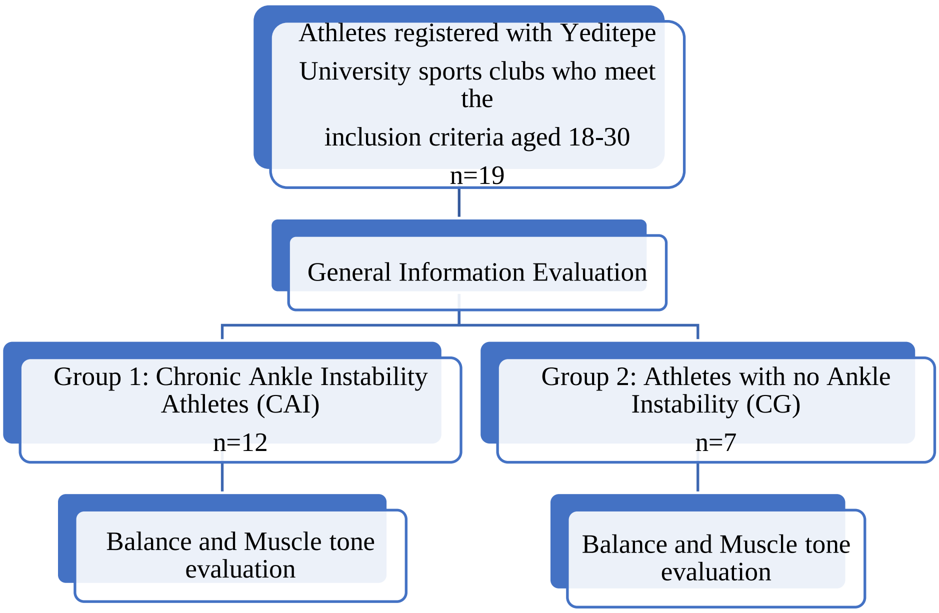

Figure 3.1 Flowchart Diagram

3.2. Study Protocol

The study commenced with 19 participants. Initially, after obtaining informed consent forms, participants were asked to complete demographic information forms. Athletes were then asked to fill out CAIT and FAAM questionnaires to assess their instabilities. Measurements were taken for all participants with using the MyotonPro and Prokin PK 252 devices, respectively. To minimize the impact of fatigue and physiological changes on balance measurements, MyotonPro measurements were taken first.

3.2.1. Patient's Demographics Form

Researchers used a standardized questionnaire to perform in-person interviews. The participants' demographic information, exercise routines, smoking habits, usage of medications, and presence of chronic conditions were all addressed by this questionnaire. Specifically, the questionnaire gathered information on age, gender, weight, height and BMI to assess the participants' demographic conditions (Appendix 3).

3.2.2. Cumberland Ankle Instability Tool (CAIT)

This tool is a valid and effective questionnaire for determining the degree of functional instability, consists of a 30-point scale with nine components. In clinical practice, CAIT demonstrates to be a benefical and suitable instrument for determining the degree of functionally restrictions, monitoring progress over time, and evaluating treatment outcomes. In research settings, CAIT helps identify, objectively define, and compare subject groups that are more homogenous.

Particularly, people who have a CAIT rate 25 or higher are less likely to show unstable ankle functions, whereas people who have a rate lower than 25 are more likely to do so. Researchers and clinicians can both benefit from CAIT as a useful tool for recognizing and treating ankle instability.[89] (Appendix 4).

Ankle instability group includes those with rate lesser than 25.

3.2.3. Foot and Ankle Ability Measurement (FAAM)

The Turkish version of the tool was used to evaluate the physical capabilities of sportsmen. The FAAM is a self-identified tool designed to evaluate a person's physical capabilities if they have foot and ankle issues. It comprises of a 29-item questionnaire with an 8-item sports subscale and a 21-item for daily life subgroup questions. The other subscale is pertinent for athletes because it explicitly evaluates one's capacity to engage in sports-related activities. Respondents rate each item's difficulty on a 5-degree scale, with zero being the easiest, four being the most difficult. For the ADL subscale, the highest possible rate is eighty four, and for the sports, it is thirty two.

Higher rate indicate more activity for both subscales. Percentage scores are used to compute total scores. On a scale from 0% (unable to do everyday and athletic performance) to 100%, participants also rated their degree of function. The Turkish version of the FAAM has been proven to be valid and trustworthy with high intraclass correlation values.[90] (Appendix 5)

All participants, following the completion of an assessment form encompassing demographic and clinical characteristics, will be classified into the Chronic Ankle Instability Group (CAI) if they obtain scores lower than 90% for daily life activities and lower than 80% for sports activities on FAAM.

3.2.4. Evaluation of Muscle Tone

Myotonometry involves the measurement of mechanical properties in soft tissues using portable, handheld myotonometers. Myotonometers enable quick stiffness assessments, typically in a little time like 4-5 seconds with the probe. These myotonometers are capable of measuring the stiffness of any palpable alive tissue, provided it is in a static condition, either actively and isometrically contracted or passively relaxed.

Myotonometers' unique capacity to assess muscular or tendon stiffness raises the possibility that they might be useful therapeutic instruments in a variety of situations.[91]

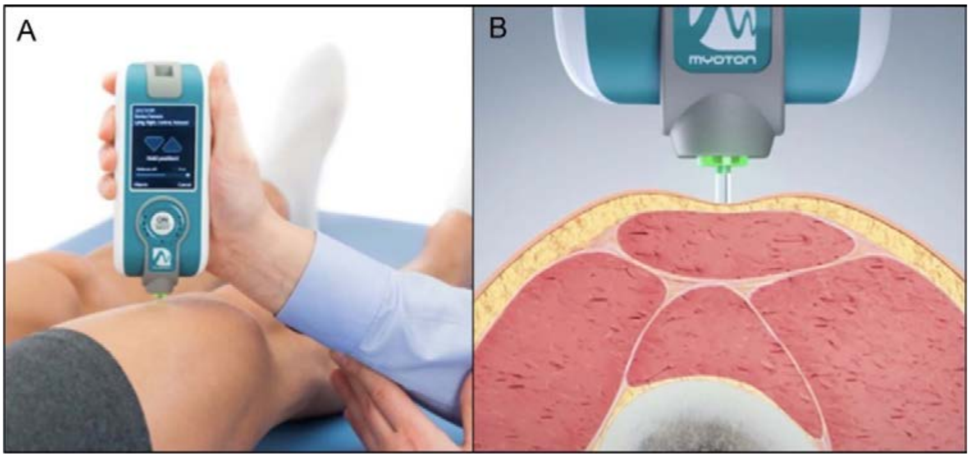

Figure 3.2 The operator positions the probe on the muscle (A), and then goes in with an indicated a green light on the device (B).[91]

Myoton Pro measurements are performed as follows:

- Placement: The user puts the device on a muscle
- Calibration: A green light on the gadget indicates that the user has lowered the object into the measuring range.
- Impulse: A fast and minimal force is started by the gadget.
- Response: Device's accelerometer detects the tissue's damped oscillation in response to the stimulus.
- Analysis: The apparatus computes the viscoelastic, biomechanical, and tone characteristics concurrently.[91]

In this study, MyotonPro (Figure 3.3) was used for myotonometric (MYO) measurements. According to the cited paper, these MYO measurements were carried out with a MyotonPRO® instrument on muscular bellies of the PL, TA, LG, and MG muscles.[5]

Figure 3.3 The myotonPRO device and measurement results on the screen

Figure 3.4 The operator positions the probe on the muscle belly of medial gastrocnemius

Figure 3.5 The operator positions the probe on the muscle belly of lateral gastrocnemius

Specifically, measurements for the PL and TA muscles were taken with the subject lying in a supine lying, while measurements for the LG and MG muscles were taken with the subject in a prone lying. (Figure 3.4)

The following MYO parameters, as described by referred article[92] were analyzed: frequency (F-value), stiffness (S-value), decrement (D-value), relaxation time (R-value), and creep (C-value).

F-value- Frequency- (Hz): It shows the muscular tonus at rest or in a stable state. The tonus or tension level is directly proportional to the obtained value.

S-value- Stiffness - (N/m): It symbolizes a muscle's resistance to contraction or an outside stimulus (one that alters the basic form). A higher obtained result denotes stiffness that is greater.

D-value- Decrement -: By displaying the logarithmic decline in the muscle's natural rebound, it exemplifies the suppleness of the muscle. The capacity of the muscle to resume its original shape following a contraction or the removal of an external stimulus is referred to as elasticity, which is a biomechanical characteristic of the muscle. Greater logarithmic decline indicates less elasticity and more evenly distributed mechanical energy.

R-value- Relaxation Time (ms): It is described as the amount of time needed for a muscle to regain its form (heal) following a voluntary contraction or the release of an external force. The quicker the muscle can fully restore its shape after experiencing maximal deformation, the lower this number is.

C-value- (Creep): Creep is the progressive lengthening of a muscle caused by prolonged continuous tension. The ratio of the R-value to the amount of time needed for an external force to generate the greatest deformation is known as the Deborah number (creep). When the gap between relaxation and deformation time is less, the value of the creep parameter, C, is larger. When muscles are younger and healthier, the C parameter has a lower value.

3.2.5. Dinamic and Static Balance

The Prokin device was utilized for assessing static and dynamic balance through the "Static Stability Assessment Program" and the "Equilibrium Management Test Program". Prokin PK 252, a proprioceptive-stabilometric assessment device, is a proprioceptive system used for evaluating and training static and dynamic balance. (Figure 3.5) It offers precise and detailed data through its stabilometry platform. Stabilometry enables the assessment of participants in a static position with the oscillation of the Center of Pressure (CoP). The Prokin PK 252 device's platform detects the CoP sways of the participants, and the postural control data are transmitted to the computer screen.

Figure 3.6 Pro- Kin PK252 system (TecnoBody, Dalmine, Italy)[93]

The data obtained from the PK 252 system for static balance are as follows [93]:

• Average CoP X (mm)

• Average CoP Y (mm)

• Average Forward-Backward Velocity (mm/sec)

• Average Medial-Lateral Velocity (mm/sec)

• Perimeter (the total distance covered by the COP [mm])

• Ellipse area (the total area circumscribed by the COP [mm2])

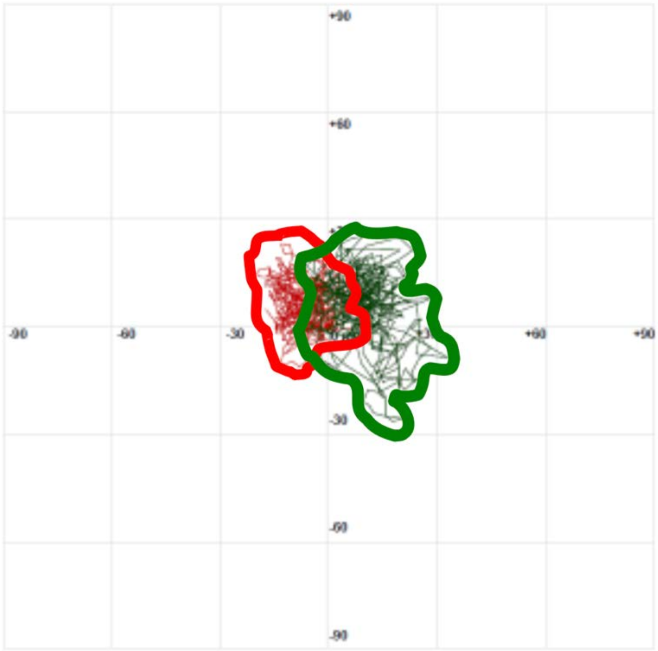

Figure 3.7 Center of Pressure (COP) Line: Perimeter (mm), Ellipse (mm2)[93]

The data obtained from the PK 252 system for dynamic balance are as follows [93]:

• Total Stability Index

• AP axis Stability Index

• ML axis Stability Index

• Total standard deviation

• AP standard deviation

• ML standard deviation

A single-legged balance test was conducted for static and dynamic conditions for assesing the balance.[11]

Unipedal static and dynamic balance assessments were conducted with 2 different type: eyes open - eyes closed. To prevent fatigue, all tests were performed once for 30 seconds, and dynamic tests were carried out at a moderate difficulty level (level 20).

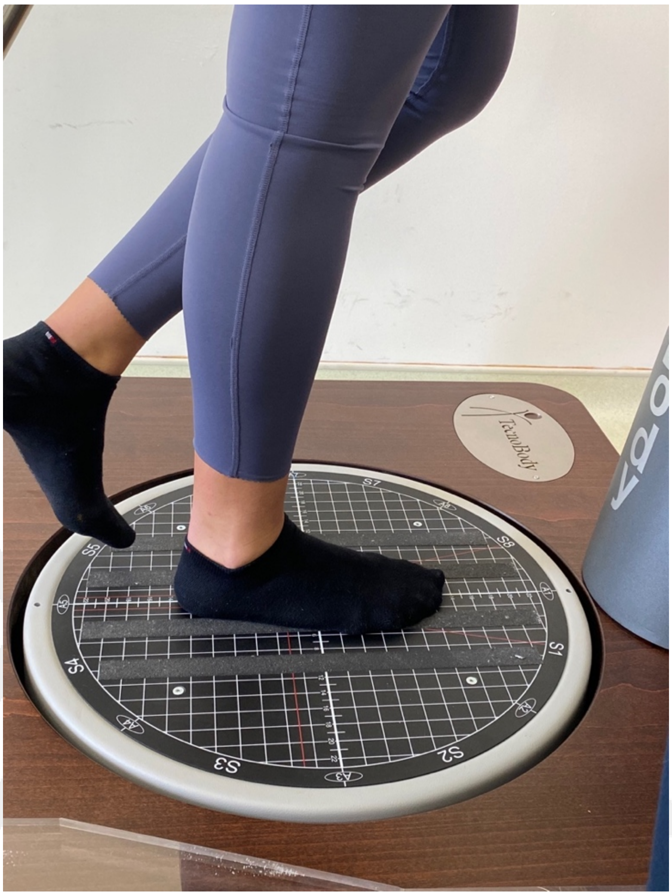

Figure 3.8 Single leg static balance test on Pro-Kin platform

The assessment was conducted following the steps below:

• The athletes instructed to show a balance on plate without shoes and align themselves with reference points after being given a brief explanation of the evaluation.

• Participants were positioned facing the screen with their arms at their pelvis.

• Participants were registered on the computer connected to the Prokin device.

• During the assessment, athletes were told to hold their stance and keep their heads facing straight ahead in a neutral position for 30 seconds.

• Assessments were conducted with both eyes open and eyes closed.

• Participants who struggled due to a lack of understanding were informed that they could retake the test if they wished, and those who wanted to were retested.

• Between each assessment, participants were asked to sit down and rest while the device was recalibrated.

• The assessment results were documented by capturing a photograph of the Prokin screen with a phone camera and then categorized.

Figure 3.9 Single-leg static balance test on the Pro-Kin platform with eyes open

For static balance tests, the ellipse area, which determines the area of the Center of Pressure (CoP) path, and the Perimeter, which assesses the sway in the CoP path, were used as key parameters and the Total Stability Index (TSI) value was used for dynamic balance tests like in a referenced articles. [94,95]

3.2.6. Statistical Analysis

Tables were created and data from the study was analyzed using SPSS (Statistical Package for Social Sciences) version 29.0.1.0. We utilized statistics like mean, standard deviation, and median to show continuous data (also known as quantitative variables). The frequency and percentage values were used to portray categorical variables (qualitative variables). The Shapiro-Wilk test and graphical approaches were used to determine if quantitative variables were suitable for a normal distribution. The Mann-Whitney U test was used to assess nonparametric variables. For all statistical tests, a p-value of 0.05 was utilized as the level of significance. To investigate connections between MYO parameters and parameters linked to balance, the Pearson's correlation coefficient (r) and the Spearman's rank correlation coefficient () were used, where applicable.

4. RESULTS

4.1. Descriptive Characteristics of Participants

Athletes having a history of CAI (n=19, 12F, 7M) who were enrolled as team members at Yeditepe University among 2022 and 2023 were included in the research. When they entered the research, the athletes kept up their active participation in sporting events and training regimens.

Table 4.1 lists the average BMI (body mass index) values for the CAI and CG along with their mean age, weight, and height. The findings revealed no age, weight, height, or BMI variations between the two groups that were statistically significant.

Table 4. 1. Participants' Physical Characteristics

	CAI Mean ± SD	**CG Mean ± SD**	**p**
Age (year)	21.16 ± 2.44	21.57 ± 2.76	0.74
Weight (kg)	70.00 ± 14.67	67.71 ± 11.19	0.78
Height (m)	1.76 ± 0.1	1.75 ± 0.08	0.72
BMI (kg/cm*cm)	22.24 ± 2.7	21.95 ±2.20	0.81

Data expressed as mean ± standard deviation. CAI, Chronic ankle instability group; CG, Control group, BMI, Body mass index.

Table 4.2 lists the research groups' genders and dominant foot. The statistical analysis of these values revealed that there was no statistically significant difference between the groups. The FAAM and CAIT scores for the groups are shown in Table 4.3. When the values of the CAIT and FAAM scores were compared, there was a significant difference between the groups.

Table 4.2. Gender, Dominant Foot and Confluence of Dominant Side and the Effected Side Between the Study Groups

		CAI %(n)	CG %(n)
Gender	**Female**	66.7 (8)	42.9 (3)
	Male	33.3 (4)	57.1 (4)
Dominant Foot	**Right**	100 (12)	42.9 (3)
	Left	0	57.1 (4)
Dominant Side- Effected Side Confluence		75 (9)	100 (7)

Data expressed as %(n). CAI, Chronic ankle instability group; CG, Control group

Table 4.3. Comparison of CAIT Score and FAAM Scores with Subscales among the Study Groups

	CAI Mean ± SD	CG Mean ± SD	p	Z
CAIT Score	14.66 ± 5.65	30. 00 ± 0	**<0.001*** **	**-3.649**
FAAM-D (%)	81.23 ± 6.43	84.3 ± 36.82	**<0.01** **	**-2.541**
FAAM-S (%)	70.15 ± 8.08	94.97 ± 5.1	**<0.001** **	

Data expressed as mean ± standard deviation. CAI, Chronic ankle instability group; CG, Control group, CAIT, Cumberland Ankle Instability Tool; FAAM-D, Foot and Ankle Ability Measure Daily Living Subscale; FAAM-S, Foot and Ankle Ability Measure Sports Subscale; The Mann Whitney- U test is used for not normally distributed data, *, **, *** - the levels of statistical significance: * - P ≤ 0.05, ** - P ≤ 0.01, *** - P ≤ 0.001.

Table 4.4. Comparison of Ellipse and Perimeter Scores with Eyes Open and Eyes Closed Conditions among the Study Groups

	CAI Mean ± SD	CG Mean ± SD	p	Z
Ellipse EO (mm^2)	665.25 ±335.07	551.14 ±222.65	0.554	-0.592
Ellipse EC (mm^2)	3444.25 ± 1865	2596.57 ± 794.96	0.499	-0.676
Perimeter EO (mm)	1024.83 ± 212.01	943. 71 ± 102.80	0.612	-0.507
Perimeter EC (mm)	2502.92 ± 669.398	4951.00 ± 6930.41	0.933	-0.85

Data expressed as mean ± standard deviation. CAI, Chronic ankle instability group; CG, Control group; EO, Eyes open; EC. The Mann Whitney- U test is used for not normally distributed data.

The statistical analysis revealed no discernible difference in the static balance measures of the various groups (Table 4.4).

Table 4.5. Comparison of Total Stability Index Scores with Eyes Open and Eyes Closed Conditions among the Study Groups

	CAI Mean ± SD	CG Mean ± SD	P
TSI EO (°)	1.02 ± 0.42	0.99 ±0.48	0.887
TSI EC (°)	2.94 ± 1.26	2.45 ± 0.80	0.374

Data expressed as mean ± standard deviation. CAI, Chronic ankle instability group; CG, Control group; TSI, Total Stability Index; EO, Eyes open; EC, Eyes closed

The statistical analysis revealed no discernible difference between the groups' dynamic balance data (Table 4.5).

Table 4.6. Comparison of Oscillation Frequency Scores for Relevant Muscles between the Study Groups

	F: Frequency- Oscillation Frequency (Hz)		
	CAI Mean ± SD	**CG Mean ± SD**	**p**
TA	19.93 ± 3.21	21.41 ±2.27	0.301
PL	18.03 ± 2.82	20.48 ± 3.96	0.134
MG	15.86 ±1.67	17.34 ± 1.71	0.084
LG	16.40 ± 2.56	17.74 ± 1.52	0.229

Data expressed as mean ± standard deviation. CAI, Chronic ankle instability group; CG, Control group; TA, Tibialis Anterior muscle; PL, Peroneus Longus muscle; MG, Medial Gastrocnemius muscle; LG, Lateral Gastrocnemius muscle

Table 4.7. Comparison of Dynamic Stiffness Scores for Relevant Muscles between the Study Groups

	S: Stiffness- Dynamic Stiffness (N/m)			
	CAI Mean ± SD	**CG Mean ± SD**	**p**	**Z**
TA	447.00 ± 84.91	506.00 ± 126.74	0.272	**-1.099**
PL	385.50 ± 96.812	477.57 ± 151.80	0.123	
MG	**280.53 ± 35.62**	**316.14 ±28.43**	**0.038***	
LG	289.08 ± 63.48	335.28 ± 31.07	0.093	

Data expressed as mean ± standard deviation. CAI, Chronic ankle instability group; CG, Control group; TA, Tibialis Anterior muscle; PL, Peroneus Longus muscle; MG, Medial Gastrocnemius muscle; LG, Lateral Gastrocnemius muscle. The Mann Whitney- U test is used for not normally distributed.

The statistical analysis results revealed that there were no significant differences in the oscillation frequency scores of muscles among the study groups (Table 4.6). Additionally, when comparing the study groups for dynamic stiffness of muscles, it was determined that no statistically significant differences existed (Table 4.7).

Table 4.8. Comparison of Decrement- Logarithmic Decay of Natural Oscillation for Relevant Muscles between the Study Groups

	D: Decrement- Logarithmic Decay of Natural Oscillation (n.u.)		
	CAI Mean ± SD	**CG Mean ± SD**	**p**
TA	0.90 ±0.16	0.84 ± 0.13	0.454
PL	0.91 ± 0.22	0.77 ± 0.13	0.144
MG	0.96 ± 0.13	0.94 ± 0.11	0.724
LG	0.87 ± 0.1	0.96 ± 0.16	0.143

Data expressed as mean ± standard deviation. n.u.: no units; CAI, Chronic ankle instability group; CG, Control group; TA, Tibialis Anterior muscle; PL, Peroneus Longus muscle; MG, Medial Gastrocnemius muscle; LG, Lateral Gastrocnemius muscle.

As a result of the statistical analysis, no significant difference was found for the decrement- logarithmic decay of natural oscillation scores of muscles between the study groups (Table 4.8).

After conducting the statistical analysis, it was observed that there was no statistically significant difference in the mechanical stress relaxation time scores of the TA and PL muscles between the groups under investigation. However, the results showed that when compared to the Control Group (CG), the Chronic Ankle Instability group (CAI) had a lower mean mechanical stress relaxation time score for the Medial Gastrocnemius (MG) muscle, but a higher mean score for the Lateral Gastrocnemius (LG) muscle (Table 4.9).

Table 4.9. Comparison of Mechanical Stress Relaxation Time for Relevant Muscles between the Study Groups

	R: Mechanical Stress Relaxation Time (ms)		
	CAI Mean ± SD	**CG Mean ± SD**	**p**
TA	12.08 ± 2.33	10.74 ± 2.32	0.244
PL	13.60 ± 3.14	11.41 ± 3.07	0.159
MG	**18.22 ± 2.17**	**16.04 ± 1.20**	**0.027***
LG	**18.06 ± 2.85**	**15.12 ± 1.38**	**0.022***

Data expressed as mean ± standard deviation. CAI, Chronic ankle instability group; CG, Control group; TA, Tibialis Anterior muscle; PL, Peroneus Longus muscle; MG, Medial Gastrocnemius muscle; LG, Lateral Gastrocnemius muscle. *, **, *** - the levels of statistical significance: * - P ≤ 0.05, ** - P ≤ 0.01, *** - P ≤ 0.001.

Table 4.10. Comparison of Deborah Number for Relevant Muscles between the Study Groups

	C: Deborah Number (Creep) (n.u.)			
	CAI Mean ± SD	**CG Mean ± SD**	**p**	**z**
TA	0.75 ± 0.13	0.68 ± 0.13	0.261	
PL	0.82 ± 0.16	9.48 ± 23.15	0.800	-0.254
MG	**1.10 ± 0.12**	**0.98 ± 0.06**	**0.032***	
LG	**1.09 ± 0.14**	**0.92 ± 0.07**	**0.013***	

Data expressed as mean ± standard deviation. n.u.: no units; CAI, Chronic ankle instability group; CG, Control group; TA, Tibialis Anterior muscle; PL, Peroneus Longus muscle; MG, Medial Gastrocnemius muscle; LG, Lateral Gastrocnemius muscle. The Mann Whitney- U test is used for not normally distributed data, *, **, *** - the levels of statistical significance: * - P ≤ 0.05, ** - P ≤ 0.01, *** - P ≤ 0.001.

Following the completion of the statistical analysis, it was evident that there was no statistically significant disparity in the deborah number scores of the TA and PL muscles among the groups being studied. Nevertheless, the findings indicated that in comparison to the CG, the CAI group showed a high mean score for deborah number scores in both the MG muscle and LG muscle (as shown in Table 4.10).

Significant correlation was found in the control group for the ellipse score with the F-value in the TA and PL muscles with eyes closed. In the CG, a positive correlation was found significantly between the S-value and the ellipse score in the peroneus longus muscle with eyes closed, and a negative correlation was found significantly with the R-value. In CAI groups, a significant positive correlation was found for the S-values in the perimeter scores of the medial gastrocnemius muscle with eyes open and closed, while significant negative correlations were observed for the R- and C- values. For the control group, in the lateral gastrocnemius muscle, significant negative correlations were found for the S- and D-values in the perimeter score with eyes closed, and significant positive correlations were found for the R- and C- values (Table 4.11).

In terms of the total stability index, a significant correlation was found for the F-value in the peroneus longus muscle with eyes closed in both groups. However, for the S-value, a significant correlation was observed only in the CAI group. With eyes open, a significant correlation was found only for the D-value in the peroneus longus muscle. With eyes closed, a significant correlation was found for the F-value in the MG muscle. With eyes open, in the LG muscle, significant correlations were found in the S- and D-values, while significant negative correlations were found in the R- and C- values (Table 4.12).

Table 4.11. Correlation of Myotonometric Parameters of Ankle Periarticular Muscles with Ellipse and Perimeter Scores with Eyes Open and Eyes Closed Conditions in Athletes with CAI and CO group

	Ellipse EO (mm²)		Ellipse EC (mm²)		Perimeter EO (mm)		Perimeter EC (mm)	
	CAI	CG	CAI	CG	CAI	CG	CAI	CG
	r (P-value)	r (P-value)	r (P-value)	r (P-value)	r (P-value)	r (P-value)	r (P-value)	r (P-value)
F-TA [Hz]	-0.159 (0.62)	0.386 (0.392)	-0.414 (0.18)	**0.868* (0.011)**	-0.154 (0.63)	0.214 (0.645)	-0.118 (0.72)	-0.207 (0.656)
S-TA [N/m]	-0.19 (0.55)	0.12 (0.798)	-0.396 (0.20)	0.737 (0.059)	-0.206 (0.52)	-0.257 (0.578)	-0.168 (0.60)	-0.011 (0.982)
D-TA [n.u.]	0.094 (0.77)	-0.73 (0.063)	0.223 (0.49)	0.103 (0.826)	-0.161 (0.62)	-0.623 (0.135)	-0.089 (0.78)	0.181 (0.697)
R-TA [ms]	0.151 (0.64)	-0.217 (0.64)	0.43 (0.16)	-0.726 (0.065)	0.144 (0.66)	0.071 (0.88)	0.12 (0.71)	-0.066 (0.888)
C-TA [n.u.]	0.139 (0.67)	-0.233 (0.615)	0.42 (0.17)	-0.722 (0.067)	0.123 (0.70)	0.078 (0.868)	0.1 (0.76)	-0.057 (0.904)
F-PL [Hz]	0.379 (0.22)	0.635 (0.125)	-0.197 (0.54)	**0.771* (0.042)**	0.261 (0.41)	0.333 (0.466)	0.06 (0.85)	-0.457 (0.302)
S-PL [N/m]	0.322 (0.31)	0.736 (0.059)	-0.268 (0.40)	**0.858* (0.014)**	0.056 (0.86)	0.195 (0.675)	-0.069 (0.83)	-0.463 (0.295)
D-PL [n.u.]	0.326 (0.30)	-0.552 (0.199)	0.036 (0.91)	-0.562 (0.189)	-0.27 (0.40)	-0.548 (0.203)	-0.188 (0.56)	0.175 (0.707)
R-PL [ms]	-0.316 (0.32)	-0.513 (0.239)	0.304 (0.34)	**-0.931** (0.002)**	-0.063 (0.85)	-0.115 (0.806)	0.167 (0.60)	0.482 (0.274)
C-PL [n.u.]	-0.333 (0.29)	-0.381 (0.399)	0.276 (0.39)	0.226 (0.627)	-0.066 (0.84)	-0.06 (0.899)	0.159 (0.62)	-0.188 (0.686)
F-MG [Hz]	0.426 (0.17)	-0.075 (0.873)	0.063 (0.85)	0.496 (0.257)	0.52 (0.08)	0.074 (0.875)	0.414 (0.18)	-0.404 (0.368)
S-MG [N/m]	0.442 (0.15)	-0.089 (0.85)	0.324 (0.30)	0.595 (0.158)	**0.667* (0.02)**	-0.181 (0.697)	**0.598* (0.04)**	-0.416 (0.354)
D-MG [n.u.]	0.273 (0.39)	0.438 (0.326)	0.326 (0.30)	0.583 (0.169)	0.281 (0.38)	0.522 (0.23)	0.106 (0.74)	-0.255 (0.582)
R-MG [ms]	-0.414 (0.18)	0.119 (0.799)	-0.322 (0.31)	-0.662 (0.105)	**-0.621* (0.03)**	0.306 (0.504)	**-0.588* (0.04)**	0.57 (0.182)
C-MG [n.u.]	-0.419 (0.18)	0.177 (0.705)	-0.357 (0.25)	-0.658 (0.108)	**-0.616* (0.03)**	0.437 (0.327)	**-0.600* (0.04)**	0.613 (0.143)
F-LG [Hz]	0.468 (0.13)	0.052 (0.911)	0.136 (0.67)	0.031 (0.947)	0.55 (0.06)	0.39 (0.388)	0.437 (0.16)	-0.318 (0.486)
S-LG [N/m]	0.433 (0.16)	0.396 (0.379)	0.126 (0.70)	0.305 (0.506)	0.552 (0.06)	-0.027 (0.955)	0.405 (0.19)	**-0.799* (0.031)**
D-LG [n.u.]	0.082 (0.80)	0.244 (0.598)	-0.317 (0.32)	0.328 (0.473)	0.279 (0.38)	0.462 (0.296)	-0.119 (0.71)	**-0.253 (0.584)**
R-LG [ms]	-0.378 (0.23)	-0.299 (0.515)	-0.096 (0.77)	-0.362 (0.424)	-0.525 (0.08)	0.118 (0.801)	-0.354 (0.26)	**0.837* (0.019)**
C-LG [n.u.]	-0.421 (0.17)	-0.253 (0.585)	-0.155 (0.63)	-0.308 (0.502)	-0.563 (0.06)	0.157 (0.737)	-0.399 (0.20)	**0.835* (0.019)**

EO, eyes open; EC, eyes closed; CAI, Chronic Ankle Instability group; CG, control group; F-, myotonometric frequency, S-, myotonometric stiffness, D-, myotonometric decrement; R-, myotonometric relaxation time and C-, myotonometric creep; TA, tibialis anterior; PL, peroneus longus; MG, medial gastrocnemius; LG, lateral gastrocnemius,; n.u.: no units; r - Pearson correlation coefficient value; *, **, *** - the levels of statistical significance of correlation: * - $P \leq 0.05$, ** - $P \leq 0.01$, *** - $P \leq 0.001$.

Table 4.12. Correlation of Myotonometric Parameters of Ankle Periarticular Muscles with Total Stability Index with Eyes Open and Eyes Closed Conditions in Athletes with CAI and CO group

	TSI EO		TSI EC	
	CAI	CG	CAI	CG
	r (P-value)	r (P-value)	r (P-value)	r (P-value)
F-TA [Hz]	0.04 0.90	0.31 0.499	0.259 0.42	0.608 0.147
S-TA [N/m]	-0.078 0.81	-0.178 0.702	0.233 0.47	0.169 0.718
D-TA [n.u.]	0.071 0.83	-0.712 0.073	-0.056 0.86	-0.275 0.55
R-TA [ms]	0.003 0.99	0.162 0.728	-0.311 0.33	-0.239 0.606
C-TA [n.u.]	-0.008 0.98	0.16 0.732	-0.332 0.29	-0.245 0.597
F-PL [Hz]	0.395 0.20	0.603 0.152	**0.673* 0.02**	**0.776* 0.04**
S-PL [N/m]	0.241 0.45	0.498 0.256	**0.659* 0.02**	0.735 0.06
D-PL [n.u.]	0.108 0.74	**-0.782* 0.038**	0.276 0.39	-0.44 0.324
R-PL [ms]	-0.156 0.63	-0.499 0.254	-0.535 0.07	-0.731 0.062
C-PL [n.u.]	-0.156 0.63	-0.206 0.658	-0.537 0.07	0.582 0.171
F-MG [Hz]	0.484 0.11	0.231 0.618	0.469 0.12	**0.792* 0.034**
S-MG [N/m]	0.508 0.09	0.155 0.741	0.384 0.22	0.689 0.087
D-MG [n.u.]	0.348 0.27	0.616 0.141	0.112 0.73	0.688 0.088
R-MG [ms]	-0.395 0.20	-0.257 0.577	-0.356 0.26	-0.713 0.072
C-MG [n.u.]	-0.354 0.26	-0.218 0.639	-0.341 0.28	-0.667 0.102
F-LG [Hz]	0.358 0.25	0.499 0.254	0.551 0.06	0.466 0.292
S-LG [N/m]	0.378 0.23	**0.877** 0.01**	0.526 0.08	0.576 0.176
D-LG [n.u.]	0.292 0.36	**0.874* 0.01**	0.364 0.24	0.349 0.443
R-LG [ms]	-0.298 0.35	**-0.855* 0.014**	-0.452 0.14	-0.598 0.156
C-LG [n.u.]	-0.279 0.38	**-0.828* 0.021**	-0.443 0.15	-0.575 0.177

TSI, total stability index; EO, eyes open; EC, eyes closed; CAI, Chronic Ankle Instability group; CG, control group; F-, myotonometric frequency, S-, myotonometric stiffness, D-, myotonometric decrement; R-, myotonometric relaxation time and C-, myotonometric creep; TA, tibialis anterior; PL, peroneus longus; MG, medial gastrocnemius; LG, lateral gastrocnemius,; n.u.: no units; r - Pearson correlation coefficient value; *, **, *** - the levels of statistical significance of correlation: * - $P \leq 0.05$, ** - $P \leq 0.01$, *** - $P \leq 0.001$

5. DISCUSSION

The aim of this study was to investigate the effects of chronic ankle sprains on the balance of the affected limb side and on muscle tone of the periarticular muscles around the affected ankle in young university athletes.

According to findings from a previous study, athletes with chronic ankle instability had considerably greater ratings for F-value and S-value for the PL and TA muscles and lower ratings for R-value and C-value. An earlier research found that those with a record of lateral ankle sprains had mechanical deficiencies in the muscles around the ankle joint, mostly on the lateral side, specifically in terms of F-value, S-value, and R-value.[5,88]Consequently, structural changes within these muscles that resulted in changes in their mechanical properties in athletes with CAI were the most likely causes of inter-group discrepancies in the myotonometric parameters of periarticular muscles (F-, S-, R-, and C-).[88]

According to a prior study, excessive pressure on sarcomeres can cause disturbances in the extracellular or intracellular membranes, which may allow structural proteins to be hydrolyzed and ultimately result in common myofibrillar disruption.[96] This effect appears to be particularly noticeable in the PL muscle, which exhibits a significantly reduced cross-sectional area in individuals following lateral ankle sprains.[97] The consensus statement [98], claims that after a muscle injury, the fascial tissue stiffens and loses flexibility due to mechanisms for the development of scar tissue, subsequent muscle repair and regeneration processes, specifically after recurred eccentric injuries of strain, such as repeated lateral ankle sprains in CAI.[99,100]

The S-value measures the resistance of muscle to outside forces that cause it to deviate from its initial structure, whereas the F-value describes the intrinsic tension of the muscle.[6] Consequently, higher levels of these two indices are linked to stiffness or tension in the muscles. R-value is an indirect indicator of "elasticity efficiency" since it evaluates the amount of time needed for a muscle to recover to its resting condition following deformation. A deformation time is the length of time required for the testing probe of a myotonometer to fully enter tissue under a constant stress. In contrast, C-value is a ratio of R-value divided by this time.[101] Deformation time therefore serves as an indirect indicator of a muscle's "resistance efficiency," which is higher in stiff muscles.

Reduced elasticity and higher stiffness result from structural changes brought on by LAS in the PL and TA muscles, which shorten the relaxation time (R-value) and reduce deformations distance (because of to stiffer muscles' greater resistance to the force applied by the examination probe). The capacity of medical practitioners and sports trainers to evaluate the effects of rehabilitative and training treatments can be improved with the use of the useful diagnostic tool known as myotonometry. [88]

The parameters of F-value, S-value and D-value for the PL and TA muscle were not significantly different across groups in the myotonometry tests we carried out to evaluate the biomechanical and elastic characteristics of the muscle. We found signifant differences on R-value and C-value for MG and LG muscles between groups and S-value only for MG muscle between groups. In terms of relaxation time and creep, significant differences were observed only in the MG muscle group for stiffness. When evaluating relaxation time and the angle of creep, it was observed that the muscles in the CAI group were negatively affected in both MG and LG muscles. However, when assessed in terms of stiffness, the MG muscle in the CAI group was observed to be less stiff.

The observed positive correlation between the tone increase and stiffness of the PL muscle and perimeter values indicates that in muscles with greater stiffness, balance is less stable. The gastrocnemius muscle's S-value, D-value, R-value time and C-value parameters revealed significant variations in CG groups when considering Perimeter and TSI paramaeters. The significant negative correlation found in the S-values of the gastrocnemius muscle in the healthy group may emphasize its importance as an anti-gravity muscle for maintaining balance. A previous study conducted on healthy individuals also found significant correlations, similar to the results presented here, between postural sway and the F-value, S-value, D-value, and R-value in the gastrocnemius muscle.[102]

A preceding study indicated a noteworthy decrease in impaired unilateral postural control on the affected side. [11] Static and dynamic balance results in individuals who have experienced ankle sprains and reported chronic ankle instability have been significantly affected in previous research.[87]

The literature extensively describes the abnormalities in postural sway and balance. [103] Moreover, it was recently shown that patients may manage mechanical limitations by functional modifications such preliminary neuro-muscular activity.[72,104,105]

In our study, the lack of an adequate number of participants and unequal group sizes resulted in the inability to find the expected significant differences in static balance and dynamic balance measurements in addition to myotonometry measurements. Previous investigations have found alterations in muscle tone in those with chronic ankle instability.[88]

Subsequent research should aim to investigate whether varying degrees of Chronic Ankle Instability (CAI) exhibit distinct levels of the functional impairments documented in this study and whether myotonometry measurements can reveal differences for assessment and treatment in the context of CAI.

6. CONCLUSION

Findings of this study did not reveal increased muscle tone and stiffness along with decreased elasticity in the periarticular ankle muscles of athletes with chronic ankle instability.

Due to the limitations in our study, our results in CAI did not align with the existing literature. Previous studies support each other, but further research in this area would contribute to the literature on CAI treatment and assessment.

More research may be needed to understand the effects of chronic ankle instability on balance and muscle tone.

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8. APPENDICES

8.1. Appendix 1 Informed Consent Form

Araştırmanın Adı: Ayak Bileği İnstabilitesi Olan Üniversiteli Genç Sporcularda Kas Tonusu ve Dengenin Değerlendirilmesi

Bilgilendirilmiş Gönüllü Olur Formu

Bu çalışma Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü tarafından yürütülen "**Ayak bileği instabilitesi olan üniversiteli genç sporcularda kas tonusu ve dengenin değerlendirilmesi**" başlıklı araştırma kapsamında planlanmıştır. Bu çalışma ayak bileği instabilitesi olan atletlerin kas tonusu ve denge bakımından sağlıklı bireylerle karşılaştırılmasını amaçlayan bir araştırmadır. Çalışmaya katılmayı kabul eden gönüllü bireyler, bilgi formunu doldurarak kriterleri karşılamaları durumunda çalışmaya dahil edileceklerdir. 4 ay sürmesi planlanan çalışma için gönüllü olacak 44 bireye ihtiyaç vardır.

Değerlendirme ve ölçümler için toplam veri toplama süresi her birey ortalama 30 dakika olacaktır. Bireyler tek bir görüşme ile değerlendirilecek, ilk olarak ayak bileği burkulmalarıyla ilgili anketi dolduracaklardır ve daha sonra ölçümleri yapılacaktır. Ölçümler için alt bacak kasları üzerinde ufak bir titreşim veren kas gerilimi ölçüm aleti ve hareketli platformu üzerinde dengede kalmaya çalışacağınız bir denge ölçüm aleti kullanılacaktır. Bu kapsamda elde edilen veriler sadece bu çalışma için kullanılacak ve korunacaklardır.

Bu araştırma dahilinde sizden herhangi bir ücret talep edilmeyecektir. Araştırmada yer almanız nedeniyle bir ödeme yapılmayacaktır. Katılımınıza dair ulaşım vs masraflar her bireyin kişisel imkanlarıyla gerçekleştirilecektir. Kişisel bilgileriniz herhangi bir aracı kurumla veya üçüncü kişilerle paylaşılmayacaktır, araştırma sonuçları yayınlansa bile kimlik bilgileriniz gizli kalacaktır.

Bu araştırma kapsamında uygulanacak cihazlarla vücudunuzda herhangi bir ağrı ve acı hissetmeyeceksiniz, bu çalışma vücudunuza zarar vermeyecektir. İstediğiniz zaman çalışma dışına çıkma hakkınız olduğunu bilmenizi isteriz.

Katılımınız için teşekkür ederiz.

Sorumlu araştırmacı: Dr. Öğr. Üyesi Sule Badıllı Hantal
Yardımcı araştırmacı: Fzt. Elif Varan-

"**Ayak bileği instabilitesi olan üniversiteli genç sporcularda kas tonusu ve dengenin değerlendirilmesi**" isimli çalışmada katılımcıya/gönüllüye verilmesi gereken bilgileri okudum ve katılım istenen çalışmanın kapsamını ve amacını gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. Çalışma yazılı ve sözlü açıklama ile adı belirtilen araştırmacı tarafından yapıldı. Bu çalışmayı istediğim zaman bırakabileceğimi ve bıraktığım taktirde herhangi bir olumsuzlukla karşılaşmayacağımı anladım.

Bu koşullarda söz konusu araştırmaya kendi isteğim ile, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum. Bu çalışma sonuçlarının kullanılmasını kısıtlamamayı, yayın, rapor ve benzeri bilimsel dokümanlarda kullanılmasını kabul ediyorum.

Gönüllünün	Araştırmacının	Tanık olan kişinin
Adı Soyadı: İmzası: Tarih: Adresi: Telefon:	Adı Soyadı: İmzası: Tarih: Adresi: Telefon:	Adı Soyadı: İmzası: Tarih: Adresi: Telefon:

8.2. Appendix 2 Ethical Committee Approval

T.C.
İSTANBUL MEDİPOL ÜNİVERSİTESİ
Girişimsel Olmayan Klinik Araştırmalar Etik Kurulu Başkanlığı

Sayı : E-10840098-772.02-3263 25/05/2023

Konu: Etik Kurulu Kararı

Sayın Elif Varan ALTUN

Üniversitemiz Girişimsel Olmayan Klinik Araştırmalar Etik Kuruluna yapmış olduğunuz "Ayakbileği İnstabilitesi Olan Üniversiteli Genç Sporcularda Kas Tonusunun ve Dengenin Değerlendirilmesi" isimli başvurunuz etik kurulu toplantımızda değerlendirilerek uygun görülmüş olup Etik Kurulu kararı ekte sunulmuştur.

Bilgilerinize rica ederim.

Dr. Öğr. Üyesi Mahmut TOKAÇ
Girişimsel Olmayan Klinik Araştırmalar
Etik Kurulu Başkanı

Ek
-Karar Formu (2 sayfa)

Medipol Üniversitesi Kavacık Yerleşkesi (Ana Yerleşke Rektörlük)
Kavacık Mah. Ekinciler Cad. No: 19, Kavacık Kavşağı, 34810 Beykoz,İstanbul
T: 444 85 44 F: 0212 531 75 55
E-Posta: bilgi@medipol.edu.tr İnternet Adresi: www.medipol.edu.tr
Kep Adresi: medipoluniversitesi@hs03.kep.tr

Ayrıntılı Bilgi İçin: Esra KAN
Tel: 5461 E-Posta: etik.kurul@medipol.edu.tr

8.3. Appendix 3 Questionnaire for the Demographic Information of the Patient

KİŞİSEL BİLGİ FORMU

DEMOGRAFİK BİLGİLER

TARİH: ..../...../...........

AD-SOYAD:

DOĞUM TARİHİ:

CİNSİYET:

BOY: DOMİNANT AYAK: SAĞ ( )

KİLO: SOL ( )

EĞİTİM DURUMU:

İLETİŞİM BİLGİLERİ:

TELEFON:

E-MAİL:

GENEL BİLGİLER

1. Kaç yıldır bu sporu yapmaktasınız?

Amatör ______ Profesyonel ______

2. Yapmakta olduğunuz spor dalında hangi mevkide oynuyorsunuz?

____

3. Ayak bileğinizi burktunuz ise bunu en çok hangi pozisyonda yaşadınız?

____

4. Bir haftada ortalama kaç antrenman yapıyorsunuz?

____

5. Yapmış olduğunuz antrenmanın ortalama süresi nedir?

____

Herhangi kronik bir rahatsızlığınız var mı?	Evet (belirtiniz)	Hayır
Herhangi bir ilaç kullanıyor musunuz?		
Herhangi bir psikolojik rahatsızlığınız var mı?		
Sigara kullanıyor musunuz?		
Alkol kullanıyor musunuz?		
Son 3 ayda bir sakatlanma geçirdiniz mi?		
Herhangi bir ameliyat geçirdiniz mi? Bir haftada ortalama kaç maç yapıyorsunuz?		

8.4. Appendix 4 CAIT- Cumberland Ankle Instability Tool

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

8.5. Appendix 5 FAAM- Foot and Ankle Ability Measurement

AYAK VE AYAK BİLEĞİ KULLANILABİLİRLİK ÖLÇÜSÜ

Lütfen her soruya geçtiğimiz haftaki durumunuzu en iyi tanımlayan durumu işaretleyiniz. Eğer soruda sorulan aktiviteyi ayak ve ya ayak bileği dışındaki başka bir neden kısıtlıyorsa uygulanamaz olarak işaretleyiniz.

	Hiç zor değil	Hafif zor	Orta derece zor	Aşırı zor	Yapamıyo-rum	Uygulana-maz
Ayakta durmak	☐	☐	☐	☐	☐	☐
Düz zeminde yürümek	☐	☐	☐	☐	☐	☐
Düz zeminde ayakkabısız yürümek	☐	☐	☐	☐	☐	☐
Yokuş yukarı çıkmak	☐	☐	☐	☐	☐	☐
Yokuş aşağı inmek	☐	☐	☐	☐	☐	☐
Merdiven çıkmak	☐	☐	☐	☐	☐	☐
Merdiven inmek	☐	☐	☐	☐	☐	☐
Düz olmayan zeminde yürümek	☐	☐	☐	☐	☐	☐
Kaldırımdan inip- kaldırıma çıkmak	☐	☐	☐	☐	☐	☐
Çömelme	☐	☐	☐	☐	☐	☐
Ayak parmakları üzerinde durmak	☐	☐	☐	☐	☐	☐
Yürümeye başlamak	☐	☐	☐	☐	☐	☐
5 dakika ya da daha az yürümek	☐	☐	☐	☐	☐	☐
10 dakika kadar yürüme	☐	☐	☐	☐	☐	☐
15 dakika ve ya daha uzun yürümek	☐	☐	☐	☐	☐	☐

Ayak veya ayak bileği ağrısı yüzünde aşağıdakileri yaparken ne kadar zorluk çekiyorsunuz?

	Hiç zor değil	Hafif zor	Orta derece zor	Aşırı zor	Yapamıyo-rum	Uygulana-maz
Ev işleri	☐	☐	☐	☐	☐	☐
Günlük yaşam aktiviteler	☐	☐	☐	☐	☐	☐
Kişisel bakim	☐	☐	☐	☐	☐	☐
Hafif-orta düzeyde işler (ayakta durmak, yürümek)	☐	☐	☐	☐	☐	☐
Ağır işler (itme/çekme, tırmanma, taşıma)	☐	☐	☐	☐	☐	☐
Rekrasyonel (eğlence ve sosyal) aktiviteler	☐	☐	☐	☐	☐	☐

Eğer ayak ve ya ayak bileği problemi yaşamadan önceki durumunuza 100 puan verseniz, hiç ayak ve ya ayak bileği hareketi yapamamaya da 0 verseniz, şu anki durumuza 100 üzerinden kaç puan verirsiniz?

...%100

Ayak ve ayak bileği problemi yüzünden aşağıdaki aktiviteleri yaparken ne kadar zorluk çekiyorsunuz?

	Hiç zor değil	Hafif zor	Orta derece zor	Aşırı zor	Yapamıyo-rum	Uygulana-maz
Koşmak	☐	☐	☐	☐	☐	☐
Zıplamak	☐	☐	☐	☐	☐	☐
Atlama	☐	☐	☐	☐	☐	☐
Harekete aniden başlayıp durabilme	☐	☐	☐	☐	☐	☐
Makaslama ve yana doğrultulu hareketleri	☐	☐	☐	☐	☐	☐
Düşük seviyeli aktiviteler	☐	☐	☐	☐	☐	☐
Normal tekniğinizle aktiviteleri yapabilme	☐	☐	☐	☐	☐	☐
Sevdiğiniz sporu istediğiniz kadar yapabilme	☐	☐	☐	☐	☐	☐

Eğer ayak ve ya ayak bileği problemi yaşamadan önceki sportif durumunuza 100 puan verseniz, hiç ayak ve ya ayak bileği hareketi yapamamaya da 0 verseniz, şu anki sportif durumuza 100 üzerinden kaç puan verirsiniz?

...%100

Genel olarak şu anki fonksiyonunuzu nasıl değerlendirirsiniz?

☐ Normal ☐ Normale Yakın ☐ Anormal ☐ Ciddi Anormal

Malkoç M, Korkmaz O, Çelik D, Yalçın S.Turkish Translation and Adaptation of the Foot and Ankle Ability Measure. Acta Orthop Traumatol Turc. Oral presentation. Vol 48 (2014) p.76. Supplementum-I.

8.6. Curriculum Vitae

A. KİŞİSEL BİLGİLER

Adı Soyadı: Elif Varan

Doğum tarihi

Yabancı dil bilgisi:

Görev yeri:

ÖZGEÇMİŞ

E-posta adresi:

B. EĞİTİMBİLGİLERİ

Mezun olduğu üniversite/fakülte:

Mezuniyet tarihi:

C. İŞ TECRÜBESİNE AİT BİLGİLER

Bugüne kadar çalıştığı kurum/kuruluşlar: