T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF PHYSIOTHERAPY AND REHABILITATION

COMPARISON OF EFFECTS OF BALANCE AND STRENGTHENING TRAINING IN TERMS OF PROPRIOCEPTION IN PEOPLE WITH CHRONIC ANKLE INSTABILITY

MASTER THESIS

AYŞE ASENA GÜLNERGİZ, Pt, BSc

İstanbul-2020

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APPROVAL

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DECLARATION

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

26/06/2020

Ayşe Asena GÜLNERGİZ

DEDICATION

To my family…

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And finally, I would like to present my sincere thanks and love to my dear family, who provided all the spiritual support without question.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Δ	Post Variables minus Pre Variables
AITFL	Anterior Inferior Tibiofibular Ligament
ATFL	Anterior Talofibular Ligament
BG	Balance Training Group
BMI	Body Mass Index
CAI	Chronic Ankle Instability
CAIT	Cumberland Ankle Instability Tool
CFL	Calcaneofibular Ligament
FTCL	Fibulotalocalcaneal Ligament
JPS	Joint Position Sense
LAS	Lateral Ankle Sprain
LTCL	Lateral Talocalcaneal Ligament
MCL	Medial Colleteral Ligament (Deltoid Ligament)
NMC	Neuromuscular Control
PB	Peroneus Brevis
PITFL	Posterior Inferior Tibiofibular Ligament
PL	Peroneus Longus
PNF	Proprioceptif Neuromuscular Facilitation
PTFL	Posterior Talofibular Ligament
ROM	Range of Motion
SD	Standard Deviation
SEBT	Star Excursion Balance Test
SG	Strengthening Training Group
SPSS	Statistical Package for Social Science
TA	Tibialis Anterior

YBT	Y Balance Test
YDT	Y Denge Testi

ABSTRACT

Gulnergiz, Ayşe, A. (2020). Comparison of effects of balance and strengthening training in terms of proprioception in people with chronic ankle instability. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, MSc Thesis, İstanbul.

In literature, it has been seen that there is no sufficient evidence about which training method is more useful for improving balance and proprioception in people with chronic ankle instability (CAI). Therefore, the aim of this study is to investigate the differences of balance and strengthening trainings on ankle proprioception in people with CAI. This study was conducted with 29 (21 F, 8 M) physical active volunteers between the ages of 18-30 between December 2019 and May 2020. Participants whose demographic information and Cumberland Ankle Instability Tool (CAIT) scores, for assessment functional ankle instability, were received, were randomly divided into two treatment groups as strengthening training group (SG, n: 14) and balance trainng group (BG n: 15). Y Balance Test (YBT) and proprioception/vibration evaluations were conducted within the scope of dynamic balance and somatosensory evaluations respectively. The methodology adopted in this study for the evaluations includes joint position sense (JPS) measurements for the proprioception and 128 Hz. vibration fork for the vibration sense evaluations. Evaluations were applied at the beginning and at the end of the treatment. Participants of the BG were taken under hop to stabilization exercises and participants of the SG to TheraBand exercises. In both groups exercises were completed with unstable ankle. Participants attend all sessions which are held two days a week for six weeks and each session lasted approximately 35 minutes. At the end of the study, differences between pre and post-treatment results were analysed and the data from two groups were compared. Although there is no significant difference was found between two groups on the dynamic balance, SG showed a statistically more significant improvement on JPS (140°) and vibration sense (fifth toe) ($p<0.05$). In conclusion the study showed that the strengthening exercises applied with TheraBand have similar effects to balance exercises in developing dynamic balance, but are more effective on vibration sense and JPS

Key words: ankle instability, proprioception, vibration sense, balance, strengthening.

ÖZET (Turkish)

Gülnergiz, Ayşe, A. (2020). Kronik ayak bileği instabilitesi olan kişilerde denge ve kuvvetlendirme eğitiminin propriyosepsiyon yönünden karşılaştırılması. Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Bölümü, Yüksek Lisans Tezi, İstanbul.

Literatürde, kronik ayak bileği instabilitesi (KAİ) olan bireylerde hangi çalışma yönteminin stabilite ve propriyosepsiyonu geliştirmek için daha yararlı olduğu konusunda yeterli kanıt bulunmadığı görülmüştür. Bu çalışmada, kuvvetlendirme ve denge çalışma yöntemleri ayrı ayrı olarak uygulanmış ve her iki grubun ayak bileği propriyosepsiyon duyusu yönünden elde edilen veriler birbirleriyle karşılaştırılmıştır. Aralık 2019 ile Mayıs 2020 tarihleri arasında 18-30 yaş arası fiziksel aktif gönüllüler ile yapılmış olan çalışmaya, 29 katılımcı (21 K, 8 E) dahil edilmiştir. Ayak bileği instabilitesini değerlendirmek için Cumberland Ayak Bileği İnstabilite Anketi (CAİT) uygulanmış ve demografik bilgileri alınmış katılımcılar, denge (BG n: 15) ve kuvvetlendirme eğitimi (SG n: 14) olarak rastgele iki tedavi grubuna ayrılmıştır. Dinamik dengeyi değerlendirmek için, Y Denge Testi (YDT) ve somatosensöri değerlendirme kapsamında, propriyosepsiyon ve vibrasyon duyusu değerlendirilmiştir. Propriyosepsiyon, Eklem Pozisyon Hissi (JPS) ile vibrasyon duyusu ise vibrasyon çatalı (128 Hz.) ile değerlendirilmiştir. Değerlendirme yöntemleri, tedavi öncesi ve tedavi sonrası olarak iki defa değerlendirilmiştir. BG' deki katılımcılara, hop to stabilizasyon SG'deki katılımcılara ise, TheraBand kullanılarak kuvvetlendirme egzersizleri uygulanmıştır. İki grup için de egzersizler stabil olmayan ayak bileği ile gerçekleştirilmiştir. Tedavi programı katılımcılara, 6 hafta boyunca haftada iki gün olacak şekilde uygulanmış ve her seans ise yaklaşık 35 dakika sürmüştür. Çalışma sonunda, tedavi öncesi ve sonrası sonuçlar arasındaki farklar analiz edilmiş ve iki gruptan veriler karşılaştırılmıştır. Dinamik denge konusunda iki grup arasında anlamlı bir fark bulunmamasına rağmen, SG, JPS (140 °) ve vibrasyon duyusu (5. parmak) üzerinde istatistiksel olarak daha anlamlı bir iyileşme göstermiştir. Sonuç olarak bu çalışmada, TheraBand ile uygulanan kuvvetlendirme egzersizlerinin, dinamik dengeyi geliştirmede denge egzersizlerine benzer şekilde etki gösterdiği ancak vibrasyon duyusu ve EPH üzerinde ise daha etkili olduğu görülmüştür.

Anahtar Kelimeler: ayak bileği instabilitesi, propriyosepsiyon, vibrasyon duyusu, denge, kuvvetlendirme.

1. INTRODUCTION AND PURPOSE

Ankle sprains are epidemic in both sport and general populations (1). It's known that 20% of all joint injuries consists of ankle injuries (2). As it is stated at many epidemiological research's %85 of ankle sprains is lateral ankle sprains (LAS) (3). LAS's are also called as inversion ankle sprains or supination ankle sprains. Symptoms remaining after LAS such as pain and instability are called "residual symptoms". %32 to %74 of individuals with LAS are experiencing these residual symptoms (4). The length and persistence of residual symptoms affect the occurrence of recurrent sprains (5).

Chronic ankle instability (CAI) occurs in individuals experiencing these residual symptoms. CAI mainly presents it self with a "giving away" feeling in the ankle -due to recurrent ankle sprains- which occurs at least one year after the initial sprain (6). When the recent studies examined, according the Hertel and Hiller CAI is divided into two groups: mechanical instability and functional instability (5, 6). According to Tropp this 2 groups are related to each other and functional symptoms like proprioception, coordination and postural control are very important for people with CAI (7). It is also thought that somatosensory damage may accompany proprioceptive deficits (5). However, studies on this subject still remain insufficient. On the other hand, mechanical symptoms causing instability are related to altered mechanic and degenerative changes on the ankle joint. If these changes are examined, pathologic laxity and synovial inflammation can be seen as mechanical symptoms. These symptoms especially occurs in talocrural and subtalar joints and causes joint instability mostly on unstable surfaces (5).

In addition, hypermobility or diminished range of motion (ROM) can cause mechanical instability and caued by muscle and artrokinematic impairments. Regarding diminished ROM, studies show that there is a relation between limited dorsiflexion and recurrent sprains (8, 9).

Supporting ligaments of the lateral aspect of ankle responsible for neuromuscular control (NMC) of the ankle. Considering maintain dynamic stability of the ankle, Peroneus longus, brevis (PL and PB), tibialis anterior (TA), gastrocinemius and soleus muscles concentric and eccentric contractions are very important (5). Thus, evaluating and strengthening these muscles necessary to support neuromuscular stability of the foot.

Therefore, to investigate PL and TA muscles, strength, fatigue, and muscle reaction times and correlations to ankle instability many studies used different methods (10-13). To understand the link between proprioception and NMC of the foot, Konradsen and Voigt developed a biomechanical model which shows the deficit in the proprioception causes to lose control on the lateral section of the foot and causes giving away episodes during the gait cycle (14).

Number of studies implemented many intervention programs to treat proprioception deficits in subjects with CAI (15, 16, 17). In one of these studies, writers concluded that the muscle strengthening training with TheraBand has significantly greater effects on joint position sense (JPS) in all ankle movements (16). In another study writers, stated that 6-week coordination training has no effect on inversion- eversion JPS and more studies should investigate how to improve JPS in people with CAI (15).

Combination of neuromuscular and proprioception deficits creates postural instability (5). To enhance balance and postural stability traditionally, rehabilitation programs include balance, strength and combination training. When some of these studies are examined, combination training method has its own positive effect on evaluation results (18, 19). On the other hand, other studies compared these training methods and writers concluded there are no significant differences between these training methods on balance and postural stability in people with CAI (17, 20). As a result of the literature reviews, it has been seen that there is no sufficient evidence about which training method is more useful for improving balance and proprioception in people with CAI. And it’s needed for improving the recovery rates and reducing the rehabilitation time and create a guideline for therapists to apply target-oriented treatment methods for people with CAI. Therefore, the aim of this study is to investigate the differences of balance and strengthening trainings on ankle proprioception in people with CAI.

Two hypotheses were decided for this study:

H0: There is no difference between balance and strengthening training on ankle proprioception in people with chronic ankle instability.

H1: There is a difference between balance and strengthening training on ankle proprioception in people with chronic ankle instability.

2. GENERAL INFORMATION

2.1. Anatomy and Biomechanics of Ankle

The human foot is divided into 3 main sections (Figure 2.1) as Hindfoot, Midfoot and Forefoot. These sections comprise 26 different bones; 2 being in the hindfoot, 5 in the midfoot and 19 being in the forefoot (21). (Figure 2.2).

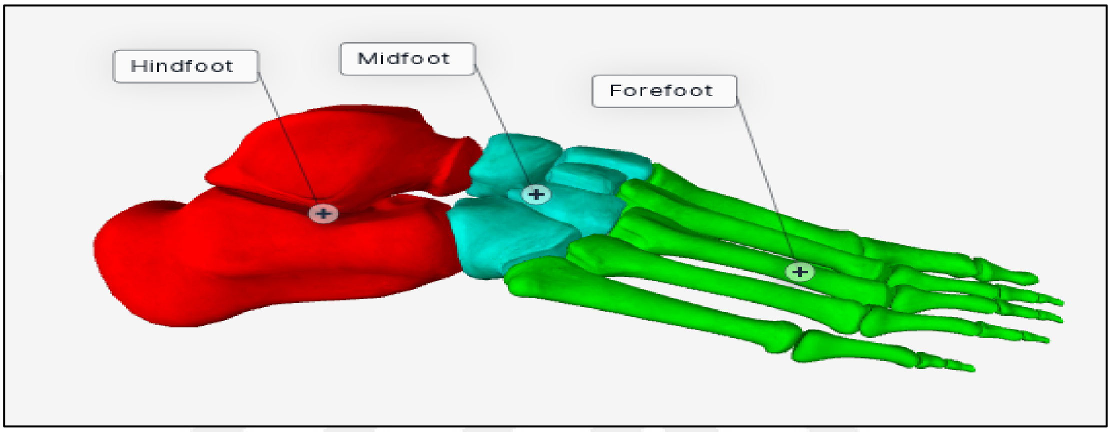

Figure 2.1. Lateral View of the Foot and Foot Areas (22)

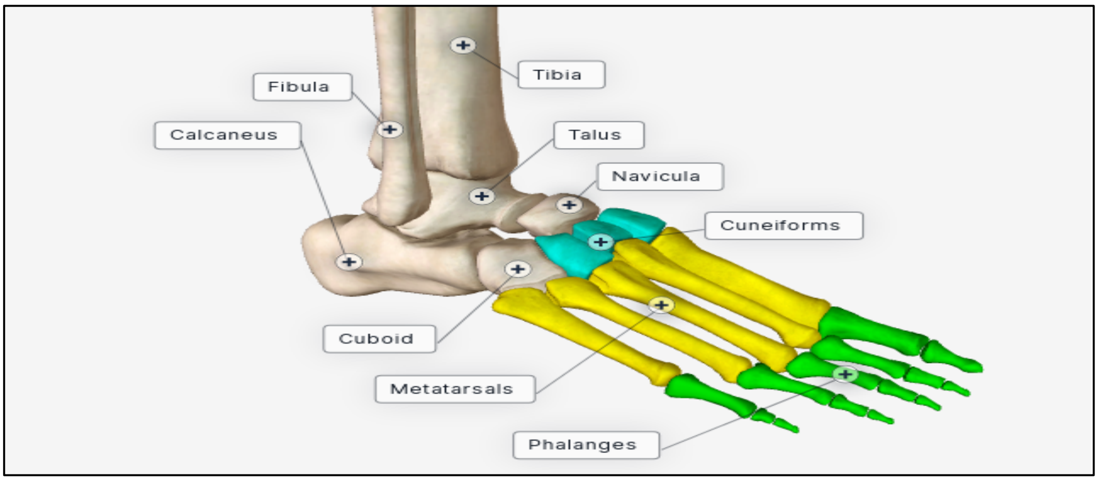

Figure 2.2. Lateral View of Ankle and Bones (22)

Ankle is a complex structure and consists of 3 articulations: the talocrural, subtalar and distal tibiofibular joints. Movements in these joints provide a coordinated movement in the hindfoot. Movements in these joints occur in 3 cardinal planes as it is shown in

Figure 2.3. When the movements in the planes are examined; sagittal-plane motion (plantar flexion-dorsiflexion), frontal-plane motion (inversion-eversion), and transverse-plane motion (internal rotation/adduction -external rotation/abduction) are seen (23, 24).

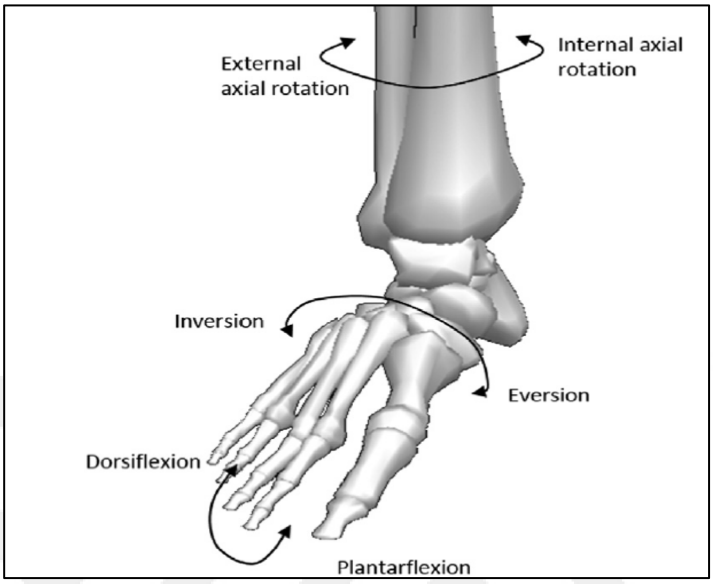

Figure 2.3. Movements of Ankle and Foot Complex (23)

Except for the movements seen in these planes, there is an exception to the talocrural and subtalar joints. They have oblique axes of rotation which provide the pronation and supination movements in the hindfoot.

Pronation and supination movements occur in two kinetic chains (open, closed) with a combination of different movements. In the open kinetic chain, dorsiflexion, eversion and external rotation comprised the pronation movement, whereas the supination movement is formed by plantar flexion, inversion, and internal rotation movements.

In the closed kinetic chain, while eversion and external rotation, which constitute the pronation movement, are seen with plantar flexion, the supination movement consists of dorsiflexion, inversion and internal rotation movements (5, 24).

2.1.1. Talocrural joint (Tibiotalar joint)

The talocrural joint is the joint between the concave surface of the tibia and fibula and the convex surface of the talus. Talocrural joint forms joints with talus, lateral malleolus and medial malleolus structures as it is presented in Figure 2.4 (5, 24).

This joint is also called a mortise joint for placement of trochlea of the talus between the malleoli. And has a hinge joint structure. Due to this structure, in the sagittal plane, it contributes to the plantar flexion and dorsiflexion movement of the foot. The joint also provides movement in the frontal and transverse plane due to the oblique axis passing through the lateral and medial malleolus.

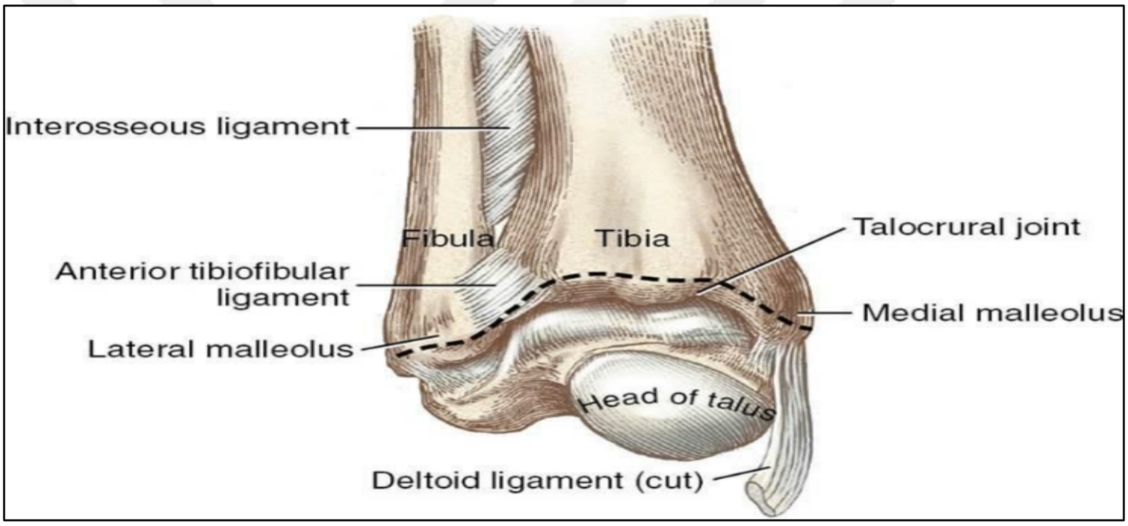

Figure 2.4. Anterior View of Ankle and Structure of the Talocrural Joint (21)

As it can be seen in Figure 2.5, the oblique axis passes through the medial malleolus, it passes slightly anterior of the frontal plane, while passing through the lateral malleolus, it passes slightly posterior of the frontal plane (5, 21, 23-25). The talus joint structure is well placed with the dorsiflexion movement under weight-bearing. Especially during weight-bearing the structures of the talocrural joint act as ankle stabilizers, and prevent excessive talar rotation and eversion. The stabilization of the talocrural joint is supported by ligaments and a thin membrane that attaching to the talus, tibia, and malleoli and surround the joint (5, 23, 24).

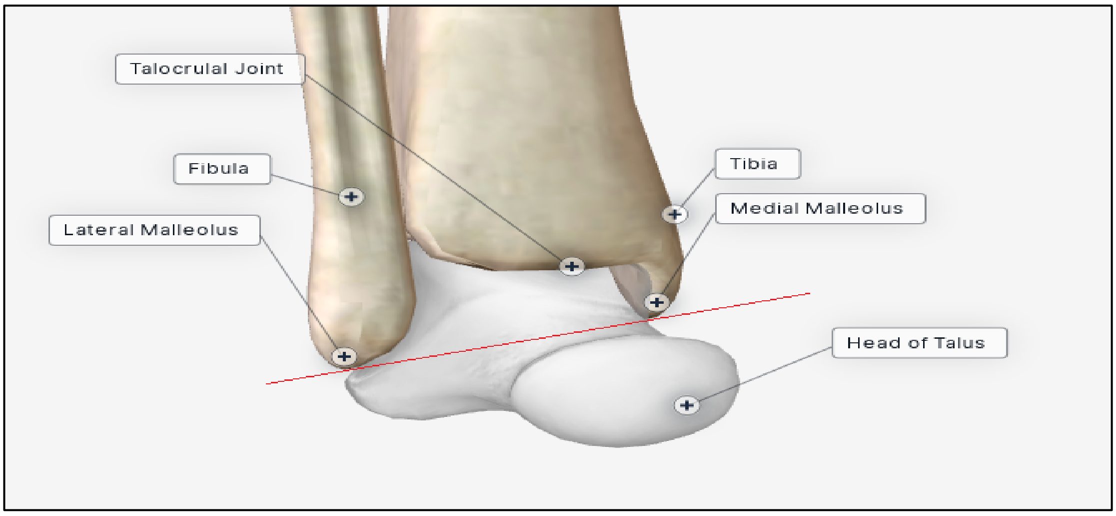

Figure 2.5. Talocrural the Axis of Rotation (22)

Ligaments are divided into 2 groups as those supporting the lateral and medial part of the ankle. Anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL) and posterior talofibular ligament (PTFL) support the lateral part of the ankle (Figure 2.6), and medial collateral ligaments (MCL- deltoid ligament) supports the medial part (Figure 2.7) (23).

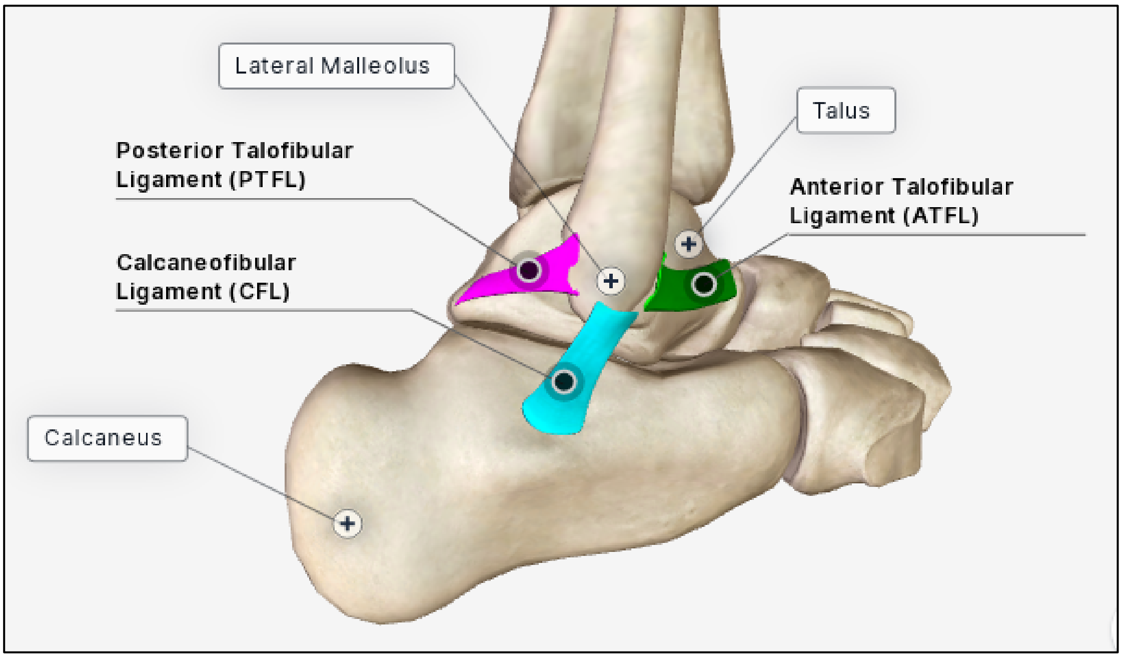

Figure 2.6. Ligaments Supporting the Lateral Part of the Ankle (22)

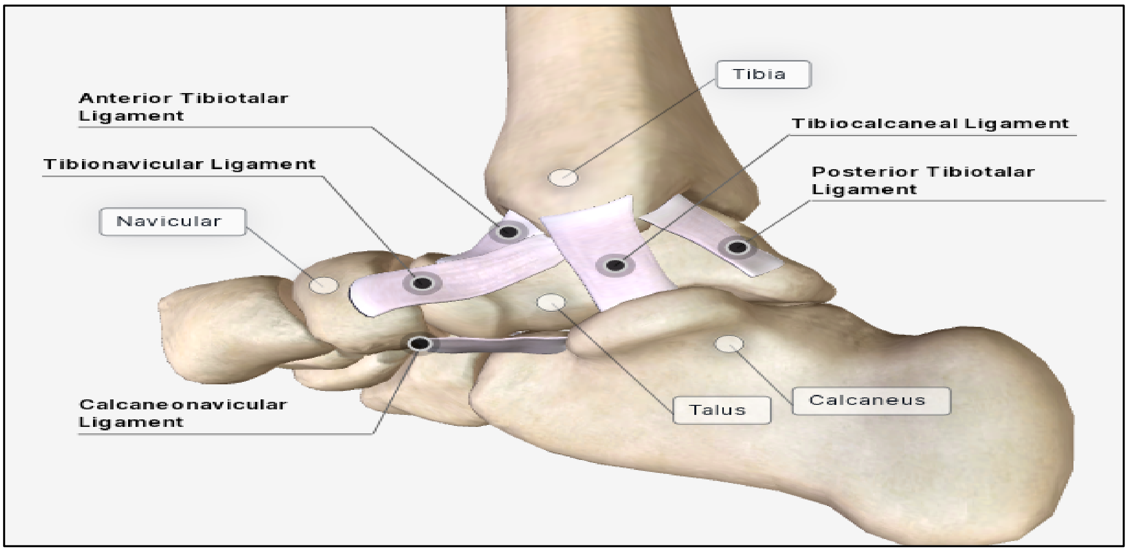

Figure 2.7. Ligaments Supporting the Medial Part of the Ankle (Deltoid Ligaments) (22)

ATFL is located between the lateral malleolus and the talus by drawing an antero-medial path. ATFL limits the inversion and internal rotation movement of the talus on the tibia and prevents the talus's displacement (26). Both ATFL and PTFL have high tensile forces against plantar and dorsiflexion. ATFL has lower maximal load and energy under tensile stress compared to other ligaments. Therefore, the probability of injury is higher compared to other ligaments and the strain is more common (5, 23, 24). CFL is located between the lateral malleolus and the calcaneus by drawing a postero-inferior path. And the sheaths of the peroneal tendon superficially cross this ligament. The CFL, is the only ligament that crosses both the subtalar and talocrural joints, restricts excessive inversion and the internal rotation of the hindfoot. And permits subtalar movements. (5, 23, 24, 26). Although it was the most stretched state during the dorsiflexion movement, some studies have shown that it's the tensest state during the varus position without the dorsi and plantar flexion movements (27, 28).

The most common injured ligament after ATFL is CFL. PTFL is located horizontally between the lateral malleolus and the talus (27). The most tensed state of the ligament during the dorsiflexion. This ligament also acts to restrict inversion and internal rotation movement, such as ATFL and CFL (5).

MCL is divided into two layers as superficial and deep and starts from the medial malleolus and ends in 3 separate bones: navicula, talus and calcaneus. Ligaments that insert in these bones are respectively; talonavicular, posterior and anterior tibiotalar and tibiocalcaneal ligament. The superficial part is divided into 4 ligament; superficial posterior tibiotalar which is the strongest fibers of superficial layer, superficial tibiocalcaneal, tibionavicular and tibiospring ligament. The tibiospring ligament ends inside the calcaneonavicular ligament (spring ligament) and acts as an anteromedial ankle stabilizer (21, 23, 24). The deep layer consists of the deep anterior tibiotalar ligament and the deep posterior tibiotalar ligaments. In this layer, the largest and strongest ligament is deep posterior tibiotalar ligament. Especially the posterior tibial muscle tendon and tendons of other muscles descending to the foot covers most of the MCL (21). Although the MCL is still not fully understood and resolved, injury to the this ligament is rare due to the position of the lateral malleolus and the total strength of the MCL (21, 29).

2.1.2. Subtalar joint

The subtalar joint is the joint between the talus and the calcaneus below the talus (Figure 2.8). The subtalar joint is divided into 2 sections and these two sections are given different joint names: Anterior chamber-talocalcaneal joint, posterior chamber-talocalcaneonavicular joint. Although both anterior and posterior parts are between talus and calcaneus, anterior part is also including the concave proximal surface of the tarsal navicular bone and supported by the plantar calcaneonavicular ligament (5, 30). Although the rotational centers of both parts are different from each other, both parts provide rotational motion as a whole. The difference of rotational centers is providing the oblique axis of rotation to the subtalar joint. The subtalar joint provides inversion and eversion movement and is supported by ligaments like other joints. The most important ligaments are cervical and interosseous ligaments. Cervical ligament, which is the strongest ligament, supports both anterior and posterior parts and limits inversion movement (5, 24). The interosseous ligament is located between the calcaneus and the talus by drawing a superio-medial path and lies only in the posterior part (Figure 2.8). This ligament limits inversion and eversion movements. Both lateral talocalcaneal (LTCL) and fibulotalocalcaneal ligaments (FTCL) restrict the movement of the subtalar joint (Figure 2.8). CFL and MCL, which are other ligaments that support the ankle, act as secondary stabilizers (5).

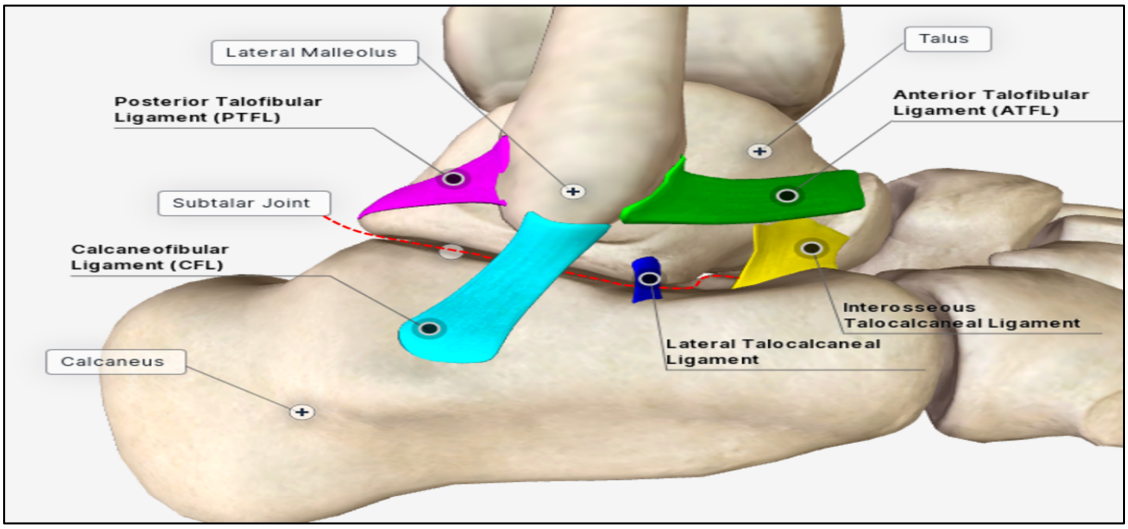

Figure 2.8. Ligaments Supporting the Lateral Part of the Ankle and Subtalar Joint and Ligaments Supporting the Subtalar Joint. (22)

2.1.3. Distal tibiofibular joint

It is the joint that connects the distal parts of the tibia and fibula with the interosseous membrane and fibrous tissue. Rather than movement, it has the role of a stabilizer for the ankle. Eversion injury is rarely seen in the joint supported by anterior inferior and posterior inferior tibiofibular ligaments (AITFL, PITFL). This joint plays an important role to support the talocrural joint and to maintain the mortise structure of the joint (5, 23) (Figure 2.9).

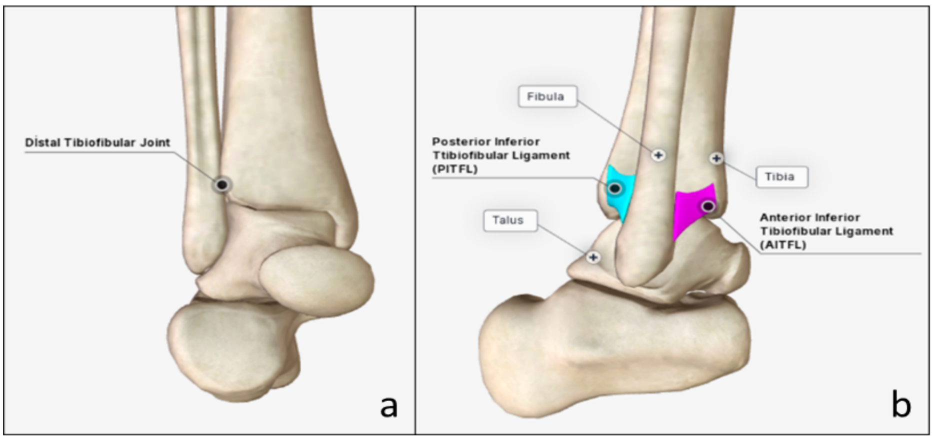

Figure 2.9. Bone Structures and Ligaments: (a) Distal Tibiofibular Joint. (b) Ligaments Supporting the Distal Tibiofibular Joint. (22)

2.1.4. Muscles and tendons

Although the eccentric contraction has a greater role, the muscles take part in dynamic stabilization due to their eccentric and/or concentric contractions (5). Dynamic stabilization of the ankle is provided by 12 extrinsic muscles. These muscles, which are divided into 4 parts, originate from the lower leg and insert within the foot. These sections are called anterior, lateral, posterior and deep posterior, and the muscles they hold in themselves are 4,2,3,3, respectively. The TA, extensor hallucis longus, the peroneus tertius and the extensor digitorum longus muscles are located in the anterior part. The first 2 muscle provides the dorsiflexion and inversion movements. While the third muscle provides dorsiflexion and eversion movement, the last muscle only functions in the dorsiflexion movement. Muscles in this part play an important role in lateral ankle stabilization thanks to eccentric contractions during the eversion movement. The PL and PB muscles in the lateral part provide plantar flexion and eversion movement.

These muscles play a protective role in lateral ankle sprains due to their involvement and control over the eversion movement.

The gastrocnemius, the soleus, and the plantaris muscles are located in the posterior part and they provide ankle plantar flexion. The tibialis posterior, the flexor digitorum longus and the flexor hallucis longus muscles in the fourth and last part are responsible for ankle plantar flexion and inversion movements (5, 23).

2.1.5. Biomechanics of ankle

Ankle movements, as plantar flexion and dorsiflexion in the sagittal plane, as internal-external rotation (adduction - abduction) in the transverse plane, in the frontal plane, it appears as inversion and eversion. The combinations of these movements form the pronation-supination movement, which is a 3-dimensional movement. While the plantar surface turns towards the medial with the supination movement, it rotates laterally with the pronation movement. In the talocrural joint, the dorsiflexion movement is seen with the abduction and eversion movement, while the plantar flexion movement is seen with the adduction and inversion movement. As it’s can be see, plantar and dorsiflexion movements take place parallel to the transverse plane, they can occur with an angle difference of up to 10 degrees in the frontal plane (23). And combined with abduction and adduction movements, which are the movements caused the tilt of ankle joint in the transverse plane and at an angle of about 5 degrees (25).

Considering the range of motion seen in the sagittal plane, 10 to 20 degrees of dorsiflexion and 45 to 55 degrees of plantar flexion movements are seen. The required angles is seen in the sagital plane, in some activities such as; walking, ascending and descending stairs, are 30, 37 and 56, respectively. While walking, the maximum dorsiflexion is seen at the point where 70 percent of the stance phase occurs, while the maximum plantar flexion is seen during the toe-off. While an 11 degree of internal tibial rotation movement provided by ankle dorsi flexion movement, 19 degrees of internal tibial rotation movement is required for toe-off during walking. In a normal foot, 1 degree of tibial rotation movement is equal to the 1 degree subtalar movement. So subtalar motion is necessary for walking. The subtalar joint itself provides 20 degrees of inversion and 5 degrees of eversion. In those with a flat foot, the subtalar inversion angle can reduce to 12 degrees. Control deficits in inversion and eversion movements can lead to many walking disorders. Like the talocrural joint and the subtalar joint also creates multiple movements during plantar flexion and dorsiflexion and allowing the pronation-supination movement, due to their axis of rotation respectively (23, 25, 31).

While the ankle carries 5 times the bodyweight while walking, this number increases to 13 during running. Studies showed that, the total load present on the ankle complex is shared as 83 to 17 percentages by talocrural joint and fibula, respectively. Thanks to the large load-bearing area, the ankle shows low stress and has high adaptability under load-bearing activities. Load-carrying and distributing functions are supported by ligaments, tendons, tendon sheaths and muscles (23). One study has shown that the weight-bearing during walking, the largest carrying area of the foot in the stance phase, while the narrowest carrying area is seen during the heel strike and toe-off (32).

2.2. Ankle Sprains

20 % of joint injuries are known to be ankle injuries. And ankle sprain is the most common form of ankle injuries in the sportive and general population (1, 2). Studies have shown that ankle sprain occurs in 2 to 7 people per 1000 people every year. And 85 percent of ankle injuries occur as injuries in lateral structures (33). Ankle sprains are caused by a partial or complete breakdown of collagen tissue and fibrils caused by

overstretching the ankle ligaments (34). And can be called dynamic injuries due to the injury mechanism (33). Long-term disability may occur in the person when the necessary treatment for ankle sprains is not applied. Acute and chronic instability may develop after an ankle sprain. Especially following the acute injury, the instability may turn into chronic instability when person is not treated. And studies have shown that chronic lateral ligament instability can later lead to degenerative arthritis. With the correct diagnosis and rehabilitation program, a person's return to daily and sportive life is provided (1, 35, 36).

2.2.1. Lateral ankle sprains

The ankle sprain mechanism generally occurs in the direction of coercive inversion and plantar flexion and damages the lateral region ligaments (37). When the LAS is not treated properly, it causes recurrent sprains and due to this recurrent sprains, residual symptoms can occur in 30 and 70 percent of people (38). Therefore, studies are still being carried out to prevent and treat recurrent sprains and ankle instability caused by the LAS (1). In order to prevent the symptoms observed, risk factors should be investigated and an appropriate rehabilitation program should be selected.

2.2.1.1. Risk factors

Risk factors are divided into two groups by many studies; intrinsic and extrinsic risk factors (35, 39). Intrinsic risk factors, divided into various factors such as height, weight, gender, age, body mass index (BMI), previous injury, anatomical alignment, aerobic capacity, dominant limb and proprioception, flexibility, muscle strength, postural stability. Extrinsic factors are the risk factors mostly seen in sports injuries. Previous injuries cause inflammatory reactions and can predispose to recurrent sprains as well as cause functional limitations (35). Regarding gender, some studies say that sprains are more common in women, especially in the sportive population (1). However, other studies argue that there is not much difference between the genders (35, 39). Because the load on the ankle joint will be higher due to the weight and increasing BMI, it will be more prone to sprain (40). Proprioceptive deficits, after the previous injury causes, ankle instability, deficits in postural stability and muscle weakness (41). Although some studies supported the causes of deficits in postural stabilization with changes in ligament structure and disruptions in the neuromuscular system, the exact mechanism could not be resolved (35, 42).

2.2.1.2. Symptoms

In a lateral ankle sprain, signs of swelling, ecchymosis, pain and tenderness occurs in ATFL and CFL. If proper treatment is not applied at this stage, the symptoms seen in the ligaments may spread to the forefoot and toe, after the acute injury phase has passed. While walking, with the effect of gravity, ecchymosis and swelling can spread to the whole foot. All symptoms that are seen after the sprain, follows an increasing pattern with motion. In people who experience dysfunction due to these symptoms, the function returns within a few days to a few months. Despite the recovery of function and other inflammatory symptoms, these individuals may be prone to recurrent sprains. A preventive treatment approach should be applied before this recurrent sprain symptom can occur after the LAS. (1, 43).

2.2.1.3. Injury mechanisms

The ankle, especially during stepping, takes a position that is vulnerable to injury; plantar flexion and inversion. It is also referred to as plantar flexion and supination. At this stage, the ankle evertor and dorsiflexor muscles have to work in harmony with the plantar flexor and inverter muscles to stabilize the ankle by contracting eccentrically. A sprain occurs when the ankle muscles do not exhibit working in this harmony (44). It is the ligament ATFL that first meets the tensile stress of the ankle in plantar flexion and inversion while the foot is in load-bearing after the step-in movement. In cases where the maximum tensile stress of the ligament is exceeded, the sprain may cause partial or complete tears in one or more ligaments as shown in Figure 2.10. In case the ATFL cannot bear the tensile stress, it dorsiflexes the foot and may cause tears on the CFL as long as the sprain in the direction of inversion continues (45) as shown in Figure 2.10. While the possibility of strain in these two ligaments together is 20 percent, CFL alone strains are very rare (38). And also, in recent years, the frequency of “the high ankle sprain”, which is manifested by AITFL injury, has increased and started to attract attention. This injury results from the internal rotation of the tibia on the talus and causes incomprehensible damage called the Maisonneuve fracture. Maisonneuve fracture is accompanied by MCL rupture, AITFL rupture and proximal fibula fracture (45).

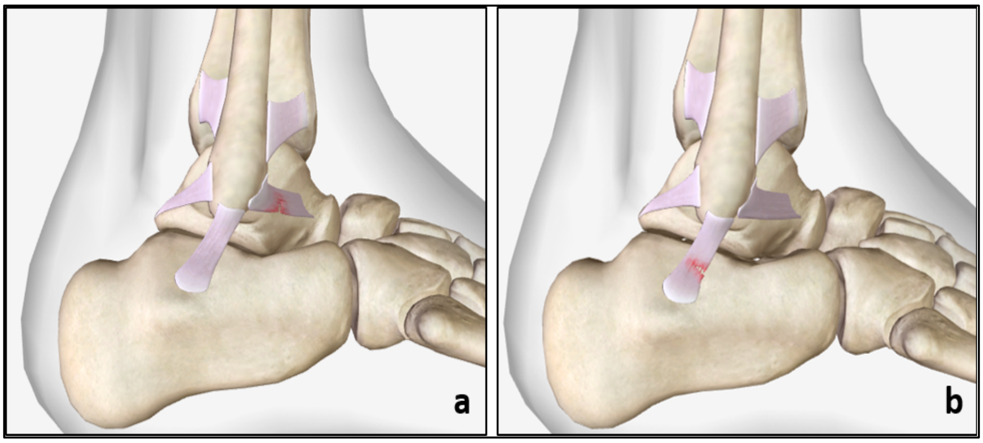

Figure 2.10. Partial Tears in ATFL and CFL after Lateral Ankle Sprain in the Direction of Inversion: (a) ATFL. (b) CFL. (22)

2.2.1.4. Treatment

Proper treatment after acute ankle sprains is very important because such cases are likely to turn into 60 percent CAI (35). Sprains in grade 1 are sprains in which ligament integrity is not impaired and can be treated with early weight-bearing, edema control (rest, ice, compression and elevation). Grade 2 sprains are characterized by partial tear in ATFL and CFL tendons, but preserved partial ankle stability.

The treatments used for sprains at this stage, after short-term immobilization, includes functional management programs such as inflammation control, proprioceptive and balance training and strengthening of the ankle muscles, respectively. Functional bracelets, external orthosis and banding techniques are used for short-term immobilization (35, 46). And some studies stated that, these immobilization methods used in the early period also increase the rate of recovery by stimulating the proprioceptive sense (47, 48). Although functional treatment speeds up the rehabilitation process, it also plays a role in preventing recurrent sprains (35). Studies have shown that functional treatment has a higher effect on reducing inflammatory findings and restoring a person compared to immobilization (47).

In both grades, besides other methods, manual therapy applications such as soft tissue massage and joint mobilization are also applied in the early period to increase the ROM and reduce inflammatory findings.

Apart from manual therapy, applications such as low level laser and ultrasound are used under the name of electrotherapy in reducing inflammatory findings (49). In grade 3 sprains, complete rupture of the lateral complex ligaments occurs and accompanied by excessive edema and ecchymosis findings (46). Weight-bearing in the early stage increases the recovery rate and rehabilitation process in grade 1 and 2 sprains as well as in grade 3 sprains (49).

Surgical operations performed after grade 3 sprains may differ due to its practitioner. But it is also recommended by some experts that conventional treatment should be implemented for 3 to 6 months before surgery (35).

Considering some studies comparing surgical treatment and functional management, no significant difference was found between these two treatments as a result of the studies (50, 51). Even in one study, although the percentage of re-injury decreased after surgery, an increase in the percentage of osteoarthritis was detected (51).

2.3. Chronic Ankle Instability

CAI develops in 30-40 percent of people who have previously had a LAS. These people have chronic symptoms called "residual symptoms" that cause CAI. These symptoms and recurrent sprains restrict the person's activities in the future and be caused of both mechanical and functional ankle instability (52).

Functional instability is more subjective, while mechanical instability is manifested by findings that can be diagnosed clinically and in physical examination (35, 53).

Although it is not known who will show which instability, it's known that functional instability incidence rather than mechanical instability is more common in CAI cases (Fig. 2.11.). However, the link between the two instabilities has not been fully resolved (52, 53).

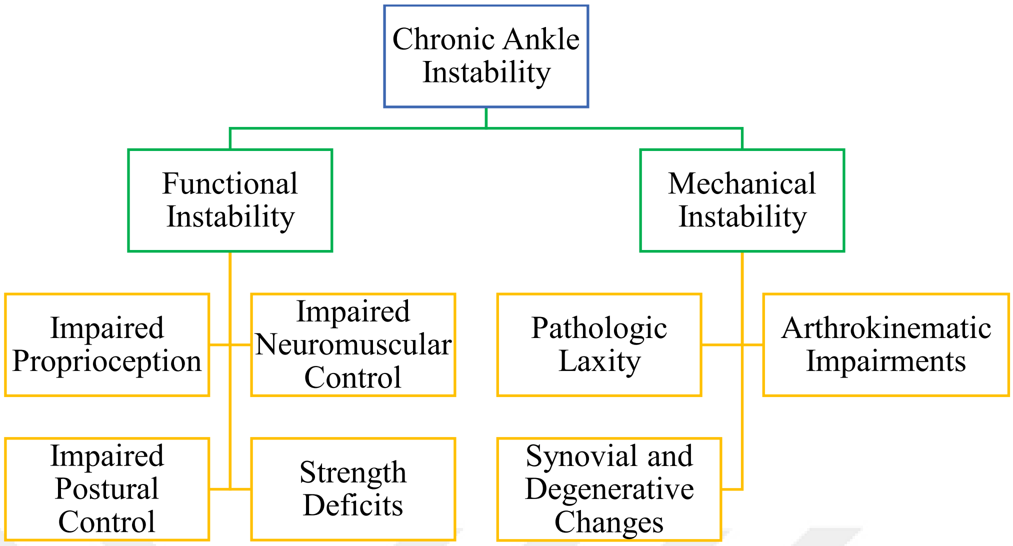

Figure 2.11. Symptoms of CAI

2.3.1. Mechanical instability

Mechanical instability results from changes in structure and mechanics of different structures that support the ankle, such as ligament, bone and joint (8). Changes in these structures can be seen at the same time or separately (5). Although changes in ligament and joint structure cause mechanical instability, it also indirectly causes functional instability (8).

2.3.1.1. Pathologic laxity

After ankle sprain and result of the ligaments damage, there is an increase in laxity, especially in the talocrural and subtalar joints. And this causes the ankle to be unstable. The majority of this increase in laxity is seen as a result of injury of ATFL and CFL ligaments from lateral complex ligaments.

Although while the injury in CFL can cause pathological laxity in both talocrural and subtalar joints, injuries in this ligament are often accompanied by cervical ligament and other ligament injuries. Especially the instability caused by pathological laxity and the resulting recurrent sprains manifest themselves during functional activity. And in order to diagnose this pathological laxity, stress radiography evaluation method is used in the clinic.

With the physical tests applied with this method, even information about which ligament contributes to pathological laxity in joint instability can be obtained. Due to the anatomical variations in the ligaments, the location of the joints and muscle fibers, a thorough examination is required for diagnosis (5, 8).

2.3.1.2. Arthrokinematic impairments

The positions of bone structures and ankle joints, and changes in their structures are other factors leading to instability. Positional impairments leading to instability can lead to recurrent sprains due to multiple causes. Especially after ATFL injury, lateral malleolus is displaced to posterior as a result of anterior displacement and medial rotation of the talus on the tibia, which is a condition mostly observed in those with pes cavus. At the same time, it has been mentioned that people with CAI may have anterior-inferior displacement of the distal fibula.

This malposition of the lateral malleolus causes changes in the ATFL mechanism during the ankle supination, causing the talus to displace more than it should. The reason for the positional change in the distal fibula is due to tibiofibular ligament injury during the sprain. The ankle becomes more vulnerable and more likely to sprain again, as a result of all these positional changes of bones and impairments in the mechanism. At the same time, the restriction especially in the dorsiflexion movement also causes instability. In cases where there is not enough dorsiflexion movement in the ankle, inversion movement occurs easily. And this situation causes recurrent sprains (5, 8). Considering the studies on the limited dorsiflexion movement that emerged after the ankle sprain, it was seen that the positional changes in the bone structure, especially the talus displacement towards the anterior, may have an effect (54-55).

In some of these studies, the authors have linked the limited dorsiflexion movement with the contraction mechanism of the triciceps surae and gastrocnemial muscles (8, 9).

2.3.1.3. Synovial and degenerative changes

Impingement and synovial hypertrophy are other impairments that cause mechanical instability. These impairments occur between the bones involved in the structure of the ankle and cause synovial inflammation, especially in the talocrural and subtalar joints. Synovial inflammation can cause pain and recurrent sprains. Synovial changes like synovitis, occurring especially in the subtalar joints may cause more repetitive bouts of ankle instability. Apart from synovial changes, degenerative changes also play a role in repeated bouts of ankle instability. Examples of these degenerative changes observed especially in those with CAI include osteophytes and subchondral sclerosis (8).

2.3.2. Functional instability

Residual symptoms that occur after ankle sprain are associated with functional instability. The feeling of giving away, which occurs in people with recurrent sprains, is explained by functional instability. Postural control deficits, muscle strength deficits, and proprioception deficits occur together with the impaired NMC after ankle sprain. The defects in the structures causing these deficits have been explained based on many models. Deficits, especially in balance and proprioception, are explained by the damage of the joint and muscle mechanoreceptors. At the same time, people with CAI may experience decreased plantar sensitivity and damage to the cutaneous sensation (5, 8, 56).

2.3.2.1. Impaired proprioception and somatosensory function

Somatosensory function has a wide network that receives information from joint mechanoreceptors, muscle and cutaneous afferents (57). Joint mechanoreceptors located in the joint capsule, ligament and bones. And provide information about JPS and joint compression (58). After ankle sprain, ligament and joint capsule are damaged and as a result of, mechanoreceptor disruption occurs. As a result of this disruption, the proprioceptive sense is damaged, and causing a feeling of giving away in the ankle and recurrent sprains.

The name of this theory is called Freeman's articular deafferentation (59, 60, 61). Although the accuracy of this theory is accepted, the points it lacks are still controversial. It has been argued that proprioception deficits may be caused not only by deafferentation due to lateral ligament damage, but also by the lack of afferent stimulus in the musculotendinosis structure of the muscles involved in ankle stabilization. And not only alpha motor neuron activity, but also gamma motor neuron activation and chronic adaptations of the muscles, such as muscle weakness, should be considered. JPS plays an important role in ankle control and thereby reducing the risk of injury. Considering the studies on this subject, in people with CAI, it was seen that deficits in JPS and re-injury risks are common (61, 62, 63). As it is known, cutaneous mechanoreceptors that perceive senses such as vibration, pressure, and temperature take part in somatosensory function and proprioception (8). However, the direct association of disruption in these senses with the CAI has not been proven (5). Therefore, more studies are needed on this subject.

2.3.2.2. Impaired neuromuscular control

Neuromuscular impairments are explained by delays in muscle reaction time. In individuals with CAI, the reaction times of the peroneal muscles, which play an important role in ankle control, are delayed. The reason for these delays can be explained by slow nerve conduction velocity and decreasing effects of proprioceptive impairments on motor control. Muscle reaction time of these muscles, especially to inversion perturbation, are associated with CAI (5, 8, 59).

2.3.2.3. Impaired postural control

Postural control impairments, which is involved in regulating balance, is very common in people with CAI and after acute LAS. Postural control needs, somatosensory, visual and vestibular stimuli and appropriate motor response in order to regulate balance. In the previous studies, the single leg stance evaluation method was used to test the static postural control, and people with CAI has shown postural control deficits in both involved and uninvolved ankle. And also, in individuals with CAI, dynamic postural control was evaluated mostly with star excursion balance test (SEBT) and y balance test (YBT) and postural control deficits were found in the involved and uninvolved ankle (5, 59).

Neuromuscular and proprioception impairments are thought to be associated with postural control deficits (64). According to the feedback mechanism in Freeman’s theory, the ankle joint that does not get the appropriate afferent stimulation and cannot reveal the correct efferent stimulation from the central nervous system and the postural control mechanisms deteriorates. Apart from this theory, it is also controversial that the motor control mechanism of the spinal region has been altered due to the defect in both the alpha and gamma efferent mechanisms of the muscle and tendon structures (59).

In order to maintain balance on single leg stance, pronation and supination movement is seen in the foot and it is called ankle strategy. People with CAI, on the other hand, use hip strategies, which is less productive, to balance on single leg stance. The reason for the emerging strategy change is the changes in central neural control. After acute LAS, although the deficits in postural control resolve after a few month, when functional deficits are not treated with appropriated rehabilitation program after acute injury, then recurrent sprains may be encountered (5, 59).

2.3.2.4. Strength Deficits

Ankle evertor muscles play a protective role for injury. It is known that PL and PB muscles have a supporting role on ligaments. Therefore, the strength of these muscles are important for the support mechanism (63). Manual methods and measurements with an isokinetic dynamometer prove that people with CAI have peroneal muscle weakness (65, 66). At the same time, some studies have been carried out showing that, there is a decrease in muscle strength of other primary muscles besides the peroneal muscles (59, 67). Although the mechanisms that causing muscle weakness have not been fully explained, it is thought to be related to the change in the muscle stimulation mechanism resulting from impaired NMC. At the same time, as a result of the changes in the contraction mechanisms of the gastrocnemial muscles, decrease in plantar flexion strength can be observed. All muscle strength deficits seen in CAI are seen as motor control deficits due to changes in muscle contraction mechanism rather than muscle damage (59).

2.3.3. Treatment

Weeks or months after acute LAS, even though the majority of inflammatory findings regress, a rehabilitation program is required to prevent recurrent sprains (5). The purpose of rehabilitation programs is to maintain the integrity of the tendon, muscle and ligament and to eliminate the symptoms that may cause mechanical and functional instability. Studies also suggest that functional exercise trainings such as balance and postural control, within the early rehabilitation program implemented after acute LAS, are preventive of recurrent sprains (68, 69). Apart from these applications, taping and bracing methods are also used to prevent symptoms that cause specifically mechanical instability and recurrent sprains (5, 35). And also reduced ROM, which causes primarily mechanical instability, can be increased by strengthening the ankle muscles, stretching and joint mobilizations (69).

In the treatment of CAI, the purpose of the rehabilitation program is to increase muscle strength and improve NMC and postural control to provide control of the ankle on the ground. According to articles, as part of the strengthening program, a holistic study should be applied in the form of eccentric and concentric contractions for all muscles involved in ankle control. Studies have shown that strengthening studies have positive effects not only on ankle muscle strength but also on proprioception. One of the methods to be applied for strengthening exercises is progressive resistance exercises. With these exercises, the ankle is gradually strengthened against resistance mostly using TheraBands, with both eccentric and concentric contraction, focusing on eccentric contraction (68).

Within the scope of neuromuscular training programs, proprioceptive exercise and postural control training are included (70, 18). Although the proprioceptive exercises applied in the studies vary, they are mostly applied in the form of various coordination exercises such as wobble board, ankle disc and trampoline (18, 71). And both static and dynamic balance and coordination studies are also used to improve postural control and stability. Especially when studies comparing the traditional rehabilitation program with dynamic balance training programs, it’s cannot be understood which component is superior, but it is known that both of them have increasing effects on both postural control and JPS (72).

In addition, dynamic balance and coordination exercise trainings, have been shown to have positive effects on muscle strength besides postural control. Dynamic balance exercises have been used in many studies to create adaptation in the spinal and supraspinal areas of motor control and restore the order of CNS and somatosensory afferent stimulus, on different surfaces, with eyes open and closed, and then to be continued with perturbations. If it is desired to be provided by perturbation, it is to reveal a controlled afferent response with appropriate sensory input. Also, when the studies on hop to stabilization exercises are analyzed, it is seen that these exercises when applied 4-

6 weeks, have increasing effects on static-dynamic balance and muscle strength (20, 59, 73, 74).

Rehabilitation programs that are implementing, both after acute LAS and CAI should be selected individually after the necessary evaluations are made.

3. MATERIALS AND METHOD

3.1. Subjects

This study was conducted with physical active volunteers between the ages of 18-30 between December 2019 and May 2020, the number of individuals to be taken while working with an alpha error share of 0.05 and a power of 80% in beta 0.20 was determined as 30 (8 M 22 F) (72). Participants whose demographic information and "Cumberland Ankle Instability Tool (CAIT)" scores were received, were randomly divided into two groups (15 for each group). The randomization conducted by using Microsoft Excel Programming. The identified participants will be informed about the study and a signed consent form will be obtained from the participants who agree to participate in the study (Appendix 1). The study protocol was approved by the Yeditepe University Ethical Committee at the date of 21.11.2019 with the issue number of 37068608-6100-15-1781 (Appendix 2). Inclusion and Exclusion criteria of this study were mentioned below.

1. Inclusion criteria

Participations of the study;

- Scored 24 or less in the CAIT,
- Participate in every therapy session for 6 weeks and
- Age between 18-30 years were included.

2. Exclusion criteria

Participations of the study;

- With a history of neuromusculoskeletal and/or vestibular disorders,
- Had a lower limb trauma for at least 3 months before the study was excluded.

3.1.3 Study protocol

The study was started with 30 individuals. In the first group participants conducted balance exercises (BG) and for the second group, participants conducted strengthening exercises (SG). In both groups, exercises were completed with an unstable ankle. Participants asked to attend all training sessions which are held two days a week for six weeks. During the study, a participant from SG failed to participate regularly and excluded from the study. In this study, dynamic balance and somatosensory evaluation were included for evaluation criteria. Evaluation criteria were applied at the beginning and end of the study and each training session lasted approximately 35 minutes. (Figure 3.1)

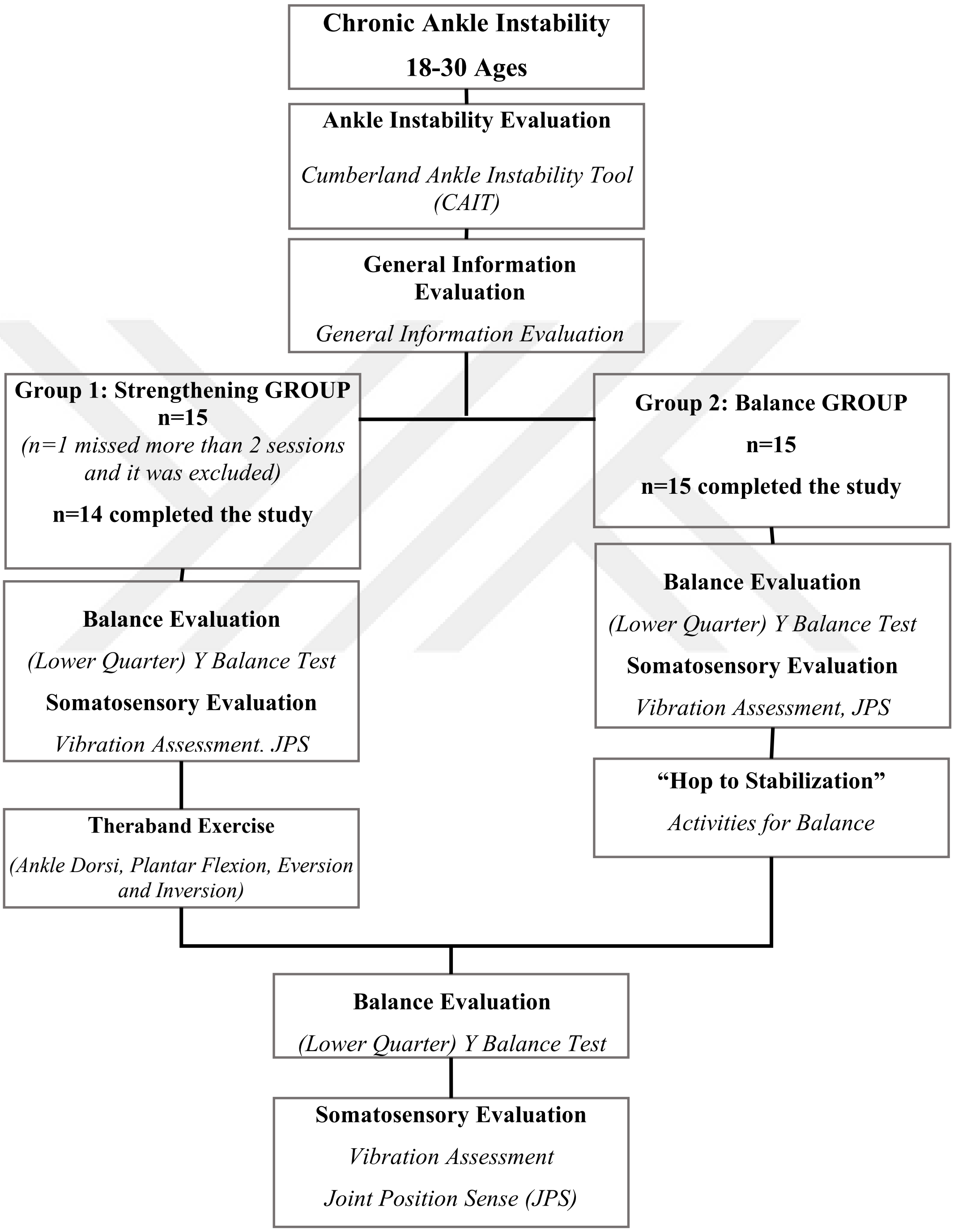

Figure 3.1. Flow chart of the study

3.2. Evaluations

In order to evaluate the participants, 4 different evaluation methods were used. Two of these methods are in the form of a questionnaire and were applied at the beginning of the study for the selection of participants. The other two, which requires a physical approach, were applied both at the beginning and at the end of the training, using techniques that provide objective data.

3.2.1. Evaluation of ankle instability

At the beginning of the study, a questionnaire called "CAIT" was used to provide numeric data about the ankle instability and to decide suitable participants before being accepted to study.

The CAIT has proved to be a valid and reliable for the assessment of functional ankle instability. This measurement tool consists of 9 items and can be used for both right and left ankle and graded out of 30 points in which the instability increases with lower score. The CAIT maintains specific symptoms like feelings of "giving away" and recurrent sprains and questions physical activities that are difficult to perform (1,75). When the CAIT results are wanted to be evaluated, participants with a score of ≥ 24 have lower and ≤ 24 have higher probability to have functional ankle instability and more likely to re-sprain (1). (Appendix 3)

3.2.2. Demographic characteristics of the participants

A form called "General Information Evaluation Form" was prepared to evaluate the demographic characteristics of the participants, who were selected based on their CAIT scores.

This form, which was prepared in accordance with the protocol of the study, was applied to all participants at the beginning. With this form, participant's demographic characteristics, socio-demographic conditions, disorders and deficits, any past or present trauma, surgical applications, sleep patterns, medications, exercise status and smoking/alcohol/caffeine use were questioned (Appendix 4).

3.2.3. Dynamic balance evaluation

Within the scope of the dynamic balance assessment, the "YBT" was used as a performance test and the data were recorded numerically before and after.

The YBT for Lower Quarter: is known as the simplified version of the "SEBT".

This test consists of the upper quarter and lower quarter test. For the lower quarter test, the system provides movement in anterior, posteromedial and posterolateral directions.

- To prepare the test, 3 tape measure should be fixed to the ground in Y shape at equal angles (90°, 135°).
- For the starter position, subjects will be stood on the grand with unstable ankle and hands on the hip. During the trial, the contralateral foot must be pushed as far as possible throughout the red line. And the reach distance is noted in centimeters (Figure 3.2).
- 4 practice trails will be completed in anterior, posteromedial and posterolateral directions with the unstable ankle.
- After that 3 trials must be completed with the unstable ankle. And the rest length between directions is determined as 15 seconds.

For the test to be successful, the balance has to be maintained, arms and heels should maintain their initial positions throughout the entire trial. Reach distance average/limb length×100 formula was used to calculate the reach distance for each direction (76-79). (Appendix 5)

3.2.4. Somatosensory evaluation

Within the scope of the somatosensory evaluation, proprioception and vibration evaluations were made objectively and the data were recorded to be at the beginning and end of the treatment.

3.2.4.1. Proprioception assessment

JPS test was performed to assess proprioception on the unstable leg. In this study, measurements were taken using an electronic goniometer. During the trial, subjects lay supine on a bad, pillows must be placed under both legs and knees and eyes should be kept closed. The stages of the test should be clearly explained to the subjects.

For the testing:

- The goniometer was placed with the pivot point on the lateral malleolus, the proximal arm at the level of the lateral surface of the fibula and the distal arm at the 5th metatarsal level as shown in Figure 3.3. In order not to trigger the tactile sense, goniometer should not be touched to the skin.
- After the goniometer is placed in the initial position of the ankle which is 145° plantar flexion, ankle was passively dorsiflexed at 105°,120°,130° and 140°.
- After that subjects were relaxed their leg to the initial positions and then they were actively dorsi flexed their leg to same degrees.

Final degrees must be measured with a goniometer. For each degree three repetitions are necessary for the assessment and as a result of these repetitions at each angle value, the average angle value was recorded. (80). (Appendix 6)

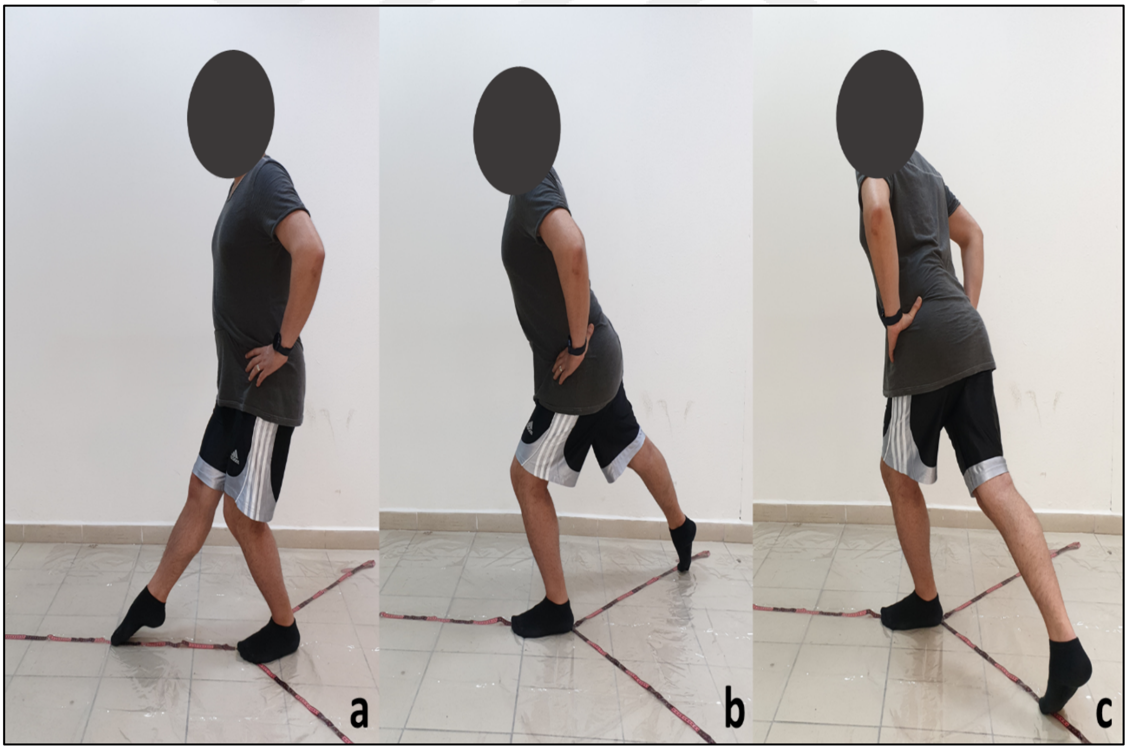

Figure 3.2. Y Balance Test: (a) Anterior Reach. (b) Posterolateral Reach. (c) Posteromedial Reach.

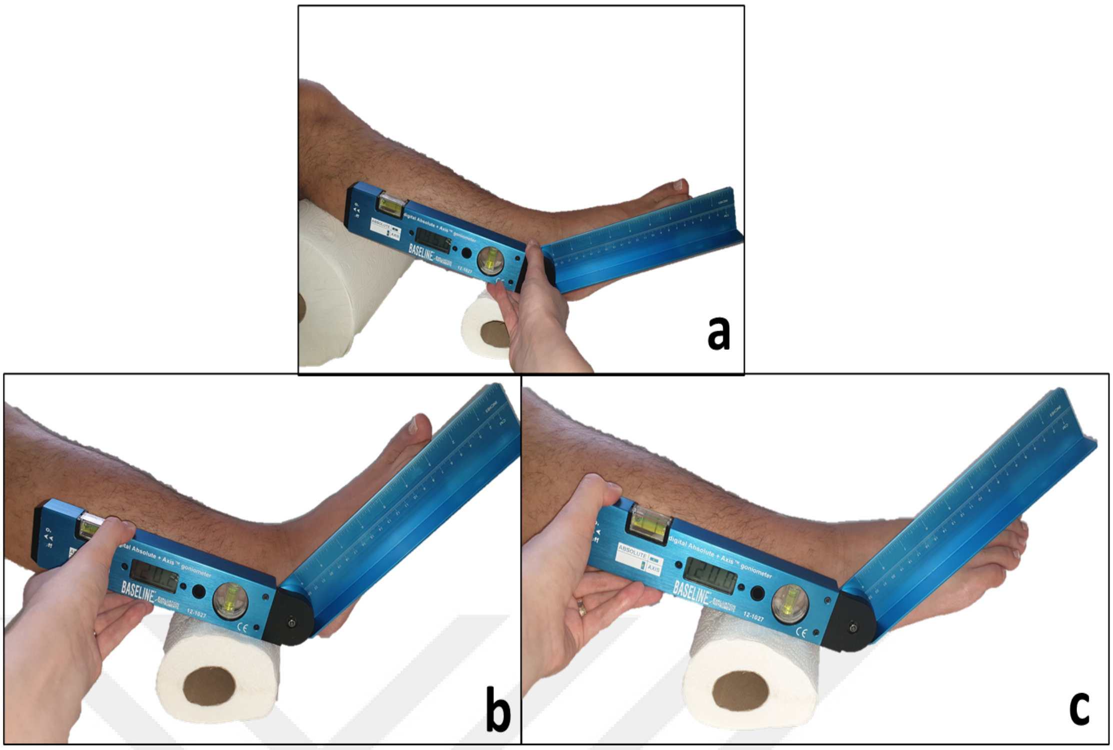

Figure 3.3. JPS Measurements: (a) 145° Plantar Flexion (Initial Position). (b) 120° Dorsiflexion. (c) Back to Initial Position.

3.2.4.2. Vibration assessment

For the vibration assessment:

- A tuning fork (128 Hz.) was used and the medial malleolus, great toe and fifth toe were selected and used as reference points (Figure 3.4).
- For the test to be successful, eyes must be closed during the entire trial. Before starting the test, a trial test was performed on the bone tissue to make the subject feel the sense of vibration.
- To perform the test, the fork must be hit on the hard ground and touch the reference point after the vibration sound has been heard sufficiently.
- After the fork was placed, for each reference point (Figure 3.4), the seconds at which the sensation of vibration ended according to the participant, was recorded by using stopwatch.
- 3 trials were made for each reference point and averaged separately. (81, 82). (Appendix 6)

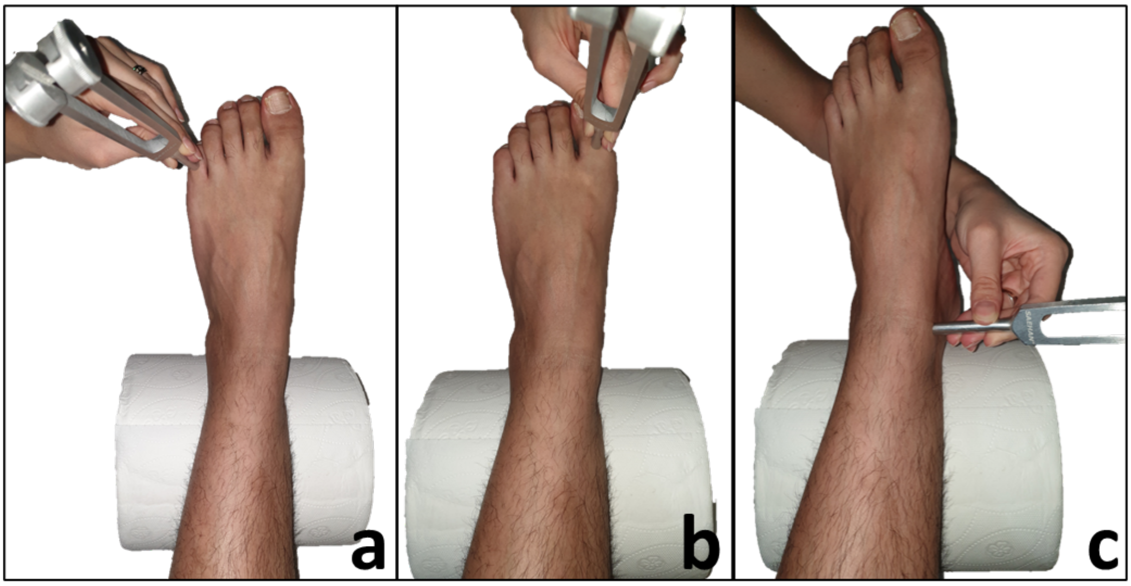

Figure 3.4. Vibration Assessments: (a) Fifth Toe. (b) Great Toe. (c) Medial Malleol.

3.3. Interventions

As a result of the literature review two types of the training program were selected for each treatment group. These training programs include strengthening and balance exercises components. For each component of treatment, visual and verbal feedbacks were given to the subjects and training complexity was increased once in two weeks for each treatment group.

3.3.1. Strengthening training group

For the strengthening exercise component,

- TheraBand was used to enhance proprioception and strength.
- TheraBand exercises were implemented in the direction of ankle dorsiflexion, plantar flexion, eversion and inversion (Figure 3.5).
- The strength of the TheraBand was increased respectively red, green, blue to provide progressive resistive exercise and a sufficient training overload, (16).

Considering the power distributions according to the colors of the TheraBands, in the first two weeks the red TheraBand was used, which it has the lowest strength, and then gradually strength increased with the green and blue TheraBand in fallowing weeks with 2 weekly periods. (Table 3.1).

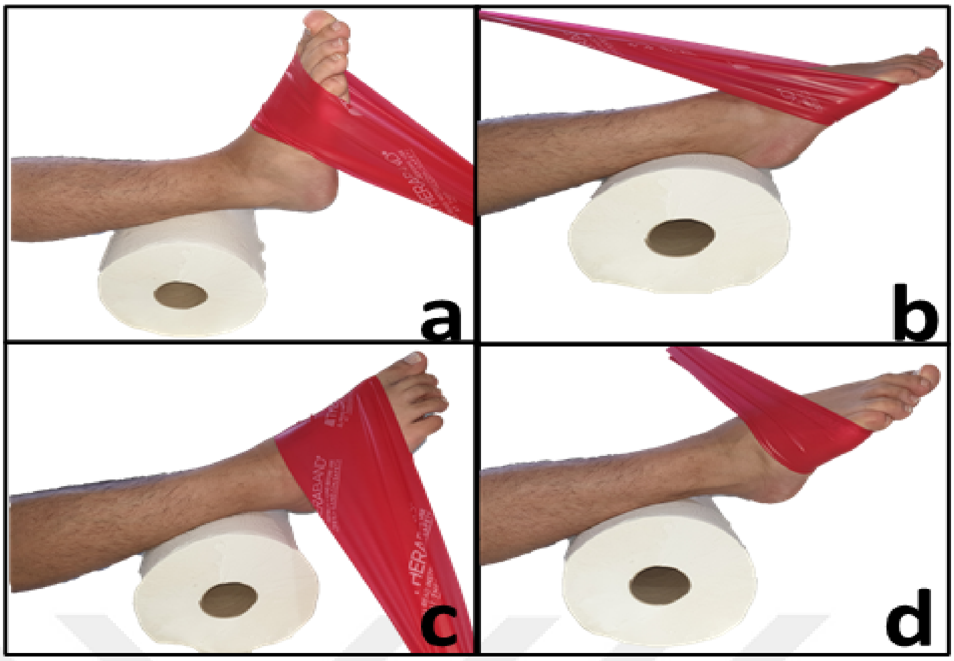

Figure 3.5. Red TheraBand Exercises: (a) Dorsiflexion. (b) Plantarflexion. (c) Inversion. (d) Eversion.

Table 3.1. Training Protocol for Strengthening Group

TRAINING PROTOCOL FOR STRENGTHENING GROUP	
WEEK 1-2	**Strengthening Group** ➔ Red TheraBand for ankle dorsiflexion, eversion, inversion and plantar flexion. 3x10
WEEK 3-4	**Strengthening Group** ➔ Green TheraBand for ankle dorsiflexion, eversion, inversion and plantar flexion. 3x10
WEEK 5-6	**Strengthening Group** ➔ Blue TheraBand for ankle dorsiflexion, eversion, inversion and plantar flexion. 3x10

3.3.2. Balance training group

Table 3.2. Hop to stabilization Activities

HOP TO STABILIZATION ACTIVITIES	
HOP TO STABILIZATION	**Level 1**
	45 cm hop. Allowed to use arms to aid in stabilizing balance after landing.
	Anterior/Posterior, Medial/Lateral, Anterolateral /Posteromedial, and Anteromedial/ Posterolateral directions.
	10 hops in each direction.
	Level 2
	45 cm hop with both hands on the hips while stabilizing balance after landing.
	Anterior/Posterior, Medial/Lateral, Anterolateral /Posteromedial, and Anteromedial/ Posterolateral directions.
	10 hops in each direction.
HOP TO STABILIZATION AND REACH	**Level 2**
	Participants hopped, stabilized, and reached back to the starting position. Then they hopped back to the starting position and reached to the target position.
	45 cm hop with both hands on the hips while stabilizing balance after landing.
	5 hops in each direction.
	Anterior/Posterior, Medial/Lateral, Anterolateral /Posteromedial, and Anteromedial/ Posterolateral directions.
SINGLE LEG STANCE EYES OPEN	**Level 1**
	Arms the across chest on a hard floor for 60 seconds.
	3 repetitions.
SINGLE LEG STANCE EYES CLOSED	**Level 1**
	Arms out on a hard floor for 30 seconds.
	3 repetitions.

For the balance exercises component:

- To enhance balance, hop to stabilization activities were used.
- These dynamic activities developed by McKeon et al. and provides subject to maintain their single-limb stance and improve automatic strategies to achieve the desired movement (74). The movements selected from these activities for use in the study are explained in detail in the table (Table 3.2).
- For the BG, each activity stages and have their progression level and increased every two weeks according to the subject's ability.
- With these progression levels it is intended to activate postural stability with increasing functional variability (74).

Detailed information about the contents of the training protocol in the BG, can be found in the table below (Table 3.3). And some of the hop to stabilization activities used in this study were shown in Figure 3.6, Figure 3.7 , Figure 3.8 and Figure 3.9.

Table 3.3. Training Protocol for Balance Group

TRAINING PROTOCOL FOR BALANCE GROUP	
WEEK 1-2	**Hop to stabilization**
	A. Anterior/posterior—Level 1 x10
	B. Medial/lateral—Level 1 x10
	C. Anterolateral/posteromedial—Level 1 x10
	D. Anteromedial/posterolateral—Level 1 x10
	Single-limb stance eyes open—Level 1 x3
WEEK 3-4	**Hop to stabilization**
	E. Anterior/posterior—Level 2 x10
	F. Medial/lateral—Level 2 x10
	G. Anterolateral/posteromedial—Level 2 x10
	H. Anteromedial/posterolateral—Level 2 x10
	Single-limb stance eyes open—Level 1 x3
WEEK 5-6	**Hop to stabilization and reach**
	I. Anterior/posterior—Level 2 x5
	J. Medial/lateral—Level 2 x5
	K. Anterolateral/posteromedial—Level 2 x5
	L. Anteromedial/posterolateral—Level 2 x5
	Single-limb stance eyes closed—Level 1 x3

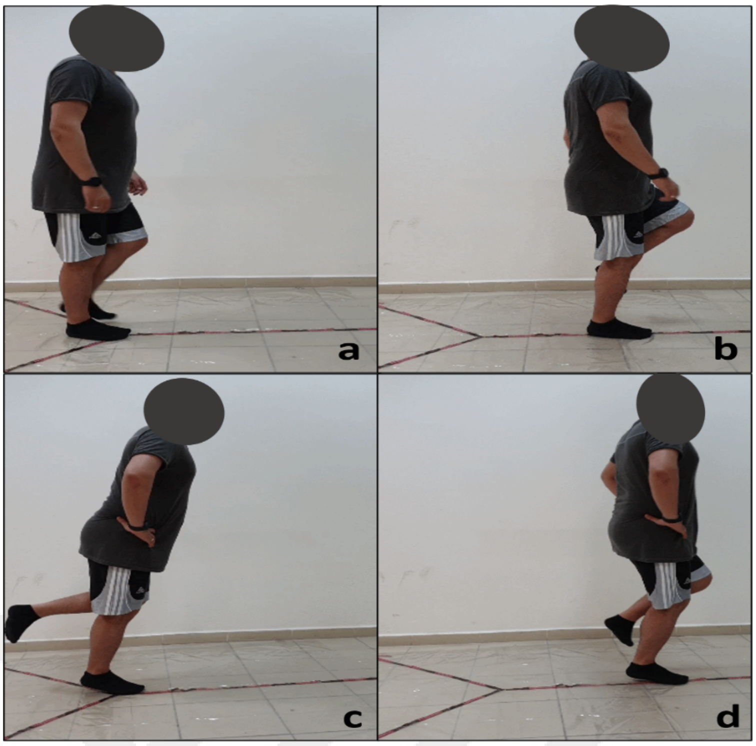

Figure 3.6. Hop to Stabilization: (a) Level 1 Initial Position . (b) Level 1 Anterior. (c) Level 2 Initial Position. (d) Level 2 Anterior.

Figure 3.7. Hop to Stabilization: (a) Level 1 Initial Position. (b) Level 1 Lateral. (c) Level 2 Initial Position. (d) Level 2 Lateral.

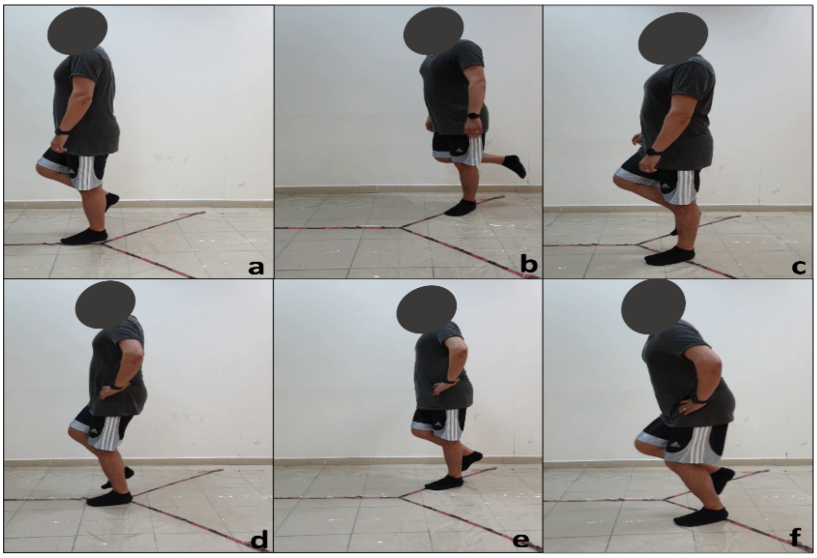

Figure 3.8. Hop to Stabilization: (a) Level 1 Initial Position. (b) Level 1 Posteromedial. (c) Level 1 Posterolateral. (d) Level 2 Initial Position. (e) Level 2 Posteromedial. (f) Level 2 Posterolateral.

Figure 3.9. Hop to Stabilization and Reach – Level 2: (a,d,e,j) Initial Positions. (b) Anterior. (c) Posterior. (e) Posteromedial. (f) Anterolateral. (h) Posterolateral. (i) Anteromedial. (k) Lateral. (l) Medial.

3.4. Statistical Analysis

SPSS (Statistical Package for Social Sciences) version 26 was used to evaluate the data obtained from the study. Mean, standard deviation (SD), median, minimum and maximum values were used for the presentation of continuous variables (quantitative variables) and frequency and percentage values were used for the presentation of categorical variables (qualitative variables). Shapiro Wilk test was used to investigate the suitability of quantitative variables to normal distribution. A Chi-Square test was used to compare categorical variables between groups. The data obtained by comparing the pre-treatment measurements between the groups were performed with independent samples t-test for parametric variables and the Mann Whitney U-Test for nonparametric variables. The difference between the pre and post-measurements taken from participants in groups was examined by student's paired sample t-test for parametric variables and Wilcoxon test for nonparametric variables. The data obtained by comparing the pre-treatment and post-treatment measurements (Δ) between the groups were performed with independent samples t-test for parametric variables and the Mann Whitney U-Test for nonparametric variables. In all statistical analyses, $p < 0.05$ was accepted as the level of significance.

4. RESULTS

4.1. Descriptive Characteristics of Participants

This study was conducted with physically active volunteers with CAI (n=29) between the ages of 18-30 between December 2019 and May 2020.

The demographic characteristics of participants includes, values of mean age, and body mass index (BMI) of the BG and SG are presented in Table 4.1.

According to these findings, there was no statistical difference in groups in terms of age, and BMI between groups according to independent samples t-test.

Table 4.1. Demographic Characteristics of Participants

	SG Mean ± SD	**BG Mean ± SD**	**t**	**p-value**
Age	27,07 ± 9,64	26,53 ± 3,90	0,19	0,84
BMI	24,76 ± 5,64	23,54 ± 3,09	0,72	0,47

SD: Standard deviation. BMI: Body mass index. SG: Strengthening training group. BG: Balance training group.

Means and SD of CAIT scores and duration of ankle instability in groups and differences between groups according to the CAIT were presented in Table 4.2.

Table 4.2. Comparison of CAIT Scores and Duration of Ankle Instability in Groups and Between Groups

	SG Mean ± SD	BG Mean ± SD	t	p-value
CAIT Scores	13,07 ± 7,00	15,73 ± 5,56	-1,13	0,26
Duration of Ankle Instability	4,86 ± 1,29	3,73 ± 1,71	1,98	0,057

SD: Standard deviation CAIT: Cumberland Ankle Instability Tool. SG: Strengthening training group. BG: Balance training group.

Means and SD of gender, dominant hand and unstable ankle values in groups and differences between groups were presented in Table 4.3.

Table 4.3. Comparison of Gender, Dominant Hand and Unstable Ankle Values in Groups and Between Groups

		SG (%) (n)	BG (%) (n)	λ²	p-value
Gender	**Female**	93 (13)	53 (8)	5,66	**0,01***
	Male	7 (1)	47 (7)		
Dominant Hand	**Right**	93 (13)	87 (13)	0,29	0,58
	Left	7 (1)	13 (2)		
Unstable Ankle	**Right**	71 (10)	60 (9)	0,41	0,51
	Left	29 (4)	40 (6)		

SD: Standard deviation CAIT: Cumberland Ankle Instability Tool. SG: Strengthening training group. BG: Balance training group. * p<0,05 statistical difference. λ²: Chi-Square Test.

4.2. Comparison of Pre-treatment Evaluations Methods Findings Between Groups

The independent samples t-test for parametric variables and Mann-Whitney U-Test for nonparametric variables were used to compare the variables between groups for pre-treatment evaluations methods.

4.2.1. Comparison of y balance test for lower quarter findings between groups

As a result of the statistical analysis, no significant difference was found between groups according to values of Y balance test in anterior, posterolateral (PL) and posteromedial (PM) directions (Table 4.4)

Table 4.4. Comparison of Pre-Treatment Y Balance Test for Lower Quarter Findings Between Groups

Y Balance Test (cm)	SG Mean ± SD	BG Mean ± SD	t	p-value
Anterior	65,07 ± 6,69	66,93 ± 9,96	-0,58	0,56
Posterolateral	71,78 ± 10,28	75,60 ± 13,75	-0,84	0,40
Posteromedial	63,28 ± 12,02	63,33 ± 14,03	-0,01	0,99

SD: Standard deviation SG: Strengthening Training group. BG: Balance Training group.

4.2.2. Comparison of JPS findings between groups

According to the pre-treatment values of JPS, there are no statistical differences between groups at 105°, 120° and 130°.

However, a statistical difference was found at 140° between groups (Table 4.5).

Table 4.5. Comparison of Pre-Treatment JPS Findings Between Groups

JPS (degree)	SG Mean ± SD	BG Mean ± SD	Z*	p-value
105	104,93 ± 6,86	105,73 ± 2,73	-1,07	0,28
120	118,79 ± 6,75	120,66 ± 2,74	-1,32	0,18
130	128,38 ± 6,82	130,53 ± 4,22	-1,19	0,23
140	134,36 ± 6,392	139,26 ± 4,28	-2,23	**0,02****

SD: Standard deviation JPS: Joint position sense. SG: Strengthening training group. BG: Balance training group. *Z: Mann-Whitney U-Test for nonparametric values. **p<0,05 statistical difference

4.2.3. Comparison of vibration findings between groups

As a result of the statistical analysis, no significant difference was found between groups according to values of vibration assessment (Table 4.6).

Table 4.6. Comparison of Pre-Treatment Vibration Findings Between Groups

Vibration (s)	SG Mean ± SD	BG Mean ± SD	t	p-value
Medial Malleolus	9,50 ± 2,98	9,66 ± 3,01	-0,15	0,88
Great Toe	10,42 ± 3,50	10,57 ± 3,03	-0,14	0,88
Fifth Toe	9,61 ± 3,64	10,80 ± 3,14	-0,93	0,35

SD: Standard deviation SG: Strengthening training group. BG: Balance training group

4.3. Comparison of Evaluations Methods Findings Between Pre and Post-Treatment in SG

To observe differences in SG, according to pre and post treatment evaluation methods findings a student's paired t-test for parametric variables and Wilcoxon test for nonparametric variables were used.

4.3.1. Comparison of y balance test for lower quarter findings between pre and post-treatment in SG

According to statistical analysis, there is no statistical significance in anterior reach distance between pre and post treatment results. However, in PM and PL reach distance statistical differences were found between pre and post treatment results (Table 4.7).

Table 4.7. Comparison of Y Balance Test for Lower Quarter Findings Between Pre and Post-Treatment in SG

Y Balance Test (cm)	**Pre Mean ± SD**	**Post Mean ± SD**	**t**	**p-value**
Anterior	65,07 ± 6,69	69,21 ± 6,07	1,93	,07
Posterolateral	71,78 ± 10,28	83,57 ± 10,69	10,21	**,00***
Posteromedial	63,28 ± 12,02	74,64 ± 12,25	5,31	**,00***

SD: Standard deviation. *p<0,05 statistical difference

4.3.2. Comparison of JPS findings between pre and post-treatment in SG

When the statistical data are analyzed, as presented in Table 4.8, there are no statistical differences between pre and post-treatment results at 105°, 120° and 130° in JPS, while in 140° a statistical difference was found.

Table 4.8. Comparison of JPS Findings Between Pre and Post-Treatment in SG

JPS (degrees)	Pre Mean ± SD	Post Mean ± SD	Z*	p-value
105	104,93 ± 6,86	104,35 ± 2,84	-0,56	0,57
120	118,79 ± 6,75	119,00 ± 3,50	-0,42	0,67
130	128,38 ± 6,82	128,50 ± 5,06	-0,05	0,95
140	134,36 ± 6,39	139,21 ± 1,52	-2,51	**0,01****

SD: Standard deviation JPS: Joint position sense. *Z: Wilcoxan test for nonparametric values. **p<0,05 statistical difference.

4.3.3. Comparison of vibrations findings between pre and post-treatment in SG

According to statistical analysis, there are statistical significances between pre and post-treatment results in medial malleolus and fifth toe vibrations.

However, in great toe vibration there is no statistical difference between pre and post-treatment results (Table 4.9).

Table 4.9. Comparison of Vibration Findings Between Pre and Post-Treatment in SG

Vibration (s)	Pre Mean ± SD	Post Mean ± SD	t	p-value
Medial Malleolus	9,50 ± 2,98	10,85 ± 2,34	2,17	**0,04***
Great Toe	10,40 ± 3,55	11,50 ± 4,50	1,59	0,13
Fifth Toe	9,61 ± 3,64	11,64 ± 4,19	2,47	**0,02***

SD: Standard deviation*p<0,05 statistical difference

4.4. Comparison of Evaluations Methods Findings Between Pre and Post - Treatment in BG

To observe differences in BG, according to pre and post-treatment evaluation methods findings a student's paired t-test for parametric variables and Wilcoxon test for nonparametric variables were used.

4.4.1. Comparison of y balance test for lower quarter findings between pre and post-treatment in BG

According to statistical analysis, as in the SG, also in the BG, in PM and PL reach distance, statistical differences were found between pre and post-treatment results.

However, there is no statistical significance in anterior reach distance between pre and post-treatment results. (Table 4.10).

Table 4.10. Comparison of Y Balance Test for Lower Quarter Findings Between Pre and Post-Treatment in BG

Y Balance Test (cm)	Pre Mean ± SD	Post Mean ± SD	t	p-value
Anterior	66,93 ± 9,96	71,06 ± 6,77	1,79	0,09
Posterolateral	75,60 ± 13,75	85,20 ± 10,00	4,35	**0,00***
Posteromedial	63,33 ± 14,03	78,06 ± 12,01	5,22	**0,00***

SD: Standard deviation. *p<0,05 statistical difference

4.4.2. Comparison of JPS findings between pre and post-treatment in BG

As a result of the statistical analysis, no significant difference was found in BG, according to values of JPS assessment between pre and post-treatment (Table 4.11).

Table 4.11. Comparison of JPS Findings Between Pre and Post-Treatment in BG

JPS (degrees)	Pre Mean ± SD	Post Mean ± SD	Z*	p-value
105	105,73 ± 2,73	105,73 ± 2,76	0,00	1,00
120	120,66 ± 2,74	119,86 ± 2,50	-1,26	0,20
130	130,53 ± 4,22	130,26 ± 2,12	-,31	0,75
140	139,26 ± 4,28	139,93 ± 2,65	-,77	0,43

SD: Standard deviation JPS: Joint position sense.*Z: Wilcoxan test for nonparametric values.

4.4.3. Comparison of vibration findings between pre and post-treatment in BG

According to statistical analysis, there are statistical significances between pre and post-treatment results in medial malleolus and great toe vibrations. However, in fifth toe vibration there is no statistical difference between pre and post-treatment results (Table 4.12).

Table 4.12. Comparison of Vibration Findings Between Pre and Post Treatment in BG

Vibration (s)	Pre Mean ± SD	Post Mean ± SD	t	p-value
Medial Malleolus	9,66 ± 3,01	11,53 ± 2,85	2,58	**0,02***
Great Toe	10,57 ± 3,03	12,40 ± 3,48	2,37	**0,03***
Fifth Toe	10,80 ± 3,14	10,60 ± 2,97	-0,29	0,77

SD: Standard deviation .*p<0,05 statistical difference

4.5. Intergroup Comparison of Differences Between Pre and Post-measurements Findings

To compare the difference between pre and post measurements findings between groups, were performed with independent samples t-test for parametric variables and the Mann Whitney U-Test for nonparametric variables.

4.5.1. Intergroup comparison of differences between pre and post-measurements finding for Y Balance Test for Lower Quarter

When the statistical data are analyzed for intergroup comparison, as presented in Table 4.13, there are no statistical differences between pre and post-treatment results in Y balance test.

Table 4.13. Intergroup Comparison of Differences Between Pre and Post-Measurements Finding for the Y Balance Test for Lower Quarter

Y Balance Test (cm)	**SG Mean (Δ) ± SD**	**BG Mean (Δ) ± SD**	**t**	**p-value**
Anterior	4,21 ± 8,16	3,80 ± 8,82	0,13	0,89
Posterolateral	11,78 ± 4,31	10,06 ± 8,46	0,68	0,50
Posteromedial	11,35 ± 7,99	14,80 ± 11,04	-0,95	0,34

SD: Standard deviation SG: Strengthening training group. BG: Balance training group.

4.5.2. Intergroup comparison of differences between pre and post-measurements finding for JPS

Between pre and post-treatment, as a result of the statistical analysis to assess the values of JPS between groups, no significant difference was found at 105°, 120°, 130°.

However, at 140° statistical difference was found. (Table 4.14).

Table 4.14. Intergroup Comparison of Differences Between Pre and Post-Measurements Finding for JPS

JPS (degree)	**SG Mean (Δ) ± SD**	**BG Mean (Δ) ± SD**	**Z***	**p-value**
105	-0,57 ± 6,22	0,00 ± 3,29	-,066	0,94
120	0,21 ± 7,10	-1,06 ± 2,60	-,946	0,35
130	0,21 ± 9,07	0,00 ± 3,13	-,442	0,68
140	4,14 ± 4,80	0,66 ± 2,63	-2,268	**0,02****

SD: Standard deviation JPS: Joint position sense. SG: Strengthening training group. BG: Balance training group. *Z: Mann Whitney-U for nonparametric values. **$p<0,05$ statistical difference.

4.5.3. Intergroup comparison of differences between pre and post-measurements finding for vibration evaluation

According to intergroup statistical analysis, there are statistical differences between pre and post-treatment results in fifth toe vibration.

However, in the great toe and medial malleolus vibrations, there is no statistical difference between pre and post-treatment results (Table 4.15)

Table 4.15. Intergroup Comparison of Differences Between Pre and Post-Measurements Finding for Vibration Evaluation

Vibration (sn)	**SG Mean(∆) ± SD**	**BG Mean (∆) ± SD**	**t**	**p-value**
Medial Malleolus	1,35 ± 2,34	1,86 ± 1,80	0,65	0,51
Great Toe	1,07 ± 2,52	1,73 ± 2,65	0,68	0,49
Fifth Toe	2,00 ± 2,66	-0,86 ± 2,50	2,99	**0,00***

SG: Strengthening training group. BG: Balance training group. *$p<0,05$ statistical difference

5. DISCUSSION

This study aimed to investigate the differences between balance and strengthening training on ankle proprioception in people with CAI. For this purpose, ankle proprioception evaluation was compared between the two groups before and after treatment. And statistical data supporting this hypothesis are presented in this study.

Participants were divided into two groups by randomization method, and between the groups pre-treatment values, there were no statistical differences were found by means of age, BMI, year of the first sprain, CAIT scores, dominant hand and unstable ankle variables.

When looking at the gender means (F, M) between the 2 groups, significant differences were observed. This difference can be explained by the fact that the number of female participants in this study is higher compared to the male participants. When studies related to this subject are examined, studies emphasizing that in the female population, the ankle sprain frequency and sprain severity are higher than the male population (35, 39). Beynonn et al. stated that the frequency of ankle injuries in women is higher than in men. Although this difference is stated, the disparity of the anatomical structure between the genders should not be ignored (39). For the evaluation methods, when the differences between the group's pre-treatment values were examined, the BG group showed better results at 140° JPS, although there was no difference in the YBT and vibration sense. This difference is assumed to not affect the outcome of the study, as the groups were randomly allocated.

In the analysis made to question the JPS difference in the effectiveness of the treatment between the 2 groups and in groups, in the evaluation of 140° JPS, only SG showed greater improvements. However, pre-treatment 140° JPS value in BG, should be considered.

The differences between groups in the JPS can be explained with multiple reasons. Looking at the literature, it is possible to come across studies related to this subject (15, 16, 18, 83, 84). When the systematic review conducted by Holmes et al. is examined, while some studies performed using multiple treatment methods together, some results related to JPS were obtained, while other studies could achieve similar results only with the strengthening training using TheraBand. Significant increases in JPS were detected in this review, with balance, combined therapy programs and only with TheraBand exercises. These data obtained from different training groups evaluated JPS with different methods (84). Eils et al. observed improvement especially in dorsi and plantar flexion JPS after 6 weeks of combined training program (18). In their study, Docherty et al. found a significant increase in JPS of all ankle joint movements, using only progressive TheraBand exercises (16). And, in both studies, measurements were made with custom built electronic goniometer devices.

However, there is no study comparing TheraBand and hop to stabilization exercises in terms of JPS in literature. Therefore, it can be said that this study is the first in this regard. As it is known, the ankle dorsi and plantar flexion muscles are involved in stabilization and should work in harmony (44). In previous studies examined above, proprioceptive positive results were observed in these movements. Also, as is known, dorsiflexion limitation is a common condition in individuals with CAI. This is why it is important to evaluate dorsiflexion with JPS (8, 9). JPS development in the current study, seen in SG, in the direction of dorsiflexion, supports the literature. Despite the significant result found in this article, the margin of error of the goniometer should not be ignored. Dorsiflexion is an important component for ankle stabilization. Individual's ability to determine the dorsiflexion angle can help adjusting the ankle inversion angle and preventing repeated sprains.

In a study by Konradsen et al., the authors revealed that proprioceptive deficits were caused by a lack of afferent stimulus in the muscle and tendon structures, not from the deafferentation in the joints and ligaments by implementing regional block of the ankle and foot with local anaesthetic (85). And also in the study conducted by Bernier et al., writers found no improvement in inversion-eversion JPS after the balance exercises programs. And they argued that the balance and coordination did not affect peripheral afferent receptors, thus leads to no change in the JPS (15). According to the one other study, muscle spindles, which transmit dynamic and static changes in muscle length, also have connections with static and dynamic gamma efferent nerves, which increase the afferent stimulus. And specific ankle muscle strengthening training may increase these efferent stimulus, which makes muscle spindles more sensitive to muscle length (16).

Considering the difference between the two groups of the current study, the increase in proprioceptive development in SG may be explained by the more specific effect of TheraBand training –compered to the balance training- on muscle and tendon structures that involved in ankle stabilization. At the same time, TheraBand may restore the muscle motor neuron stimulus mechanism its normal order by eliminating the chronic adaptations such as muscle weekness and deteriorations of muscle flexibility, that these stabilizers show due to muscle contraction damage. In this way, by reducing the feeling of giving away, it may reduce the risk of recurrent sprain. In addition to these results, future research may focus more on this issue, and within the scope of proprioception evaluation, different studies can be compared with TheraBand.

In his article, Reggards states that in order to understand the severity of the somatosensory damage, it is necessary to determine in which regions the vibration sense deficits are seen and the width of the legion where the deficits are seen. And it also states that, although the vibration sense is an important evaluation method for assessing somatosensory damage, the most accurate measurement locations are distal joints, which are feet and hands (81). Apart from this, in another study by Takahara et al., the authors stated that the most valid measurement points used for the foot were medial malleolus, fifth toe and great toe. In the study conducted with individuals with peripheral neuropathy suspicions, both the interactions between the vibration senses at each point and the pressure senses at these points were examined. And according to the results, there was a connection between the pressure and vibration sensations especially of the great toe and the fifth toe. Apart from this result, it was seen that the sense of vibration at 3 points is also connected (82).

Disruption of peripheral afferent stimulus in CAI is thought to cause not only damage to the proprioceptive sense but also damage to the other cutaneous senses. (8). There is one study on this subject that prove that the decrease in the sensation of pressure and touch in the sole foot caused an increase in postural oscillations. (86). On the other hand, when the study conducted by Lee et al. in individuals with CAI, the medial malleolus vibration threshold sense measured by an electronic device and it was compared for 2 separate exercise groups (short foot exercises and proprioceptive sensory exercises). And significant improvements were observed in short foot exercises group (57). However the exercise methods used in that study are intended to increase balance and sole foot sense, and partially overlap with the exercise methods applied in the current study.

Apart from the main aim, when looking at the other evaluation method in this study, statistical difference between the 2 groups were found. In the fifth toe vibration sense assessment, SG again showed better results.

Although there was a greater increase in SG according to the fifth toe vibration sense evaluation, an increase was observed in medial malleolar vibration sense in both groups. Again, these results are similar to those found by Lee et al. (57). This increase in BG is thought to be due to the connection between postural stabilization and somatosensory sensation. This shows that balance exercises may have positive effects on somatosensory performance and it should be remembered that balance exercises can be used for this purpose in training sessions.

In the current study, especially the improvement in the 5th finger vibration sense in SG can be explained by the pressure-vibration relationship. Another study showed that the pressure in the lateral and central regions decreases when the arch of the foot is unstable (87). And also another study states that people with CAI have loss of control, especially in the lateral part of the foot, resulting in a feeling of giwing away in the ankle (23). Considering all the studies described above, TheraBand exercises applied in the current study are thought to have a positive effect on arc stabilization, provide a partial increase in lateral zone pressure and eventually an increase in lateral region vibration sense.

The current study has gained the quality of being one of the rare studies to better understand the relationship between proprioception and other somatosensory sensation in people with CAI. No other study investigating the effects of TheraBand and hop to stabilization exercises on vibration senses have been found in literature. The current study is also the first in this regard. In the comparison between groups, as in JPS, more significant improvements were observed in the sense of vibration in SG. This may prove that the proprioceptive sense increases in parallel with the other somatosensory senses. Although the connection between them is not fully understood, it can be thought that TheraBand exercises can also enable the activation of cutaneous sensations other than JPS, and it has positive effects on both the muscle contraction mechanism and the peripheral afferent stimulus.

When the YBT evaluation is examined, although there is no significant difference between the 2 groups, significant differences within the 2 groups (SG, BG) attracted attention. While significant increases were observed especially in the PL and PM directions, in the anterior direction, non-significant but better results were observed within the SG and BG.

As it is known, delays and deterioration in stabilization, esspecially for dynamic adjustments, are very common in people with CAI. When the articles to improve the dynamic balance are examined, in the 4-week combined study conducted by Hale et al., a great improvement was found in the post-treatment values especially in PM and PL directions (19). Although this result supports our data, when we look at another study in which strengthening exercise protocols are applied separately, no significant difference was found in the evaluation of the YBT in the groups with TheraBand exercises. Therefore, the authors concluded that not only ankle strengthening but also proximal joint strengthening is required to improve dynamic balance and contradicts with the results in this article (88).

In another study conducted by Hall et al., hop to stabilization balance exercises and TheraBand exercises were compared with each other in terms of dynamic balance and although there was no difference between the groups, a significant improvement in SEBT was found in the TheraBand group, which is also in line with the data in this study. In the article made by Hall et al., TheraBand exercises were applied with PNF (Proprioceptive Neuromuscular Facilitation) technique and they linked the significant increase in dynamic balance to this technique (20).

However, the current study has shown that only progressive TheraBand exercises can improve dynamic balance as well as hop to stabilization exercises. Which this results partially overlap with the data with those found by blackburn et al. (17). The reason for this may be that TheraBand exercises have their positive effects on the muscle contraction mechanism and these effects may improve functional performance. It is recommended that future research should analyze this inference in more detail. Besides, it should not be ignored that the hop to stabilization exercises, used in the present study and previous studies, were performed similarly to the positions in the YBT. However, in 2 groups, only in PL and PM directions, reach distance improvement was observed. In a study, regarding to this subject, it has been disscussed that the reaching in the anterior direction may have a different restrictive effect on the postural control and that the reaching in this direction can cause a vulnerable position more than the other two directions due to the ankle structure (77).

Since the results in this study partially overlap with these data, the reasons for the increase in the anterior reach distance were not significant, is that the postural control may be more difficult in this direction due to the arthrokinematic structure of the ankle. Future studies may differentiate exercise methods, taking this into account.

Future studies may also investigate the relationship between proprioception and cutaneous sensory deficits in people with CAI and other exercise methods that can treat these deficits.

Although the number of individuals to be taken within the scope of reference articles and alpha error share of 0.05 and beta 0.20 while working with 80% power was determined as 30, more participants could be included in future studies.

In this study, apart from limitations it’s suggested, somatosensory measurements can be made with more technological devices in order to obtain a lower margin of error. And to evaluate the long-term effects of balance and strengthening exercises after a 6-week treatment, evaluation methods can be performed follow-up.

6. CONCLUSIONS

- Hop to stabilization exercises, performed to improve dynamic balance and showed positive effects on dynamic balance and it is recommended to be used for this purpose in rehabilitation programs.
- The positive effects of hop to stabilization exercises, which are applied for 6 weeks, on the sensation of vibration have been stated, and it is recommended that these effects can be used as therapeutic in this area.
- With TheraBand exercises that are applied progressively for 6 weeks, JPS, vibration and dynamic balance components can all be improved simultaneously.
- In people with CAI, it has been concluded that TheraBand exercises, favor to the positive effects on somatosensory performance and can reduce the feeling of giving away and the risk of recurrent sprain.
- It was concluded that TheraBand exercises that were applied progressively for 6 weeks had a more positive effect on JPS and vibration senses compared to hop to stabilization exercises and were as effective as hop to stabilization exercises on dynamic balance.
- Considering the positive effects of both exercises on the evaluation results, both interventions should be implemented separately and/or combine, in the treatment of CAI.

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8. APPENDICES

8.1. Appendix 1. Informed Voluntary Consent Form

Bilgilendirilmiş Gönüllü Onam Formu

Araştırmanın Adı: Kronik Ayak Bileği İnstabilitesi Olan Kişilerde Denge Ve Kuvvetlendirme Eğitiminin Propriyosepsiyon Yönünden Karşılaştırılması.

"Sayın gönüllü katılımcı,

Yeditepe Üniversitesi Sağlık Bilimler Enstitüsü Fizyoterapi ve Rehabilitasyon Yüksek Lisans Tezi kapsamında planlanmış olan yukarıda adı yazılı araştırmaya katılmak üzere davet edilmiş bulunuyorsunuz. Bu araştırmada yer almayı kabul etmeden önce, araştırmanın ne amaçla yapılmak istendiğini anlamanız ve kararınızı bu bilgilendirme çerçevesinde özgürce vermeniz gerekmektedir. Aşağıdaki bilgileri lütfen dikkatlice okuyunuz, sorularınız olursa sorunuz ve açıkça yanıtlar isteyiniz."

Çalışma kapsamında, genel durumunuz hakkında ki bilgiler sizlere sorularak elde edinilecektir. Bu sorular, genel sağlık durumunuz, fiziksel durumunuz ve alışkanlıklarınız hakkında ki bilgilerden oluşacaktır. Alınan bilgiler haricinde, Fizyoterapist tarafından uygulanacak bir dizi değerlendirmeye tabi tutulacaksınız. Bu değerlendirmede; denge durumunuzu ölçecek testler ve duyu değerlendirmesi yer alacaktır. Değerlendirmeler dışında, Fizyoterapist tarafından haftada 2 gün olarak 6 hafta sürecek kuvvetlendirme ve denge egzersizleri içeren bir tedavi programına katılacaksınız ve verilen süre sonunda başta yapılan değerlendirmelerin tekrarı yine fizyoterapist tarafından gerçekleştirilecektir.

Bu araştırmada yer almak tümüyle sizin isteğinize bağlıdır. Araştırmada yer almayı reddedebilirsiniz ya da başladıktan sonra yarıda bırakabilirsiniz. Bu araştırmanın sonuçları bilimsel amaçlarla kullanılacaktır. Araştırmadan çekilmeniz ya da araştırmacı tarafından araştırmadan çıkarılmanız halinde, sizle ilgili veriler kullanılmayacaktır. Ancak veriler bir kez anonimleştikten sonra araştırmadan çekilmeniz mümkün olmayacaktır. Sizden elde edilen tüm bilgiler gizli tutulacak, araştırma yayınlandığında da varsa kimlik bilgilerinizin gizliliği korunacaktır.

Sorumlu Araştırmacı: Dr. Öğr. Üyesi Çiğdem Yazıcı Mutlu

Yardımcı Araştımacı: Fzt. Ayşe Asena Gülnergiz

“Kronik ayak bileği instabilitesi olan kişilerde denge ve kuvvetlendirme eğitiminin propriyosepsiyon yönünden karşılaştırılması.” adlı çalışmaya başlanmadan önce gönüllülere verilmesi gereken bilgileri içeren metni okudum (ya da sözlü olarak dinledim). Eksik kaldığını düşündüğüm konularda sorularımı araştırmacılara sordum ve doyurucu yanıtlar aldım. Yazılı ve sözlü olarak tarafıma sunulan tüm açıklamaları ayrıntılarıyla anladığım kanısındayım. Çalışmaya katılmayı isteyip istemediğim konusunda karar vermem için yeterince zaman tanındı. Bu koşullar altında, araştırma kapsamında elde edilen şahsıma ait bilgilerin bilimsel amaçlarla kullanılmasını, gizlilik kurallarına uyulmak kaydıyla sunulmasını ve yayınlanmasını, hiçbir baskı ve zorlama altında kalmaksızın, kendi özgür irademle kabul ettiğimi beyan ederim.

Gönüllünün Adı /Soyadı /İmzası /Tarih

Açıklama Yapan Kişinin Adı /Soyadı /İmzası /Tarih

8.2. Appendix 2. Ethical Committee Approval

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15- 1781 **21/11/2019**
Konu: Klinik Araştırmalar
Etik kurul Başvurusu hk.

İlgili Makama (Ayşe Asena Gülnergiz)

Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizik Tedavi ve Rehabilitasyon Dr. Öğr. Üyesi Çiğdem Yazıcı Mutlu'nun sorumlu araştırmacı olduğu **"Kronik Ayak Bileği İnstabilitesi Olan Kişilerde Denge ve Kuvvetlendirme Eğitiminin Propriyosepsiyon Yönünden Karşılaştırılması''** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası **(1765)** kayıt Numaralı KAEK Başvuru Dosyası, Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **20.11.2019** tarihli toplantıda incelenmiştir.

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isimi belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir (**KAEK Karar No: 1126**).

Prof. Dr. Turgay ÇELİK
Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurulu Başkanı

Yeditepe Üniversitesi 26 Ağustos Yerleşimi, İnönü Mahallesi Kayışdağı Caddesi 34755 Ataşehir / İstanbul
T. 0216 578 00 00 www.yeditepe.edu.tr F. 0216 578 02 99

8.3. Appendix 3. Cumberland Ankle Instability Tool

The Cumberland Ankle Instability Tool

NAME, SURNAME: DATE OF BİRTH:

	Left	Right	Score
1. I have pain in my ankle			
Never	□	□	5
During sport	□	□	4
Running on uneven surfaces	□	□	3
Running on level surfaces	□	□	2
Walking on uneven surfaces	□	□	1
Walking on level surfaces	□	□	0
2. My ankle feels UNSTABLE			
Never	□	□	4
Sometimes during sport (not every time)	□	□	3
Frequently during sport (every time)	□	□	2
Sometimes during daily activity	□	□	1
Frequently during daily activity	□	□	0
3. When I make SHARP turns, my ankle feels UNSTABLE			
Never	□	□	3
Sometimes during running	□	□	2
Often when running	□	□	1
When walking	□	□	0
4. When going down the stairs, my ankle feels UNSTABLE			
Never	□	□	3
If I go fast	□	□	2
Occasionally	□	□	1
Always	□	□	0
5. My ankle feels UNSTABLE when standing on ONE leg			
Never	□	□	2
On the ball of my foot	□	□	1
With my foot flat	□	□	0

	Left	Right	Score
6. My ankle feels UNSTABLE when			
Never	□	□	3
I hop from side to side	□	□	2
I hop on the spot	□	□	1
When I jump	□	□	0
7. My ankle feels UNSTABLE when			
Never	□	□	4
I run on uneven surfaces	□	□	3
I jog on uneven surfaces	□	□	2
I walk on uneven surfaces	□	□	1
I walk on a flat surface	□	□	0
8. TYPICALLY, when I start to roll over (or “twist”) on my ankle, I can stop it			
Immediately	□	□	3
Often	□	□	2
Sometimes	□	□	1
Never	□	□	0
I have never rolled over on my ankle	□	□	3
9. After a TYPICAL incident of my ankle rolling over, my ankle returns to “normal”			
Almost immediately	□	□	3
Less than one day	□	□	2
1–2 days	□	□	1
More than 2 days	□	□	0
I have never rolled over on my ankle	□	□	3

8.4. Appendix 4. Demographic Characteristics of Participant

Genel Bilgi Değerlendirme Formu

ADI-SOYADI:
YAŞ:
CİNSİYET: K ☐ E ☐
DOMİNANT TARAF: sağ ☐ sol ☐
BOY: **KİLO:** **BKI:**
MESLEK: İşçi ☐ Memur ☐ Bankacı ☐ Öğretmen ☐ diğer …………..
ÖZGEÇMİŞ (kendinde varolan hastalıklar) Kardiyak ☐ SVO ☐ Diyabet ☐ Hipertansiyon ☐ Diğer ………………………………
SOYGEÇMİŞ (ailede varolan hastalıklar) Kardiyak ☐ SVO ☐ Diyabet ☐ Hipertansiyon ☐ Diğer ………………………………
NÖROLOJİK HASTALIKLAR Migren ☐ Epilepsi ☐ Multiple Skleroz (MS) ☐ Kas hastalıkları ☐ …………….. Diğer ……………………………
VESTİBULER HASTALIKLAR Vertigo ☐ Duyma Kaybı ☐ Çınlama ☐ Görsel Bozukluklar ☐ Diğer …………
GEÇİRİLMİŞ AMELİYAT YOK ☐ VAR ☐ VAR İSE ………………………..
GEÇİRİLMİŞ TRAVMALAR Kalça ☐ Var ise……….. Ne zaman….. Diz ☐ Var ise …………. Ne zaman….. Ayak bileği ☐ Var ise……….. Ne zaman……….
İLAÇ KULLANIMI: YOK ☐ VAR ☐ VAR İSE ………………………………………
SİGARA YOK ☐ VAR ☐ …...adet/gün — **ALKOL** YOK ☐ VAR ☐ …...kadeh/hafta — **KAFEİN** YOK ☐ VAR ☐ ……kupa/gün
UYKU SÜRESİ: ………saat/gün
DÜZENLİ EGZERSİZ DURUMU: YOK ☐ VAR ☐ …………................… ……gün/hafta ……saat/gün
REHABİLİTASYON PROGRAMINA KATILIM SÜRESİ: …….. hafta haftada …….. gün

8.5. Appendix 5. Y Balance Test Score Card

Anterior (cm)	Posterolateral (cm)	Posteromedial (cm)	Leg Length (cm)
1.	1.	1.	
2.	2.	2.	
3.	3.	3.	

8.6. Appendix 6. Somatosensory Evaluation Tests Score Card

Joint Position Sense – JPS

105°	**120°**	**130°**	**140°**
1.	**1.**	**1.**	**1.**
2.	**2.**	**2.**	**2.**
3.	**3.**	**3.**	**3.**

Vibration Assessment

Medial Malleolus (s)	**Great Toe (s)**	**Fifth Toe (s)**
1.	**1.**	**1.**
2.	**2.**	**2.**
3.	**3.**	**3.**

9. CURRICULUM VITAE

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ACADEMIC PUBLICATION AND PRESENTATIONS

- Gulnergiz E. T., **Yekdaneh A. A.**, Dilibal S., Sahin H. (2019). Katmanlı İmalat Yöntemiyle Üretilmiş Çoklu Serbestlik Dereceli Pnömatik Rehabilitasyon Ortezi, 5. Türkiye Robotbilim Konferansı (ToRK-2019) Bildiriler Kitabı, Özyeğin Üniversitesi, ISBN: 978-605-5625-16-0

PROFESSIONAL EXPERIENCE

- Özel Sempati Özel Eğitim ve Rehab. Merkezi, İstanbul - *Şubat 2018 – ---*
- Özel Manavgat Yaşam Hastanesi, Antalya - *Mart 2017 - Ocak 2018*