Adopted: 2/1/16

Ankle Sprains: Assessment

Background

Ankle sprains are among the most common musculoskeletal injuries seen by health care providers. It is estimated that in the United States one in every 10,000 people sprains an ankle every hour, totaling nearly 30,000 ankle sprains per day. The incidence rates of ankle sprain range from 2.15 per 1000 person-years* in the general population to 58.4 per 1000 person-years in physically active populations. They account for up to 40% of all athletic injuries and over half of the injuries occurring in basketball alone. Ankle sprains are also commonly seen in athletes participating in soccer, football, running and dance. (Prado 2014, Chan 2011, Waterman 2010)

Despite the high prevalence and severity of lifestyle-limiting symptoms that follow the injury, ankle sprains are often regarded as benign injuries that will resolve on their own and therefore many people who suffer ankle sprains do not seek treatment from a healthcare provider. The incidence of residual symptoms following an acute ankle sprain varies, but has been reported with rates of between 40% and 50%. It is also reported that as many as 20% of acute ankle sprains develop chronic ankle instability (Chan, 2011). Ankle sprains in sport may result in varying degrees of debilitation including decreased performance, absence from competition and adverse psychological effects. Ankle sprains also have high economic costs associated with the diagnosis and treatment of the injury and loss of work productivity. It has been reported that one quarter of all people who sustain an ankle sprain are unable to attend school or work for more than 7 days following the initial injury . (Doherty, 2014)

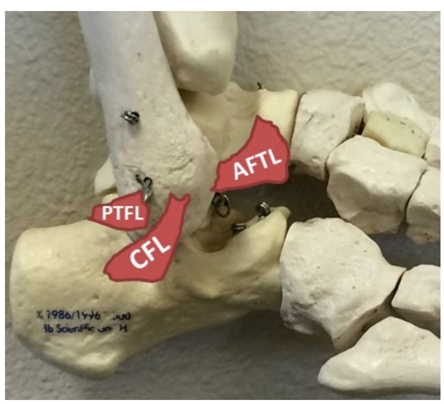
The consequences of the developed insufficiencies following an acute ankle sprain are not exclusive to active populations. Chronic ankle instability is a leading cause of post-traumatic ankle joint osteoarthritis. It has also been demonstrated that chronic lower extremity injury, such as chronic ankle instability, negatively alters central mechanisms of motor control, leading to an increased risk of falls. (Doherty, 2014)

* The incidence rate is 2.15 cases per 1000 person-years means that 2.15 cases would be expected for every 1000 persons observed for 1 year or 21 cases for every 1000 persons if observed for 10 years.

A 2014 systematic review with meta-analysis found that females in sports and military populations had a higher incidence of ankle sprains per 1,000 exposures* compared to males: 13.6 sprains [95 % CI 13.25–13.94] for females vs 6.94 [95 % CI 6.8–7.09] for males. It also found an increased incidence in children compared to both adolescents and adults: 2.85 sprains [95 % CI 2.51–3.19] per 1,000 exposures for children, 0.94 [95 % CI 1.73–2.14] for adolescents, and only 0.72 [95 % CI 0.67–0.77] in adults. However, the trends in incidence (i.e., number of new sprains) and prevalence (overall number of sprains) were not the same. Surprisingly, the prevalence of ankle sprains was essentially equal between females and males: 10.55 % [95 % CI 10.84–11.15] vs 10.99 % [95 % CI 10.84–11.15]. Likewise, most of the differences disappear when looking at age groups: 12.62 % [95 % CI 11.81–13.43] in children, 10.55 % [95 % CI 9.92–11.17] in adolescents and 11.41 % [95 % CI 11.28–11.54] in adults. Ice and water sports had the lowest overall prevalence within the sport subcategory, and indoor and court sports were reported to be the highest risk activities. Participants were also reported to be at a significantly higher risk of sustaining a lateral ankle sprain compared with syndesmotic and medial ankle sprains. (Doherty, 2014)

Inversion and eversion sprains

About 95% of ankle sprains involve the lateral ankle ligaments. The most common mechanism for lateral ankle sprain is a combination of inversion, plantar flexion and medial rotation. While in plantar flexion, the ankle mortise is in a less stable, loose-packed position. This is due to the talar dome being wider anteriorly. Injuries in this position primarily affect the anterior talofibular ligament (ATFL) but can also damage the calcaneofibular (CFL) and posterior talofibular ligaments (PTFL) when greater forces are involved.



Pure inversion injures, which might occur when an athlete lands on another athlete's foot for example, are less common and primarily injure the calcaneofibular ligament. Injuries to the

* *Exposures* in this context refers to the number of times the participants of these studies engaged in athletic events, practices or training sessions.

deltoid ligament of the medial ankle are rare and generally involve traumatic over pronation, abduction, eversion and dorsiflexion. (Hyde, 2007)

High ankle sprain (aka syndesmotic sprain)

Injury to the distal tibiofibular articulation and/or interosseous membrane is commonly referred to as a ***high ankle sprain*** *(aka syndesmotic sprain)*. The structures which stabilize this syndesmotic joint include the anterior inferior tibiofibular, posterior inferior tibiofibular, inferior transverse and interosseous ligaments and the interosseous membrane. High ankle sprains are reported to range from about 10% (Dubin 2011) to as high as 25% of acute ankle injuries (and even higher among athletes) and can involve damage to one or more of these structures. Some believe this involvement to be underestimated due to misdiagnosis. The incidence of syndesmotic injury is much higher in collision sports and those which involve rigid immobilization of the ankle in a boot such as skiing and hockey. Examples include catching the inside edge of an uphill ski while avoiding an obstacle or in a field sport pivoting suddenly to the inside with the outside foot fixed on the playing surface. (Dubin 2011)

The most common mechanism of injury involves external rotation with the foot in a dorsiflexed pronated position; however various studies have shown that any injury which causes forceful rotation of the talus within the mortise, such as a severe inversion sprain, may injure the syndesmotic ligaments. (Williams 2007, Sman 2014)

Risk Factors

The most commonly reported risk factor for an ankle sprain is a previous ankle sprain (Fulton, et al., 2014). Various other factors have been proposed to potentially increase a person's risk of suffering an ankle sprain. A 2002 literature review found very little consensus in the literature with regard to the risk factors for ankle injury derived from well-controlled, prospective investigations. Their conclusions were as follows: (1) gender does not appear to be a risk factor for suffering an ankle sprain in the general population (the higher incidence women in the previously cited study was specifically in sports and military populations), (2) the use of a brace is effective for reducing the risk of reinjuring the ankle, and (3) foot type (classified as supinated, neutral, or pronated) and generalized joint laxity are not ankle-injury risk factors. They found disagreement in the literature with regard to whether or not height, weight, limb dominance, ankle-joint laxity, anatomical alignment, muscle strength, muscle-reaction time, and postural sway are risk factors for ankle sprains. (Beynnon, 2002)

Since the 2002 review, studies have continued to try to identify risk factors. In a 2005 study of high school football players, Tyler reported that athletes who were *both* overweight and had a prior history of ankle sprain were 19 times more likely to sustain a subsequent sprain. (McCriskin 2015) Another more recent study of elite female soccer players found that players with a greater maximal knee valgus angle in a vertical drop jump landing was the only risk factor significantly associated with new ankle injury and that increased BMI was a risk factor for lower extremity injuries in general. (Nilstad, 2014)

Unlike ankle sprains in general that have a higher incidence in women, the less common *medial* and s*yndesmotic* ankle sprains specifically have been reported to have over a threefold greater risk among male athletes. Male sex and higher level of competition appear to be risk factors for syndesmotic ankle sprain during athletics. (Waterman 2011)

Evaluation

Assessment Strategy

For patients who present with suspected ankle sprain, the following assessment strategy should be followed.

Summary

Step 1: Determine if there is a need for radiographs
Step 2: Determine whether a neurological/vascular assessment is necessary
Step 3: Identify which ligaments may have been sprained
Step 4: Identify the grade of sprain
Step 5: Identify any additional structure injured
Step 6: Assess for loss of function and/or stability
Step 7: Assess for contributing factors & effects on kinetic chain

Step 1: Determine if there is a need for radiographs

In acute patients, use the modified Ottawa rules to determine the need for exams (see p. 9) In acute and chronic instability cases occasionally additional imaging is useful (see p. 20).

Step 2: Determine whether a neurological/vascular assessment is necessary.

In acute cases where fractures or moderate to severe ankle sprains are suspected a neurological and vascular screen should be performed to rule out additional neurovascular injury. (See p. 12.)

Step 3: Identify which ligaments may have been sprained.

Based on the history and physical, a general diagnosis should be made of *inversion sprain* (identifying which lateral ligaments are involved), *high ankle (syndesmotic) sprain*, *chronic ankle sprain and/or instability,* or *deltoid ligament sprain* (see pp. 21-26).

Step 4: Identify the grade/category of sprain

In the case of inversion and eversion sprains, the grade of sprain (1-3) should be determined. (See p. 22). In the case of high ankle sprains, determine the category of injury: (1) sprain of the syndesmotic membrane without pathological separation of the ankle mortise; (2) diastasis that is only apparent after stress radiographs; and (3) frank diastasis that is usually accompanied by a fracture (see p. 24).

Step 5: Identify any additional structural injured.

Other structural injuries should also be assessed. For example, forced dorsi-flexion injuries may create ankle sprain as well as a fibula fracture; inversion sprains can be associated with an avulsion fracture of the 5th metatarsal (Dancer fracture); eversion sprains can be accompanied by high ankle sprains.

Step 6: Assess for loss of function and/or stability.

After the acute phase of an injury resolves, initial functional test such as the single leg balance test and the start excursion balance test should be performed. Other functional and return to sports tests can be also be used as outcome measures (see pp. 27-31 and the CSPE protocol Ankle Spain Management).

Step 7: Assess for contributing factors and effects on the kinetic chain.

A brief assessment of the kinetic chain may also be useful, especially in moderate to severe injuries, patients returning to high demand activities, and in individuals who present with chronic ankle pain or instability.

History

Key Questions Summary

Mechanism of injury
Presence of a popping sound at time of injury
Ability to bear weight through the injured leg
Pain in any other location
History of ankle injury, including treatment & imaging
Presence of significant health problems
Sport-specific goals

Patients presenting with ankle injury should be asked to describe the mechanism of the injury and location of pain. Since most ankle sprains are injuries to the lateral ligaments of the ankle and are caused by inversion of the ankle with some degree of plantar flexion and rotation, history of another mechanism of injury should raise suspicion of an unusual ligamentous injury or fracture. (Tiemestra, 2012) The patient should be asked about pain (or symptoms) in other areas as well, particularly if there was a collision or fall involved.

The patient's ability to bear weight both at the time of injury and currently can help determine severity of the injury and the necessity of imaging (see CSPE Protocol: Imaging Decision Making, Acute Ankle Injury). Inability to bear weight suggests a more serious injury. In an injury to the distal tibiofibular syndesmotic articulation (high ankle sprain), the patient may report pain with loaded dorsiflexion such as when pushing off while walking (Williams 2007). Whether or not the patient heard or felt a pop or crack may also be significant. Sensation of a pop or crack may indicate a more severe injury as well (Hyde, 2007).

For patients with acute ankle injuries, the provider should inquire about prior care and their response to the care as patients often present after self-treatment, treatment by an athletic trainer or treatment prescribed by an emergency room provider. The patient should also be asked about previous ankle injuries and what, if any, treatment was received.

The age of the athlete may influence the differential diagnosis. Concomitant avulsion fractures are more likely in patients older than 55 and epiphyseal injuries are a concern in young patients (Hyde, 2007). The patient should be asked about current illnesses since systemic diseases may have an effect on treatment decisions and the patient's recovery from the injury. As always, the patient's goals are important to know since this will correlate with the aggressiveness of treatment and help to guide rehabilitation (Hyde, 2007).

In the case of athletes, it may be beneficial to know any sport-specific goals that they have. This information may affect clinical decision making relative to the necessity of prompt diagnosis and perhaps more aggressive treatment procedures. (Dubin 2011)

Physical Examination

<u>Recommended Flow</u>

Observation
Apply modified Ottawa Rules
Active range of motion
Gait/functional screen
Static palpation
Neurological testing (if necessary)
Check pulses
Orthopedic loading
Muscle Tests
Motion palpation

The first step in examining the injured ankle should be observation beginning with whether or not the patient can walk (see Ottawa rules below) and if so observe any possible gait abnormalities. Thorough observation of the foot, ankle, and lower leg on the injured side (carefully comparing to the non-injured side) should provide further insight as to which anatomic structures may be injured. The clinician should look for deformity, swelling, and discoloration. Gross deformities are typically seen with fractures and dislocations, but it is important to note that not all fractures present with deformity. The location and degree of swelling and bruising should be noted. In a typical ankle sprain, swelling and bruising are found over the area of the injured ligaments. Within the first 24 hours after an ankle injury, swelling or bruising over the forefoot or toes is not generally seen. However, if the injury is at least one day old and if the patient has been ambulating, swelling and bruising may be found down the entire foot and toes as a result of gravity (Kaminski 2013, Tiemestra 2012) Swelling magnitude has not been shown to correlate with self-reported function after acute ankle sprain (Kaminski 2013). Quantification of swelling with a measure of ankle girth or water volumetrics[*] may be useful in tracking changes over the course of treatment. Alternatively, swelling can also be measured by way of figure 8 taping (see p.10).

[*] Both the involved and uninvolved feet are placed one at a time into a container of water. The water displaced by each foot is measured separately. The difference in volumes represents the potential amount of swelling. This technique is more often used in research than in routine clinical practice.

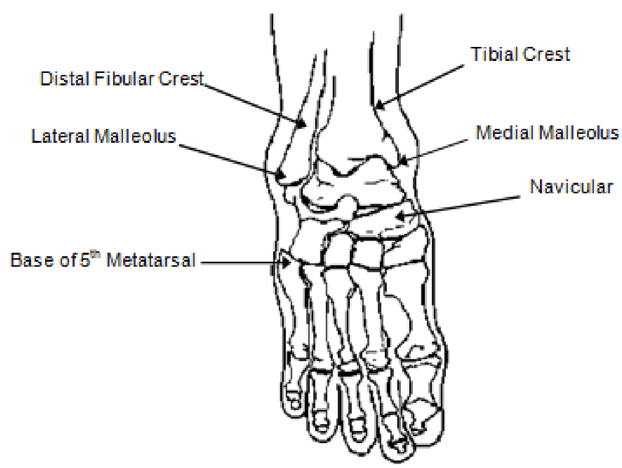
Indications for Imaging After Ankle Injury

Before engaging in more provocative exam procedures it should be determined whether or not imaging is indicated to rule out a fracture. The Ottawa Ankle and Foot Rules are well established guidelines for determining the necessity of radiography. (Bachman 2003, David 2015, Jonckleer 2016). Ankle and foot studies each entail anteroposterior (AP), medial oblique, and lateral radiographs. For more information, please see CSPE Protocol: Imaging Decision Making, Acute Ankle Injury for additional information.

Indications for ankle/foot radiography immediately after an injury

- Inability to bear weight for four consecutive steps right after the injury and when presenting to the clinic (2 steps with each foot), regardless of limping or painful expression of the patient
- Bone tenderness (mechanical hyperalgesia) along crests of the tibial or fibular malleolus any-where within a 6 cm zone proximal to the tip of either malleolus (not including tenderness localized only at the ligamentous attachments (Buffalo modification) (Leddy 1998) **[ankle series]**
- Bone tenderness at the navicular or styloid process of the fifth metatarsal. **[foot series]**
- Patients presenting with multiple injuries, isolated skin injuries, altered sensorium, diabetes, 10 days post-injury, obvious deformity of ankle and/or foot, pregnancy

Key Palpation Points



Indications for ankle radiography 3 - 7 days following acute injury

Radiographs of the ankle are indicated after the injury if any one of the following exists (Loomer 1993, Libbetta 1999):

- Pain localizes over anterior talus
- Pain or swelling does not improve, or continues to get worse
- Patient develops inability to bear weight
- If the patient is not undergoing further office-treatment, they should be advised to return in 5-7 days if their symptoms have not improved.

Indications for MRI or CT

- Suspected talar fracture or radiographs demonstrate a talus fracture
- Negative radiographs with disproportionate pain that persists or fails to improve with immobilization
- Suspected Salter Harris type 1 fracture (suspect in cases of tenderness along anterior distal tibia, persistent pain while under care or severe swelling and bruising).
- Radiographs suggest an osteochondral injury
- Radiographs and/or physical examination suggest syndesmotic injury

Indications for MRI, CT or MSK-ultrasound

- >1 week persistent pain and initial radiographs were negative

Once it has been determined that imaging is not indicated or if radiographs are taken and found to be negative for fracture, the clinician may proceed with the examination.

Important Note: Palpation and exam procedures should be performed on both extremities for comparison. Charting should always clearly indicate which ankle is injured.

Range of Motion

Active, passive and resisted ranges of motion (ROM) in plantar flexion, dorsiflexion, inversion and eversion should be performed. Differences from one side to the other should be noted. If active range of motion measurements are to be used for outcome assessments, a goniometer may be used in order obtain more precise measurements.

AROM

plantar flexion (40°)
dorsiflexion (20°)
inversion (20°)
eversion (10°)

Limited ROM may be due to an intra-articular lesion or swelling within the joint. Pain with passive ROM helps to identify injured joint structures, whereas active and resisted ROM may be used to identify musculotendinous damage, muscle inhibition associated with joint injury, or both (Tiemestra, 2012).

Static Palpation

In order to ensure an accurate diagnosis and proper treatment of all structures involved in the injury, a systematic approach to palpation of the leg, ankle and foot should be implemented starting proximally and working towards the site of pain.

- All the musculature of the lower leg as well as the length the fibula and tibia should be palpated.
- It is important to include palpation of the proximal tibiofibular joint which can be injured in dorsiflexion injuries and the proximal fibula which can be the location of a Maisonneuve fracture associated with syndesmotic injuries. Note: the patient may not complain of pain at the proximal fibula until it is palpated. (Taweel 2013)
- The Achilles tendon is also important to palpate for pain or deformity since a patient with an Achilles injury may present reporting a sprained ankle.
- Palpation of the foot includes the metatarsals and base of the 5th metatarsal in particular.
- Palpation of the navicular and cuboid should be performed followed by the ankle ligaments, beginning at the deltoid ligament and the tendons of the medial compartment and proceeding to the peroneal tendons and the posterior talofibular ligament.
- If swelling is minimal, palpation of the lateral tubercle of the posterior talus is possible.
- Palpation should include the bifurcate ligament and sinus tarsus, the anterior inferior tibiofibular, calcaneofibular and anterior talofibular ligaments (Hyde, 2007).

Point tenderness over ligaments is a good indicator of the injured structures. Bony tenderness over the fibular attachment sites of the anterior talofibular ligament should not raise suspicion of a fracture (Kaminski 2013).

Measuring Edema

One optional method to quantify the amount of edema is the Figure 8 method. A tape measure is placed around the ankle, crossing over the navicular tuberosity, the tip of the lateral malleolus, the tip of the medial malleolus, and the base of the fifth metatarsal, forming a figure 8. (Malliaropoulos 2009)

Neurovascular Assessment

Summary
Sensory testing (light touch, sharp & dull) Motor testing of big toe and ankle Capillary refill at the toes Dorsal pedal & posterior tibialis pulses

Nerve injuries are common in moderate to severe ankle sprains. Approximately 86% of severe sprains involve the peroneal nerve and 83% involve the tibial nerve. Approximately 17% of moderate ankle sprains involve injury to the peroneal nerve and 10% to the tibial nerve (Hyde, 2007). Nerve involvement is postulated to result from mild nerve traction or hematoma. Concomitant motor loss due to nerve involvement can prolong rehabilitation time. (Nitz 1985).

In order to determine whether there is nerve damage, a neurological exam of the lower extremities should be performed, minimally including manual muscle tests and sensation. Due to the potential for vascular damage, dorsalis pedis and posterior tibialis pulses should be assessed along with capillary refill in the toes (Mellion 2002)

Orthopedic Tests for Inversion and Eversion Sprains

During the acute phase of injury, pain, swelling, and spasm may hinder an accurate assessment of the degree of instability. The anterior drawer and the talar tilt tests are thought to have an increased sensitivity when performed 4 to 5 days after injury. (Dubin 2011)

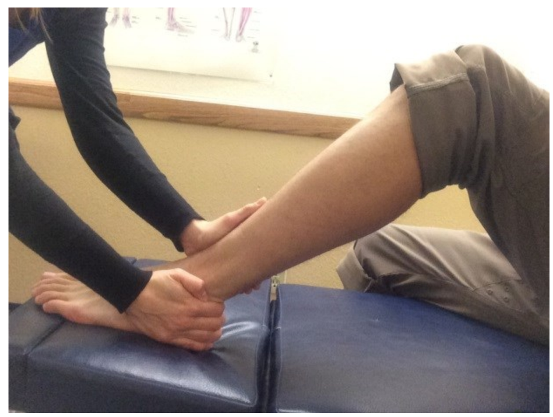
Summary of orthopedic tests for inversion and eversion sprains
Anterior drawer test Inversion talar tilt Eversion talar tilt

Anterior Drawer Test

<u>Indication:</u> Since this test assesses the integrity of ankle ligaments, especially the ATFL, it should be performed after any traumatic ankle injury.

<u>Procedure:</u> The test is performed by stabilizing the tibia and fibula with one hand while the other hand holds the calcaneus with the ankle in a neutral position. A shear force is applied pulling the calcaneus anteriorly while pushing the tibia and fibula posteriorly. An alternative method of performing this test is, instead of grasping the calcaneus, the other hand stabilizes over the anterior foot and with the calcaneus against the table and the hand contacting the tibia and fibula applies a shear force pushing towards the table. The test should be done in neutral and in a plantar flexed position (Hyde, 2007). Testing the ankle with the knee at 90 degrees of flexion may help prevent the Achilles tendon creating a false sense of stabilization (Souza 2015)

Ankle in neutral



Ankle in plantar flexion

<u>Interpretation:</u> A positive test is excessive anterior translation of the talus or the sensation of a clunk. It is also considered positive if anterior translation is more than 4-5 mm more on the injured side than the uninjured side. This would indicate a tear of the ATFL. (Hyde 2007, Dubin 2011).

<u>Reliability & Validity:</u> Sensitivity values have been reported to range from 32% to 80%. Specificity of the anterior drawer test has been reported as 80%. A positive anterior drawer test 5 days after injury is more sensitive and specific than an examination performed within 48 hours of injury (Van Dijk 1996, Kaminski 2013).

<u>Follow-up Testing:</u> Correlate with inversion and eversion talar tilts. If a complete tear of the ATFL is suspected, referral for Diagnostic Musculoskeletal Ultrasound or MRI may be indicated for confirmation. Rule out concomitant tibiofibular syndesmosis injury.

Inversion Talar Tilt

Indication: This test assesses the integrity of the lateral ankle ligaments. It should be performed after any traumatic ankle injury.

Procedure: The test is performed by stabilizing the distal leg while inverting the rearfoot. This should be done in both a neutral and a plantarflexed position (Hyde, 2007). Care should be taken not to needlessly provoke soft tissue structures due to inappropriate pressure/contact by the provider's hand.

Interpretation: In a neutral position, this test assesses calcaneofibular ligament (CFL) integrity and in a plantarflexed position it assesses ATFL integrity. A positive finding would be pain in the area of the ligament being assessed or the sensation of a clunk. A spongy or indefinite end feel may indicate a complete rupture. This test may also be considered positive if 5-6 degrees more motion is seen on the injured side compared to the uninjured side (Hyde, 2007).

Clinical tip: Increased inversion of 5° to 10° can indicate a tear of the CFL. (Dubin 2011)

Clinical tip: Palpate the CFL or ATFL ligaments and feel it pushing against the fingertip if it is intact.

Reliability & Validity: A test sensitivity of 52% has been reported in a single study (Blanshard 1986). Specificity has not been reported.

Follow-up Testing: Correlate with eversion talar tilt and anterior drawer test. If a complete ligament tear is suspected, referral for Diagnostic Musculoskeletal Ultrasound or MRI may be indicated for confirmation. Rule out concomitant tibiofibular syndesmosis injury.

The *Eversion Talar Tilt*

Indication: This test assesses the integrity of the deltoid ligament. It should be performed after any traumatic ankle injury.

Procedure: The test is performed by stabilizing the distal leg while everting the rearfoot (Hyde, 2007).

Interpretation: A positive finding would be pain in the area of the deltoid ligament which would indicate damage to the ligament. A spongy or indefinite end feel may indicate a complete rupture.

Reliability & Validity: Reliability, specificity and sensitivity of the eversion talar tilt test have not been reported.

Follow-up Testing: Correlate with inversion talar tilt and anterior drawer test. Rule out concomitant tibiofibular syndesmosis injury.

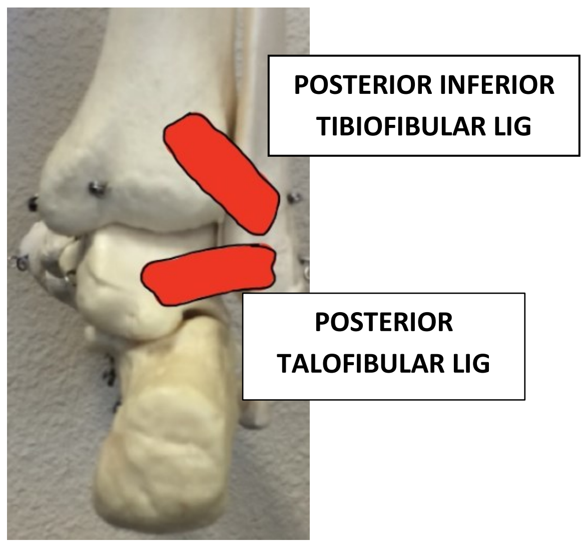
Clinical tip: While performing the test, one can palpate the deltoid ligament and feel it pushing against the fingertip if it is intact.

Orthopedic Tests for Syndesmotic Injuries (high ankle sprains)

Summary of orthopedic tests for high ankle sprains

Squeeze test
Dorsiflexion-external rotation test (Kleigers)
Cotton test (side to side test)

Numerous orthopedic tests have been described for syndesmotic injuries yet relatively little is known regarding their clinical utility. Their diagnostic accuracy, prognostic potential, ability to distinguish severity of injury, or capability to correlate with the degree of instability present has not been well established. It is unlikely that any one test can consistently gauge the degree of tibiofibular displacement and the degree of pain does not correspond with the extent of laxity.

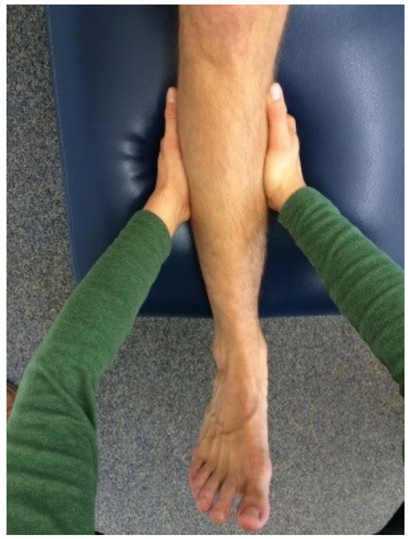


The following tests are some of the more common provocative stress tests for a syndesmotic ankle injury. The reproduction of symptoms is the best indicator of pathology as opposed to the perceived amount of laxity (Williams 2007, Mulligan 2011).

The Squeeze test

Indication: This test assesses the integrity of the distal tibiofibular ligaments. It should be performed after any traumatic ankle injury.

Procedure: It is performed by squeezing the proximal third of the leg firmly enough to cause a reciprocal splaying at the distal end of the tibia and fibula.



Interpretation: A positive test is replication of pain in the area of the anterior inferior tibiofibular ligament. Note that this is similar to Simmonds's test for Achilles tear—if the ankle does not plantar flex this may indicate an Achilles tendon rupture.

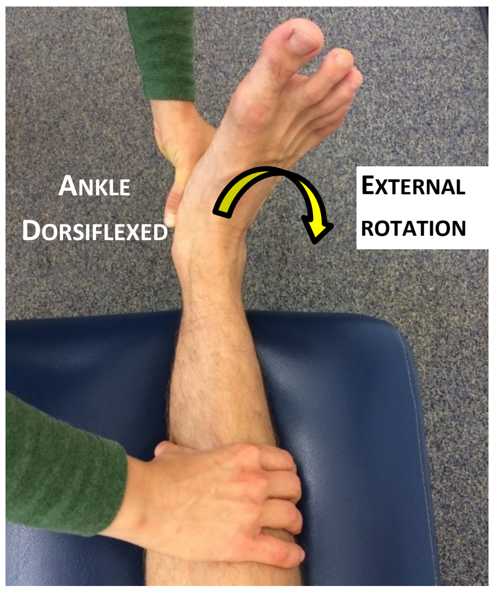
Reliability & Validity: There is conflicting evidence on the diagnostic accuracy of this test. It was reported to have a +LR of 2.68 in one study (Nussbaum 2001) but another reported a +LR of just 0.67 (Beumer 2002). It is also reported to have poor inter-examiner reliability (Alonso 1998) but did show good intra-examiner reliability in one study (Smam 2013). Nussbaum et al (2001) reported a significant relationship (p=0.03) between a positive squeeze test and a longer time lost from competition, making the result a potentially useful prognostic tool.

Follow-up Testing: Correlate with other syndesmosis tests. If significant damage to the syndesmotic ligaments is suspected, stress radiographs of the ankle or MRI may be indicated to assess for instability.

The Dorsiflexion-External Rotation Test (Kleiger's)

Indication: This test assesses the integrity of the distal tibiofibular ligaments. It should be performed after any traumatic ankle injury.

Procedure: It is performed by stabilizing the leg just above the ankle (avoid compressing/ approximating the distal tib/fib) and then externally rotating the foot (transverse plane abduction) with the ankle in maximal dorsiflexion. Optionally, an inferior to superior load can be added through the heel with the ankle in neutral (instead of dorsiflexion) while externally rotating the foot.



Interpretation: Reproduction of pain in the area of the tibiofibular syndesmosis indicates injury to the tibiofibular ligaments. Medial ankle pain indicates deltoid ligament involvement.

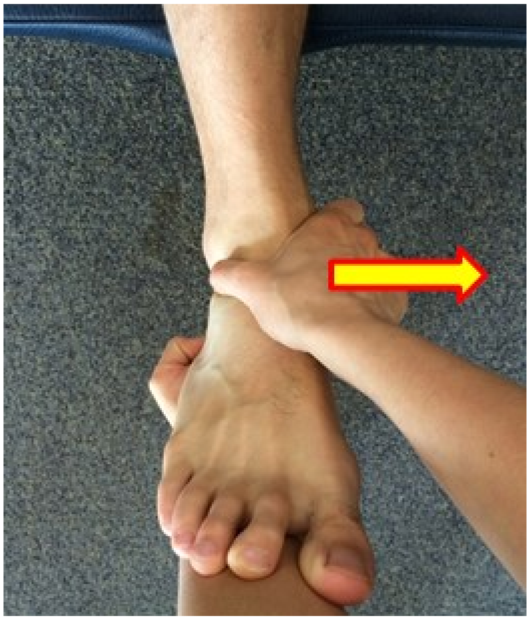
Reliability & Validity: This test has the highest degree of inter-tester agreement (k=0.75) and the lowest rate of false positives compared to other syndesmosis injury tests (Alonso 1998). It also showed good intra-rater reliability in one study (Smam 2013).

Follow-up Testing: Correlate with other syndesmosis tests. If significant damage to the syndesmotic ligaments is suspected, stress radiographs of the ankle or MRI may be indicated to assess for instability.

The *Cotton Test (aka Side to Side or Shuck)*

Indication: This test assesses the integrity of the distal tibiofibular ligaments. It should be performed after any traumatic ankle injury.

Procedure: is performed by translating the talus within the mortise from medial to lateral in a neutral position.



Interpretation: Increased translation or pain may suggest syndesmosis involvement, as well as a deltoid ligament injury depending on the location of the pain (Porter 2014). This test may also be positive with a distal fibula fracture (Hyde, 2007).

Reliability & Validity: This test is reported to have a high rate of false positives secondary to the examiner's interpretation of the degree of translation (Mulligan, 2011) but did show good intra-rater reliability in one study (Smam 2013).

Follow-up Testing: Correlate with other syndesmosis tests. If significant damage to the syndesmotic ligaments is suspected, stress radiographs of the ankle or MRI may be indicated to assess for instability.

Joint Motion Palpation

For muscles ligaments, tendons and other soft tissue structures to heal properly and remain healthy, it is important that joint function be optimal. Ankle sprain and chronic ankle instability, a common sequela of acute ankle sprain, have well documented short and long-term effects on the kinetic chain. (Kivian 012, Choi 2015, Gribbe 2012) These include functional impairments affecting balance; movement patterns; hip, knee, and ankle stability; calf, hamstring and quadriceps flexibility; and core stability.

For this reason, the joints of the foot, ankle, knee, hip, pelvis and spine should be assessed to determine if there is any restriction in joint movement which would warrant mobilization or manipulation (Hyde, 2007).

Additional Imaging

Most athletes who visit the emergency room are examined using radiographs to rule out fractures despite the fact that the prevalence of ankle fractures is less than 15 % (van den Bekerom 2013). To decrease the number of unnecessary radiographs, the Ottawa rules are generally recommended for patient selection.

Stress radiography is not commonly used in the routine diagnosis of lateral ankle ligament injury; however, it may have some value in diagnosing syndesmotic instability (Williams GN, 2007). In suspected high ankle sprains, recommended views are weight-bearing A-P, lateral and mortise (with tibia internally rotated 15-20 degrees). The A-P view should include the entire length of the fibula and tibia to rule out fractures at the proximal fibula. Unilateral weight bearing on the injured ankle will show the most amount of displacement, but this may be too painful in the acute phase and so bilateral weight bearing or non-weight-bearing may be done instead. The most reliable indicator is the clear space between the distal tibia and fibula measuring > 6mm (measured 1 cm above the inferior border of the tibia). A positive test is usually indicative, but a negative test cannot rule out because of its poor sensitivity. (Mulligan 2011)

Musculoskeletal ultrasound and MRI can be useful in diagnosing associated injury (bone, chondral or tendon). Ultrasound has been demonstrated to be accurate and minimally invasive but requires technical expertise. The sensitivity and specificity of ultrasound investigation for an ankle ligament rupture are 92% and 64%, respectively (+LR 2.5, -LR 0.13). The predictive value of a positive ultrasound investigation is 85% and of a negative ultrasound investigation 77%. Ultrasound is accurate in demonstrating the presence of joint effusion.

MRI is reliable in the diagnosis of acute ligamentous ankle injuries, evaluation of tendon disorders, occult fractures and osteochondral lesions, although the latter can be diagnosed more reliably with a CT scan (van den Bekerom 2013). Disadvantages of MRI for acute ankle injuries include cost, lack of accessibility in the average clinical setting, and time required for the test (Kaminski 2013).

Magnetic resonance imaging can be used to diagnose a syndesmosis injury. A cadaveric study demonstrated that high-resolution MRI can effectively image the structures of the syndesmosis, and a clinical study demonstrated high interobserver agreement ($\kappa = 0.9$) in the evaluation of these structures. A subsequent study correlating MRI evaluation of the syndesmosis with arthroscopy in 52 patients showed a sensitivity of 100% and a specificity of 93% (+LR 14) for the diagnosis of an anterior inferior tibiofibular ligament tear and sensitivity and specificity of 100% for the diagnosis of posterior inferior tibiofibular ligament tear (Williams2007).

Diagnosis

Conditions

Lateral ligament sprain (inversion sprain)
High ankle sprain (syndesmotic sprain)
Chronic ankle sprain and instability
Medial ligament sprain (deltoid)

1. Inversion Sprain (Lateral Ligament)

A diagnosis of a lateral ankle sprain is relatively straight forward. The key findings include the following (Dublin 2011):

- Swelling distal to the lateral malleolus of the ankle (may extend to the foot if the lateral capsule is torn).
- Tenderness over the ATFL and, in more severe cases, the PTFL and CFL.
- Excessive translation during the anterior drawer and the talar tilt test may reveal joint laxity due to tearing of the ATFL and/or the CFL ligament (suggesting at least a grade 2 sprain)
- Stress radiographs may reveal excessive anterior translation of the talus or inversion of the talus. (Dubin 2011)

Lateral Sprain Grading

Once a diagnosis of ankle sprain has been made it is common practice to grade the severity of the sprain. The following table outlines a common grading system (Ivins, 2006).

Sign/Symptom	Grade I	Grade II	Grade III
Ligament tear	None	Partial	Complete
Loss of functional ability	Minimal	Some	Great
Pain	Minimal	Moderate	Severe
Swelling	Minimal	Moderate	Severe
Ecchymosis	Usually not	Common	Yes
Difficulty bearing Weight	None	Usual	Almost always

Grade 1 (microscopic tearing of the ATFL). Symptoms may include minimal swelling, point tenderness directly over the ATFL, and reproduction of pain with stress testing (but no instability). Walking causes little or no pain. Bruising is not usually present unless the patient is on an anti-coagulant (e.g., prophylactic aspirin for heart disease). Usually there is full function and full strength.

Grade 2 (a partial tear of the ATFL). Symptoms may include a broader region of tenderness over the lateral aspect of the ankle, a painful limp (if able to walk), and bruising and localized swelling due to tearing of the anterior joint capsule, ATFL, and surrounding soft tissue structures. Stress testing may reveal some excessive motion (assessed by talar tilt and anterior drawer test) if caught in the "golden period" before swelling or after swelling recedes. There may be some loss of function and loss of strength and proprioception.

Grade 3 (a large/complete rupture of the ATFL, possible microscopic or complete failure of the calcaneofibular ligament, rarely posterior talofibular ligament involvement). Symptoms include tenderness on the lateral aspect of the ankle, bruising, diffuse swelling (obscuring the margins of the Achilles tendon), and inability to walk. Stress tests reveal significant joint laxity and loss of function. (Dubin 2011, Tenforde 2016)

This commonly used grading system historically focused on a single ligament and not the injury as a whole. Because of this, some providers use a classification based on clinical severity. This system has 3 clinical grades: grade I (mild), grade II (moderate), and grade III (severe). Grading of ankle sprains remains a largely subjective interpretation, and agreement among independent observers varies (Lynch, 2002).

2. **Syndesmotic (high ankle) Sprain**

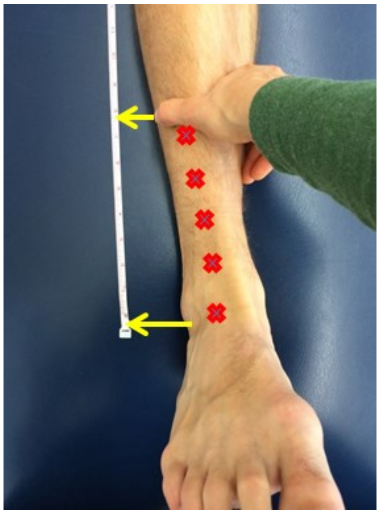
The mechanism often is an eversion ankle injury. This can be caused, for example, to a blow to the lateral aspect of the leg or knee with the foot fixed to the ground. The patient commonly will complain of difficulty "pushing off" during gait and generally lacking power in the subacute phase when attempting to return to activities (Kaminski 2013)

Examination findings of a syndesmotic sprain may include the following:

• Swelling proximal to the ankle mortise. The bruising pattern for high ankle sprain and spiral fibular fracture in comparison to inversion sprain is certainly above the lateral malleolus, often 2-6 inches and there is an excessive amount of bruising compared to the lower sprain.

- Palpatory tenderness over the anterior inferior tibiofibular ligament (rather than the ATFL associated with inversion sprains). See picture.

• Measuring the *tenderness length.* Palpate for tenderness over the AITFL and continue up the leg along the interosseus space until the patient no longer reports any tenderness.



The interosseous space lies between the lateral palpable border of the tibia and the medial border of the fibula. Measure from the tip of the fibula up the interosseous space to the most superior point of palpable pain. The *tenderness length* has been reported to correlate with the severity of the sprain. (Nussbaum 2001)

• Positive external rotation test, squeeze test, and/or stabilization tests. An active rotation test can be performed by having the patient stand on the injured extremity and rotate the pelvis away from the injured side (AKA single limb standing stress test). Similarly a single leg calf raise can be attempted. Pain or instability would implicate a possible high ankle sprain. (Anderson 2010)

• Standard or stress radiographs may reveal abnormal widening of the ankle mortise. (Dubin 2011)

Syndesmotic sprains can be separated into 3 categories: (1) sprain without diastasis (pathological separation) of the ankle mortise; (2) latent diastasis or diastasis that is only apparent after stress radiographs; and (3) frank diastasis that is usually accompanied by a fracture. (Dubin 2011)

Diagnostic ultrasound examination may be useful in the early diagnosis and grading of syndesmotic sprains. A 2009 study found that ultrasound was accurate in visualizing a tear of the anterior inferior tibiofibular ligament and abnormal widening of the ankle mortise. If symptoms persist after 6 weeks of therapy, computed axial tomography or magnetic resonance imaging may be considered to aid in ruling out osteochondral lesions and tumors or in reevaluating the grade of injury. (Dubin 2011)

3. **"Chronic" ankle sprain & ankle instability**

The key findings include the following (Klein 2011):

- prior history of acute ankle injury resulting in persistent ankle pain (often localized to the anterolateral aspect of the ankle) and/or a history of recurrent sprains
- a sense of instability
- the inability to participate in sports
- difficulty in walking on uneven ground.

The physical examination should focus on assessing for mechanical ankle stability and looking for associated pathology. Mechanical (i.e. "structural") instability consists of excessive talocrural translation. A positive anterior drawer testing ($\geq$10 mm of motion or a 3-mm difference compared with the contralateral side measured on a radiograph) or a talar tilt of greater than 9° (or a 3° difference compared with the contralateral side) can be indicators of mechanical instability. Comparing with the contralateral side is imperative, since patients may have varying degrees of inherent laxity. The overall positioning of the hindfoot also is important to consider—varus malalignment predisposes to recurrent inversion injuries. (Klein 2011)

Functional instability is a subjective sensation of the ankle "giving way" during activities of daily living; it may be accompanied by mechanical instability. The single leg balance test (see p. 27) and the star excursion balance test can be performed (see p. 29).

In patients with persistent pain between acute sprains, additional ankle pain generators should be evaluated because chronic instability itself often is painless. Pain generators include peroneal tendinopathy, syndesmotic injuries, complex regional pain syndrome, sinus tarsi syndrome, osteochondral lesions of the talus, loose bodies, synovitis, and ankle arthritis. (Klein 2011)

4. **Eversion Sprain (deltoid ligament)** (Hintermann 2006)

Deltoid sprains, typically caused by eversion or pronation, are much less common than inversion sprains. A typical injury is having the foot firmly planted on the ground while a valgus load is delivered to the ankle or an internal rotation load is applied to the rear foot. Deltoid sprains are associated with activities such as running down stairs, landing on an uneven surface, and planting the foot and then rapidly rotating in the opposite direction while dancing. These same mechanisms may also lead to an accompanying high ankle sprain or stress fractures and these additional injuries should be ruled out.

Chronic deltoid injuries can lead to ankle instability. In addition, even recurrent *inversion* ankle sprains can eventually lead to incompetence of the deltoid ligament. A pronation deformity of the foot can also cause sustained loading of the deltoid ligament, eventually leading to instability.

The typical presentation of an acute deltoid sprain is pain on the anteromedial and even the lateral aspect of the ankle, especially with the ankle in dorsiflexion. Bruising may also be evident.

<u>Chronic medial ankle instability:</u> The patient may report a sensation of the ankle giving way, especially going downhill or on uneven ground. Key findings include pain over the medial gutter (just anterior to the medial malleolus) and a valgus and pronation deformity. This deformity can often be corrected by contracting the tibialis posterior muscle or rising up on toes. Additionally there can be pain along the posterior border of the Achilles tendon, found in 27% of patients in one series of 52 deltoid ligament sprains. (Hintermann 2006)

The tilt and drawer tests may be positive for pain, or in the case of instability, may exhibit increased movement. The cotton test (AKA side to side test) may demonstrate increased translation and lateral ankle pain (Porter 2014).

Based on the modified Ottawa rules, plain film radiographs may be necessary to rule out fracture or other bony pathologies. If chronic instability is suspected, weight bearing radiographs can detect the extent of the valgus deformity in the rear foot. Arthroscopy can be helpful in assessing medial instability, but is no longer commonly done in the case of acute tears. MRI, however, may enable the practitioner to detect associated cartilage lesions.

Assessing for contributing factors and effects on the kinetic chain

Mild inversion sprains usually do not require extended assessment. More severe injuries, however, and sprains in patients with a high professional or recreational demand may benefit from management strategies that additionally target suspected modifiable risk factors to prevent recurrence. Risk factors include weight/BMI, neuromuscular control, postural stability, and muscle strength. Pre-participation sports examinations could also incorporate screening for these risk factors for running sports.

Impairments of neuromuscular control and stability may both be sequelae from ankle injuries and potential risk factors for chronic ankle instability. Studies of acute ankle sprains in athletes have reported impairments of balance, ankle stability, and strength. For example, McGuine et al (2000) reported that those high school basketball players who suffered acute trauma leading to ankle instability demonstrated considerably greater postural sway on stabilometry than matched controls. Other studies have reported similar results (McCriskin 2015). Poor strength and endurance of the lower extremity further exacerbated by poor motor control may also lead to functional instability and later to structural instability as well. (McCriskin 2015)

In addition, a more thorough screen may be appropriate to identify potential effects on the rest of the kinetic chain. Ankle sprains have been reported to lead to inhibition of gluteus maximus. Significant delay of the onset of activation of the gluteus maximus has been measured on the side of the injured ankle. (Bullock-Saxton 1994)

1. Functional Testing

Summary of functional tests for ankle sprains

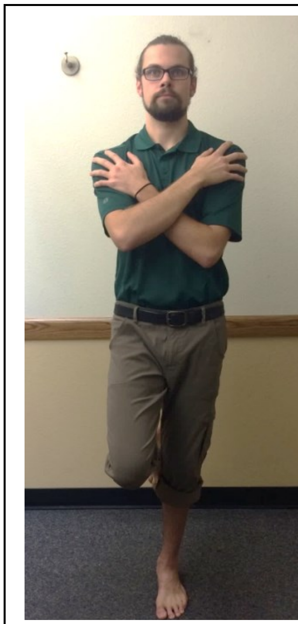
Single leg balance test (SLBT)
Star excursion balance test (SEBT)

Single Leg Balance Test (SLBT)

Indication: In a study of 18 of 42 high school basketball players who sustained ankle sprains during the follow-up season, high variation of postural sway observed during a single leg stand correlated with increased risk of an ankle injury (resulting in an approximately 20% increase in OR). The test may be used as a screening tool to recommend balance training before basketball season. (Wang 2006)

In a 2006 prospective cohort study, Trojian demonstrated that the single leg balance test (SLBT) might help predict future ankle sprains in a group of 230 male and female high school and college athletes (ranging in age 14 through 21) participating in football, soccer, and/or volleyball. The study was conducted for 14 weeks after initial testing. This procedure may be useful as part of pre-participation sports physicals, for patients with chronic sprain symptoms or instability, and patients with high occupational or recreational demands who are recovering from acute sprains

Procedure: Have the bare-footed, open-eyed patient stand on one foot with arms crossed for up to 10 seconds without external support. The contralateral leg should be bent at the knee and not allowed to touch the weight-bearing leg. Both legs are to be tested. The test is considered positive if the patient fails to maintain his/her balance or states a sense of balance loss during the test on either leg.



Time starts when the foot comes off the floor and *ends* when:

- arms uncross
- raised foot hits ground,
- weight-bearing foot moves,
- eyes open during the eyes closed trial

The patient gets 3 trials with eyes open and 3 trials with eyes closed. Ideally, allow 5 minutes rest between sets.

Interpretation: The relative risk for future ankle sprain for all participants with a positive SLBT was 2.43 (95% CI 1.02 to 6.03) controlling for sex, sport, school, previous history of ankle sprain and taping. Subgroup analysis offered some support for the prevailing idea that ankle taping has a protective effect. Subjects who had a positive SLBT and did not tape their ankles or report a history of ankle sprains prior to the study had a relative risk of 7.18 for future ankle sprains (95% CI 1.05 to 61.70). Subjects who had a positive SLBT and did not tape their ankles if they did report a history of ankle sprains prior to the study had a higher relative risk of future ankle sprains (RR 8.82, 95%CI 1.07 to 72.70).

Interestingly, athletes who reported an ankle sprain in the two years prior to the SLBT had an increased likelihood of failing the test (odds ratio of 2.66). Likewise, those with two or more ankle sprains in this same two year period were likely to fail compared to those with less than 2 sprains (odds ratio of 2.03) Surprisingly, however, they did not seem to have a statistically higher relative risk of ankle sprains during the 14 week study period. This discrepancy may call into question the predictive ability of the SLBT at least for those with prior ankle sprains.

For those athletes who had sought treatment for a previous ankle sprain, there appeared to be no relationship between who the athlete sought treatment from (MD or ATC) and performance in the SLBT. Surprisingly, proprioceptive retraining for past ankle sprains was not associated with a negative SLBT.

One can also time subjects and compare how long they can maintain the position against age-based normative values. Below are the mean values (and standard error) for three trials (Springer 2007). Timing the SLBT can also be part of a fall prevention assessment. Test ends if 45 seconds elapse.

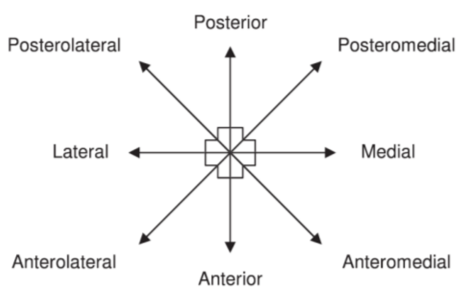
Age (yrs)	Eyes open (sec)	Eyes closed (sec)
18-39	43.3 (5.1)	9.4 (9.4)
40-49	40.3 (10.8)	7.3 (7.0)
50-59	37.0 (12.6)	4.8 (4.8)
60-69	26.9 (16.6)	2.8 (2.2)
70-79	15.0 (13.9)	2.0 (1.6)
80-99	6.2 (9.3)	1.3 (0.6)

Reliability & Validity: The SLBS has excellent interrater reliability (ICCs = .994-.998). (Springer 2007)

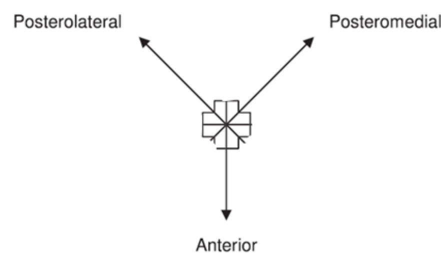
Star Excursion Balance Test (SEBT)

Indication: The star excursion balance test (SEBT) is a simple clinical test that can be used to evaluate the severity of ankle or other lower extremity injuries and deficits as well as an outcome measure to track treatment response. (Gribble 2012) It is useful for evaluating balance and postural control. It can be used to predict occurrence or recurrence of lower extremity injuries and could be a useful component of a pre-participation physical.

Procedure (modified after Gribble 2012): The SEBT consists of multiple, single leg stance, reaching tasks on a star grid. The original studies were first done on star with eight spokes and this version is still popular. More recent research suggests that reaching into three directions may be just as accurate as an assessment.



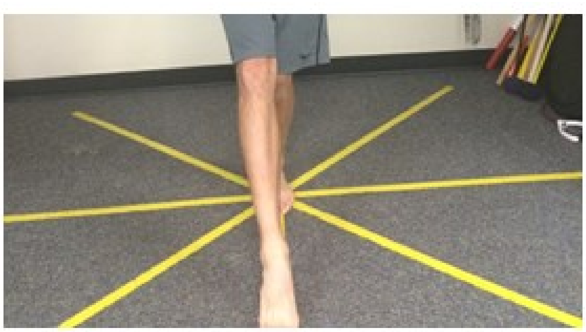
8 arms: each arm is at a 70° angle

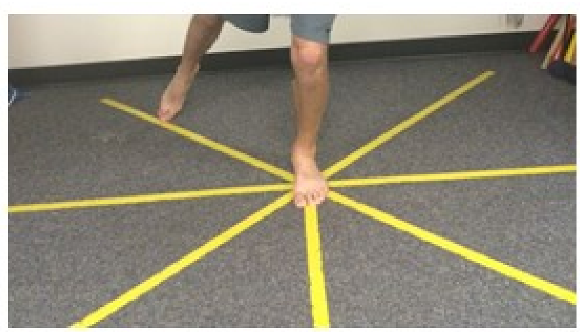


3 arms: the posterior arms are 90° to each other and both are 135 ° from the anterior line.

The subject stands on one leg in the center of a “star” and with their opposite foot, attempts to touch the floor at their maximal reach along each of three lines on the floor. Early versions of the test had the patient reaching along 8 vectors on the floor, but more recent versions of the test suggest that 3 vectors are adequate: anterior, posterolateral, and posteromedial.

While standing on one foot, the subject reaches and lightly touches each line with the toe of the opposite foot and then returns to a resting position in the center. The maximal reach is noted in each direction, left and right sides are compared.





If the subject loses their balance, supports their weight on the reaching foot, or shifts the stance foot, then they have failed in that direction of reach.

For a video example using an 8 star variation see
http://www.oandp.org/olc/lessons/html/SSC_10/section_33.asp?frmCourseSectionId=07D239AC-2644-45F2-8427-64D6AA9D5742

- First, the patients' legs are measured from the ASIS to the medial malleolus.
- The patient is barefoot.
- The stance foot and heel are aligned with anterior tape.
- Hands are placed on hips.
- Warm up consists of 4-6 trials in each of 3 directions (changing the order of reaching randomly). Toe is lightly touched down at the point of maximum reach and the distance is measured. The heel is allowed to come off of the ground.
- Both legs are usually tested.
- The distance in each direction can be expressed both in centimeters and as a percentage of the leg length. The measurements are compared side to side or the injured side can be re-evaluated and compared to the patient's baseline.

The trial is nullified and has to be repeated if the subject commits any of the following errors (Gribble 2003):

- makes a heavy touch,
- rests the foot on the ground,
- shifts the stance foot,
- loses balance,
- or cannot return to the starting position under control

Interpretation: There is only limited information on cut-off scores and side to side differences. Predicting future injury: Basketball players with anterior reach difference of more than 4 cm left to right were 2.5 times more likely to sustain a lower extremity injury (primarily ankle or knee). Girl players with a composite reach score of less than 94% of their limb length were 6.5 times more likely to be injured. (Plisky 2006).

Research studies have used this test as an outcome measure specifically for chronic ankle sprains, reporting statistically significant improvement with 4 week rehabilitation programs (emphasizing balance and/or neuromuscular control, strength and ROM training) and found in McKeon study to have a moderate to strong effect size (range 0.67-1.05).

Reliability & Validity: Most, but not all, studies conducted have demonstrated that the test can differentiate normal controls from those patients with chronic instability. Traditional test validity values (sensitivity, specificity, LRs) have not been reported, but effect sizes reflecting a statistical difference in performance between various injuries and controls range from small to moderate differences. Test-retest reliability has been reported as excellent (ICC=0.84-0.92) among healthy individuals. Intra-tester reliability is good to excellent (78-.96) whereas inter-tester is much more variable (.35-.93). (Gribble 2012)

Further analysis has suggested that the posteromedial direction was the best predictor of overall performance in all directions which, in part, lead to the simplified 3 directional approach. The intertester and intratester reliability of this simplified version were good to excellent. (Kaminiski 2013)

2. Weight and BMI

The role of weight and risk of ankle injury is controversial. Biomechanically, increased weight and BMI increases the load on the talocrural joint which, in turn, theoretically may increase the risk for acute ankle sprain. High school football players with a BMI greater than 25 sprained their ankles significantly more often than those with a normal BMI. (McCriskin 2015) Likewise Waterman et al (2011) observed an increased incidence of ankle instability in male United States Military Academy cadets who had a higher mean weight and BMI than sex-matched, uninjured controls. Yet other investigations have not found weight and BMI to be independent risk factors for ankle sprain. The provider must decide whether addressing these issues may be appropriate for their patient. (McCriskin 2015)

Primary Author: Shawn Hatch, DC

Contributing author: Ron LeFebvre, DC

Single leg balance test contributor: Shireesh Bhalerao, MCR, DC, CCSP

Reviewed by: Shireesh Bhalerao, MCR, DC, CCSP
Stan Ewald, DC, MPH, M.Ed.
David Perham, DC
Joseph Pfeifer, DC
Bev Harger, DC, DACBR

Edited by: Ron LeFebvre, DC

Photos by: Alyssa Salava

Reviewed by CSPE Working Group (2015)

- Amanda Armington, DC
- Lorraine Ginter, DC
- Shawn Hatch, DC
- Ronald LeFebvre, DC
- Owen Lynch, DC
- Ryan Ondick, DC
- James Strange, DC
- Michael Tarnaski

References

Alonso, A., Khoury, L., & Adams, R. (1998). Clinical Tests for Ankle Syndesmosis Injury: Reliability and Prediction of Return to Function. Journal of Orthopedic and Sports Physical Therapy, 27(4), 276-284.

Anderson RB, Hunt KJ, McCormick JJ. Management of Common sports-related injuries about the foot and ankle. J Am Acad Orthop Surg 2010;18:546-556.

Bachman LM, Kolb E, Koller MT, Steurer J, ter Riet G. Accuracy of Ottawa ankle rules to exclude fracture of the ankle and midfoot: systematic review. BMJ 2003; 326:417.

Beumer, A., Swiestra, B. A., & Mulder, P. G. (2002). Clinical diagnosis of syndesmotic ankle instability: evaluation of stress tests behind the curtains. Acta Ortjpaedica Scandinavica, 73, 667-669.

Beynnon, B. e. (2002). Predictive Factors for Lateral Ankle Sprains: A Literature Review. Journal of Athletic Training, 37(4):376–380.

Blanshard, K. S., Finaly, D. B., Scott, D. J., Ley, C. C., Siggins, D., & Allen, M. J. (1986). A radiological analysis of lateral ligament injuries of the ankle. Clinical Radiology, 37(3), 247-251.

Bullock-Saxton JE. Local sensation changes and altered hip muscle function following severe ankle sprain. Phys Ther. 1994 Jan;74(1):17-28

Chan, K. e. (2011). Acute and Chronic Lateral Ankle Instability in the Athlete. Bulletin of the NYU Hospital for Joint Diseases, 69(1): 17-26.

Choi H-S, Shin W-S. Validity of the lower extremity functional movement screen in patients with chronic ankle instability. Journal of Physical Therapy Science. 2015;27(6):1923-1927. doi:10.1589/jpts.27.1923.

David S, Gray K, Russell J, Starkey C. Validation of the Ottawa Ankle Rules for Acute Foot and Ankle Injuries. J Sport Rehabil. 2015 Aug 10.

Doherty, C. e. (2014). The Incidence and Prevalence of Ankle Sprain Injury: A Systematic Review and Meta-Analysis of Prospective Epidemiological Studies. Sports Med, 44:123–140.

Dubin JC, Comeau D, McClelland RI, Dubin RA, Ferrel E, Lateral and syndesmotic ankle sprain injuries: a narrative literature review. Journal of Chiropractic Medicine (2011) 10:204-219.

Fulton, J., Wright, K., Kelly, M., Zebrosky, B., Zanis, M., Drvol, C., & Butler, R. (2014). Injury risk is altered by previous injury: a systematic review of the literature and presentation of causative neuromuscular factors. International Journal of Sports Physical Therapy, 9(5), 583.

Gribble PA, Hertel J, Plisky P. Using the star excursion balance test to assess dynamic postural-control deficits and outcomes in lower extremity injury: a literature and systematic review. Journal of Athletic Training. 2012;47(3):339-357.

Hammer, WI Functional Soft Tissue Examination and treatment by Manual Methods 3rd edition. Jones and Barlett, Boston. 2007

Hintermann B, Knupp M, Pagenstert GI Deltoid ligament injuries: diagnosis and management Foot Ankle Clin N Am 2006; (11): 625-637.

Hupperets MDW, Verhagen EALM, van Mechelen W. The 2BFit study: is an unsupervised proprioceptive balance board training programme, given in addition to usual care, effective in preventing ankle sprain recurrences? Design of a Randomized Controlled Trial. BMC Musculoskeletal Disorders 2008;9:71.

Hupperets MDW, Verhagen EALM, van Mechelen W. Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomized controlled trial. BMJ 2009;339:b2684.

Hyde TE, Gengenbach MS. Conservative Management of Sports Injuries (2nd edition) Jones and Barlett, Boston. 2007

Ivins, D. (2006). Acute Ankle Sprain: an Update. American Family Physician, 74(10), 1714-1720.
Jonckheer P, Willems T, De Ridder R, Paulus D, Holdt Henningsen K, San Miguel L, De Sutter A, Roosen P. Evaluating fracture risk in acute ankle sprains: Any news since the Ottawa Ankle Rules? A systematic review. Eur J Gen Pract. 2015 Dec 22:1-11.

Jonckheer P, Willems T, De Ridde Rr, Paulus D, Henningsen KH, San Miguel L, De Sutter A, & Roosen P. Evaluating fracture risk in acute ankle sprains: Any news since the Ottawa Ankle Rules? A systematic review. European Journal of General Practice, 2016 DOI: 10.3109/13814788.2015.1102881

Kaminski, T. W., Hertel, J., Amendola, N., Docherty, C. L., Dolan, M. G., Hopkins, J. T.Richie, D. (2013). National Athletic Trainers' Association Position Statement: Conservative Management and Prevention of Ankle Sprains in Athletes. Journal of Athletic Training, 48(4), 528-545.

Kemler E, van de Port I, Back F, van Diik CN. A systematic review on the treatment of acute ankle sprain. Brace versus other functional treatment types. Sports Med 2011;41(3):185-97.

Kerkhoffs, G. M., van den Bekerom, M., Elders, L. A., Van Beek, P. A., Hullegie, W. A., & Bloemers, G. M. (2012). Diagnosis treatment and prevention of ankle sprains: an evidence-based clinical guideline. British Journal of Sports Medicine, 46, 854-860.

Kivlan BR, Martin RL. Functional performance testing of the hip in athletes: a systematic review for reliability and validity. International Journal of Sports Physical Therapy. 2012;7(4):402-412.

Klein AJ, Current concepts in managing chronic ankle pain, J Musculoskel Med. 2011;28:425-432,

Leddy JL, Smolinski RJ, *et al.* Prospective Evaluation of the Ottawa Ankle Rules in a University Sports Medicine Center. Am J of Sports Med 1998; 26(2):158-65.

Libetta C, Burke D, Brenna P, Yassa J. Validation of the Ottawa ankle rules in children. J Accid Emerg Med 1999; 16:342-4.

Loomer R, Fisher C, *et al.* Osteochondral Lesions of the Talus. Am J of Sports Med 1993; 21:13-19.

Lynch, S. A. (2002). Assessment of the Injured Ankle in the Athlete. Journal of Athletic Training, 37(4), 406-412.

McCriskin BJ, Cameron KL, Orr JD, Waterman BR. Management and prevention of acute and chronic lateral ankle instability in athletic patient populations. World J Orthop 2015 March 18; 6(2): 161-171

McGuine TA, Greene JJ, Best T, Leverson G. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med 2000; 10: 239-244

Mellion, M. B., Walsh, W. M., Madden, C., Putukian, M., & Shelton, G. L. (2002). Team Physicians Handbook 3rd edition. Philadelphia, PA: Hanley & Belfus.

Malliaropoulos N, Ntessalen M, Paracostas E. Reinjury after acute lateral ankle sprains in elite track and field athletes. Am L Sports Med 2009 (37)9::1755

Mulligan, E. P. (2011). Evaluation and Management of Ankle Syndesmosis Injury. Physical Therapy in Sport, 57-69.

Nilstad, e. a. (2014). Risk Factors for Lower Extremity Injuries in Elite Female Soccer Platers. The American Journal of Sports Medicine, online.

Nitz AJ, Dobner JJ, Kersey D. Nerve injury and grades II and III ankle sprains. Am J Sports Med; 1985; 13(3):177-82

Nussbaum ED, Hosea TM, Sieler SD, et al. Prospective evaluation of syndesmotic ankle sprains without diastasis. Am J Sports Med 2001;29:31–5.

Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. J Orthop Sports Phys Ther. 2006;36(12):911–919.

Prado, M. e. (2014). A Comparative, Prospective, and Randomized Study of Two Conservative Treatment Protocols for First-episode Lateral Ankle Ligament Injuries. Foot & Ankle International, 35: 201.

Sman, A. D., Hiller, C. E., & Refshauge, K. M. (2013). Diagnostic acuracy of clinical tests for diagnosis of ankle syndesmosis injury: a systematic review. British Journal of Sports Medicine, 47, 620-628.

Sman AD, e. a. (2014). Predictive factors for ankle syndesmosis injury in football players: a prospective study. Journal of Science and Medicine in Sport, http://dx.doi.org/10.1016/j.jsams.2013.12.009.

Springer BA, Marin R, Cyhan T, et al. Normative values for the Unipedal Stance Test with eyes open and closed. *J Geriatr Phys Ther* 2007;30:8-15

Souza TA, Differential Diagnosis and Management for the Chiropractor (5th edition) Jones and Bartlett, Burlington MA, 2016

Taweel NR, Raikin SM, Karanjia HN, Ahmad J. The proximal fibula should be examined in all patients with ankle injury: a case series of missed maisonneuve fractures. J Emerg Med 2013; 44(2):e251-255

Tenforde AS, Yin A, Hunt KJ. Foot and ankle injuries in runners. In Clinics Review Articles: Running injuries ed Fredericson M, Tenforde AS Physical Medicine and Rehabilitation Clinics of north America,2016: 27 (1): 121-137.

Tiemestra, J. D. (2012). Update on Acute Ankle Sprains. American Family Physician, 85(12), 1170-1176.

Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. Brit J Sports Med 2006;40:610-13.

Van Dijk, C. N., Lim, L. S., Bossuyt, P. M., & Marti, R. K. (1996). Physical Exam is Sufficient for Diagnosis of Sprained Ankles. Journal of Bone and Joint Surgery, 78(B), 958-962.

Wang H-K, Chen C-H, Shiang T-Y, Jan M-H,Lin K-H. Risk-factor analysis of high school basketball–player ankle injuries: a prospective controlled cohort study evaluating postural sway, ankle strength, and flexibility. Arch Phys Me Rehabil 2006;87:821-5.

Waterman BR, e. a. (2011). Risk Factors for Syndesmotic and Medial Ankle Sprain: Role of Sex, Sport, and Level of Competition. American Journal of Sports Medicine, Vol. 39, No. 5.

Waterman, e. a. (2010). The Epidemiology of Ankle Sprains in the United States. The journal of Bone and Joint Surgery, 92:2279-84.

Williams GN, e. a. (2007). Syndesmotic Ankle Sprains in Athletes. The American Journal of Sports Medicine, Vol. 35, Num. 7.