Adopted: 7/13/16

Ankle Sprains: Management

Early diagnosis and appropriate management of ankle injuries is important to decrease the probability of sequelae such as chronic instability which is reported to result in as many as 60% of patients. (McCriskin 2015)

A patient who has rolled his/her ankle or landed awkwardly but who can bear weight and can jump, run and cut well enough to play may return to the activity immediately. (Anderson 2010). Depending on the nature, duration, and severity of ankle ligamentous injuries which do require treatment, there is some disagreement in the literature between the appropriateness of surgical vs conservative management. A 2010 Cochrane review found that although some evidence demonstrated relative superiority for surgery in terms of return to work/play, recurrence, stability and long term pain, these advantages lost their statistical significance with further scrutiny of the quality of the evidence. There was limited evidence associating surgery with longer recovery time, with higher incidence of residual ankle stiffness, and with impaired ankle mobility. Two subsequent systematic reviews have suggested that the majority of ankle sprains can be managed conservatively without the need for surgery (Mulligan 2011, Petersen 2013).

Besides management of the common inversion sprain, conditions such as severe sprains (see pp 28), deltoid sprains (see pp 29), high ankle sprains (see pp 30), and chronic ankle pain or instability (see pp 35), require additional consideration. Prevention programs (see pp 37) can be considered as a separate type of intervention track, either targeting athletes without a current sprain or incorporated into a functional rehab program for those recovering from an injury.

Management programs are generally divided into acute care and *functional rehabilitation* phases. The general goals of acute interventions are to reduce pain and swelling. The general goals of a rehabilitation program are to restore proper range of motion, strength, proprioception and balance, resulting in overall return to pre-injury function (return to work/play) and reducing the probability of chronic instability and re-injury.

In the case of competitive athletes and military service members serving in the field, particularly if there are also multiple risk factors for recurrence, McCriskin et al (2015) recommended that overall management should include the following components:

- Semi rigid ankle bracing,
- functional rehabilitation protocols emphasizing neuromuscular coordination,
- peroneal muscle strengthening,
- and proprioceptive training.

Acute Phase Care

Short term goals: limit inflammation, reduce pain, unload and protect the joints as necessary
Functional goal: Ability to weight bear
Outcome measures: observe gait for ability to walk without a limp (pass/fail), observe/measure degree of swelling, and measure pain intensity

The acute phase of injury is defined as the period from the time of injury until the signs of inflammation (pain, heat, swelling, redness, and loss of function) peak and then begin to diminish. Generally, this is about a 24-72 hour period. Acute management is generally the same regardless of the severity of the sprain. The injured ankle should be protected to prevent aggravating or worsening the injury. Bracing or taping should be used to protect the ankle if weight bearing is possible. Immobilization with casting or splinting while using crutches, or wearing short leg walking brace for up to ten days may be necessary in more severe injuries (Hyde 2007, Kerhoffs 2012).

Along with protecting the ankle from further injury, the immediate goals of acute care are to control pain, limit swelling and begin the process of restoring function. The following are modalities that are commonly used to help achieve these goals.

Summary of Acute Interventions

1. **RICE**
2. **Modalities (EMS, US, Laser)**
3. **NSAIDs or other anti-inflammatories**
4. **Encourage motion**
5. **Manual mobilization/manipulation**
6. **Protect, brace & support**

1. REST, ICE, COMPRESSION, ELEVATION (RICE)*

RICE is commonly accepted as best practice by most health care professionals immediately after acute ankle sprains to help control pain and limit swelling (Kerkhoffs 2012, van den Bekerom 2013, Ivins 2006, Kaminski 2013, Petersen 2013). Despite its wide spread use, a 2012 systematic review found that there is a lack of high quality evidence from randomized controlled trials to determine the relative effectiveness of RICE therapy for acute ankle sprains in adults (van den Bekerom 2012). Typically, all of the components of RICE are applied simultaneously in both clinical practice and research studies, making it impossible to determine which components are truly effective or potentially harmful. Most of the rationale for using RICE or its individual components is based largely on low-quality clinical trials and laboratory studies with uninjured participants or animal models (Kaminski 2013).

The ankle should be elevated as soon as possible and as often as is reasonable (e.g., 25% of the time) for the first 12-24 hours. (Eisenhart 2003) "High elevation" (i.e., having an athlete lie on the floor with his leg upon the table or having a teammate hold his leg in the air) can be also be employed. Prolonged high elevation, however, can become extremely uncomfortable and is usually restricted to 10-15 minutes. (Wallace 1979)

The effects of cryotherapy include reducing nerve conduction velocity, causing analgesia of the skin, curbing swelling formation, and decreasing metabolic activity and subsequent secondary injury (Kaminski 2013). Strong clinical evidence for using cryotherapy, however, is limited (Kaminski 2013). Some clinicians suggest that using ice to decrease inflammation could theoretically negatively affect healing. Since inflammation is part of the body's natural healing process, it is speculated that decreasing inflammation may actually prolong healing. However, this theory has not been clinically tested. In one study looking at short term effects, ice combined with exercise therapy had a more beneficial effect compared to the application of moist heat. (Kerkhoffs 2012).

Cryotherapy is generally applied in the form of a bag of ice or a frozen gel pack placed directly on the site of injury for 15 to 20 minutes every 1-2 hours or at least twice a day (Eisenhart 2003). In one small RCT (N=85), a briefer application of ice (10 minutes on, 10 off, 10 on, every two hours) had a small additional benefit compared to the standard 20-minute application in terms of pain with activity during the first week of care. (Bleakley 2006) In the case of gel packs, a thin towel is placed between the treated area and the gel pack to protect the skin from damage from cold exposure. (See CSPE Protocol: *Physical Therapy Modalities* for a detailed description of the use of

* Other abbreviations are used to combine various elements of the acute care including POLICE (Protect, Optimal Loading, Ice, Compress, Elevate) (Bleakley 2011) and PRICE (Protect, Rest, Ice, Compress and Elevate).

cryotherapy). Alternatively, ice massage may be applied locally to decrease inflammation and pain. This application should be applied only until the tissue is numb (CBAN).[1]

Applying compression against the skin over the injured tissue controls hemorrhaging and is thought to increase the hydrostatic pressure at the injury site and counteract the increased osmotic pressure resulting from the injury (Kaminski 2013). Clinical studies have reported conflicting results in terms of effectiveness when used in isolation (Kerkhoffs 2012). Compression can be applied using an elastic wrap or an open taping method such as the open Gibney (Hyde, 2007). (See Appendix A.) Many types of ankle braces can also provide compression. In the early stages, elevation and compression should be emphasized as gravity dependence may supersede the positive effects of icing when the ankle is left below the heart (Hyde, 2007).

Clinical Tip: In the acute phase of the injury, a blood pressure cuff lined with a towel-covered ice pack may be placed around the ankle. The cuff is then inflated until there is mild pressure and the cuff is snug to create compression and increased cold penetration around the ankle. Apply compression for 60 seconds and release of compression for 60 seconds alternating for no longer than 15 minutes.

2. MODALITIES

Electrical Muscle Stimulation (EMS)

Electrical muscle stimulation, in its various forms (i.e., high voltage or neuromuscular electrical stimulation),[*] is a common adjunct to PRICE/POLICE in the acute and subacute phases of ankle sprains to control edema (Kaminski 2013). However, a 2015 systematic review found that regardless of the waveform or parameters used, current evidence does not support the use of EMS for reducing edema, decreasing pain, or improving function following acute lateral ankle sprain more effectively than no EMS (Feger 2015).

Providers apply HVPC [high voltage pulsed current] to sprains to control edema which theoretically should improve recovery time to normal function (Kaminski 2013). In an RCT, Mendel et al (2010) applied near-continuous HVPC within 24 hours of acute lateral ankle sprains but could not improve the return to play time in intercollegiate and professional athletes.

[1] CBAN stands for the progressive stages of cold, burning, and achy until the area becomes numb.

[*] Another type of EMS, IFC has not been tested specifically for its effect on ankle sprains.

Ultrasound

A 2011 Cochrane review (van den Bekerom et al.) reported the results of 5 trials (N=606) using therapeutic ultrasound. The outcomes may have been affected by relatively poor reporting quality. They failed to demonstrate either clinical or statistical significance at 1-4 weeks follow up. The reported RR was a weak 1.04 (CI 95% 0.92-1.17), the differences between placebo and ultrasound ranging from only 1-6%.

Likewise, a 2012 systematic review (Kerkoff 2012) concluded that the current literature does not support the use of ultrasound in the treatment of acute ankle sprains since the potential treatment effects of ultrasound appear to be generally small and probably of limited clinical importance.

Low Level Laser Therapy

Low Level Laser therapy (LLLT) is the application of light to a biologic system to promote tissue regeneration, reduce inflammation and relieve pain and is commonly used in the treatment of acute musculoskeletal injuries. The molecular and cellular mechanisms of LLLT suggest that photons are absorbed by the mitochondria which stimulates more ATP production to induce many gene transcript products responsible for its beneficial effects (Farivar 2014).

A systematic review found that LLLT reduces pain immediately after treatment in acute neck pain (Chow 2009). It has also been shown to be an effective alternative to corticosteroid injections and NSAIDs for lateral elbow tendinopathy (Bjordal 2008). Another systematic review found that treating joint areas with LLLT can be an effective pain relief treatment and that the pain relieving effects might be a good alternative to the use of NSAIDs since it has no reported side effects. It also reported that clinical studies have shown that applying laser therapy in addition to exercise might show greater pain reduction effects than using laser therapy alone (Jang 2012).

Studies specifically on the effects of laser on ankle sprains tend to be older and somewhat conflicting. One study (deBie 1998) on laser therapy and ankle sprains reported that 12 treatments of 904nm laser therapy in 4 weeks could demonstrate no benefit for pain, function or recurrence. Stergioulas in a 2004 study did find that treatment with an 820-nm GaA1As diode laser (40 mW at 16 Hz) plus RICE reduced edema more effectively than RICE alone or RICE plus a placebo laser. On the other hand, a 1993 double-blind randomized clinical trial found no statistically significant differences regarding discoloring, pain, edema, and use of analgesics compared with placebo.

3. NONSTEROIDAL ANTI-INFLAMMATORY DRUGS & ANALGESICS

Evidence indicates that nonsteroidal anti-inflammatory drugs (NSAIDs) used during the acute and subacute phases of injury may decrease pain and improve short-term function after acute ankle sprains (Bleakley 2008).

Short and intermediate term effects of oral or topical NSAIDs include decreased pain (with weight bearing and at rest) and decreased swelling. (van den Berkerom 2015)

In a 2014 systematic review, Strujis reported that based on 5 RCTs (N=364), oral NSAIDs are more effective than placebo for short term improvement (up to 2 weeks). The evidence is judged to be low quality due to issues with concealed allocation, blinding of outcome assessors, and drop outs. Longer term studies were not discovered. Selective COX-2 inhibiters and topical NSAIDs may also be beneficial compared to placebo. No studies have compared the interventions to each other for ankle sprains.

A 2015 Cochrane review (16 trials, N=2149) on NSAIDs and soft tissue injuries in general concluded that studies could provide no evidence that NSAIDs or paracetamol (i.e., acetaminophen) was more effective than the other relative to pain control, swelling, or function. Differences between these two interventions either lacked statistical or clinical significance. There was evidence, however, that NSAIDs had slightly more GI side effects (RR 1.76, 95% CI 0.99 to 3.14). Overall the evidence was low quality but consistent. No studies were found comparing NSAIDs to CAM "medicines." (Jones 2015)

Besides GI symptoms, other adverse effects should also be taken into consideration. One study found that along with the positive therapeutic effects, those treated with NSAIDs had greater instability, less ROM, and more swelling 14 days after injury. The authors speculated that the analgesic effect of the NSAIDS might have allowed the participants to return to activity before the healing process was complete (Slayter 1997).

Animal and human studies have linked NSAID use to delayed fracture healing. Animal studies provide conflicting evidence of NSAID effects on ligament healing, but human trials, evaluating functional recovery, have shown that short courses (3-7 days) of NSAIDs may be of benefit in acute ligament injury. (Patel 2011, Randellli 2010).

Adverse effects and other medical concerns must be factored into the decision to include NSAIDs in the treatment plan for an acute ankle sprain (Kaminski 2013). When deciding whether or not to recommend NSAIDs, the provider should discuss with the patient the potential benefits versus risks. For more details, see the CSPE protocol: NSAIDs—Use of Over-the-Counter Nonsteroidal Anti-Inflammatory Drugs and Analgesics

Supplements for Inflammation

Another option is to use an anti-inflammatory substitute although the effectiveness of these has not been as thoroughly studied as NSAIDs.

A variety of supplements are also options to help control acute inflammation in the acute phase (1-14 days post injury).

Substance	Therapeutic Effects	Dose
Bromelain Chymotrypsin Trypsin	Anti-inflammatory	4-8 tablets/capsules per day of high potency enzymes (2000 GDU per gram or equivalent) in divided doses between meals
Citrus bioflavonoids, Curcumin/tumeric	Anti-inflammatory	900-1800 mg/day: May be useful only before peak of inflammatory phase.
Proprietary enzyme/ flavonoid combinations	Anti-inflammatory	3-4 tablets, 3-4 times per day at least 30 minutes before meals

Beware of allergies and cross reactions (e.g., bromelain and pineapple). For more details, see the CSPE protocol Trauma: Diet, Nutritional Supplements and Botanical Considerations.

Supplements to Promote Healing and Tissue Repair

In treating any tissue trauma, one must consider the patient's diet and recommend appropriate nutritional and botanical supplements that may promote and/or support the healing process. The following are some options to consider.

Phase of Injury	Substance	Therapeutic Effects	Dose
Rehabilitative (after inflammation has subsided)	Broad-spectrum vitamin and mineral supplement	Tissue-healing support	At least 100% RDA or Daily Value of most ingredients
Rehabilitative	Vitamin C	Tissue-healing support	Up to 1000 mg/day
Rehabilitative	Zinc	Tissue-healing support	Up to 50 mg/day
Rehabilitative	Glycosaminoglycans (GAGs)	Tissue-healing support	Chondroitin sulfate,1200 mg/day; glucosamine sulfate, 1500 mg/day

For more details, see the CSPE protocol Trauma: Diet, Nutritional Supplements and Botanical Considerations.

4. Encourage Motion

Promoting motion as soon as possible my help prevent stiffness and maintain greater post -injury range of motion.

Ankle pumps

The patient lies supine, preferably with ankles slightly elevated off the end of a bench or bed, and slowly moves them through a pain free range of dorsi and plantar flexion. Recommend 10-20 pumps per hour. (Dubin 2011)

Modified activities. If the sprain is relatively mild, activities like stationary cycling can be allowed.

5. Mobilization/Manipulation

Associated with the ligamentous injury itself, hypomobility and/or malposition of the ankle joints may also occur in both acute and chronic ankle sprains (Hubbard 2008). For example, based on radiographic measurements, it has been suggested that the distal fibula may be displaced, usually anteriorly after a lateral ankle sprain. (Mulligan 2011, Hubbard 2008) Mobilization or manipulation of the foot and ankle joints can be an effective treatment as long as it is done with proper positioning to minimize the risk of aggravating the injury and within the patient's tolerance. After an ankle sprain, restricted posterior glide of the talus can contribute to decreased dorsiflexion. The addition of an anteroposterior joint mobilization of the talocrural joint to a standard RICE protocol has been shown to improve dorsiflexion ROM and gait as compared with a group that received RICE alone (Kaminski 2013). A 2014 systematic review found that manual foot and ankle joint mobilization/manipulation diminished pain and increased dorsiflexion range of motion in acute ankle sprains (Loudon 2014). Also, early mobilization has been shown to aid in a more rapid recovery and the prevention of late residual symptoms and instability (Eiff 1994). In the case of chronic ankle sprains, Van Ochhten 2014 reported that there is moderate evidence that chiropractic therapy and/or manual therapy may improve pain and function based on short-term follow-up. The theoretical basis for these various benefits range from re-positioning a painfully malpositioned joint, restoring normal joint motion, providing an analgesic effect from the manipulation, and triggering a reflexive reduction of muscle spasm. (Whitman 2009)

There is currently no evidence suggesting that one type of manipulation or mobilization is more effective than another. Authors of this protocol recommend that manipulative thrust vectors should be determined by correlating not only mechanism of injury with static osseous findings but also other static and motion palpatory findings. If a fracture is not suspected, high velocity

manipulation may be performed. Some practitioners may choose to incorporate speeder boards, instrument assisted manipulation, or drop tables. Repetitive mobilization has also been used in clinical trials, usually to the distal anterior fibula.

Generally, the provider will manipulate joint restrictions where they are found throughout the ankle complex. However, in research studies some providers have applied various pre-determined "packages" of manual procedures (see Appendix B for various procedures that have been used in published studies.) Likewise, certain consistent examination findings have been speculated to occur. For example, it has been suggested that one pattern of joint restriction that may be present in an inversion sprain is medial talus, inferior cuboid, inferior fibula. The proximal tibiofibular joint may need to be manipulated in a P-A direction (Eisenhart 2003).

Whitman et al derived a 2009 clinical prediction rule suggesting that when 3 of the 4 following criteria were met the initial beneficial response to mobilization techniques improved from 75% to 95% (+LR 5.9; 95%CI 1.1-41.6): 1) symptoms worse with standing, 2) symptoms worse at the end of the day, 3) a navicular drop > 5.0mm[2] and 4) distal tibiofibular hypomobility. This prediction rule has not been validated as yet. The small sample size along with wide confidence intervals poses significant limitations to its application.

6. PROTECT, BRACE & SUPPORT

Weight bearing should be encouraged as soon as is tolerable while simultaneously protecting the joint.[3] Once the patient becomes more ambulatory, a variety of options are available to support and protect the ankle.

Crutches

If the patient is unable to fully bear weight and is using crutches, light weight bearing can be implemented putting around 5-10% of the body weight on the injured ankle. This will help prevent calf shortening that can occur due to maintaining the ankle in a plantarflexed position while using the crutches (Hyde, 2007). As the patient recovers, an "optimal loading" strategy is followed, i.e., slowly adding sufficient load to stimulate appropriate tissue repair and return of function but without promulgating further injury.

The patient should progress from non-weight bearing to partial weight bearing with a heel to toe gait. Crutches may be necessary initially in severe sprains. Tenforde et al (2016) suggest using a walking boot for about 7-10 days and transitioning into a functional brace.

[2] The provider measures directly on the patient the distance from the navicular tuberosity to the floor in a standing non weight bearing stance (standing with most of the weight on the uninvolved leg) compared to a relaxed bilateral stance while the provider holds the subtalar joint in neutral. The difference between the two measurements is the navicular drop.

[3] This concept is often blended into the RICE acronym as **P.**R.I.C.E with the P standing for *protect*

Bracing options

Ankle bracing is generally recommended rather than an elastic wrap (Kerkhoffs 2012). A 2011 systematic review also found evidence that patients had a better functional outcome when using an ankle brace compared to no brace or an elastic wrap. Braces examined included the Aircast brace, Bledsoe boot, Tubigrip, and below the knee cast. (Kemler2011).

Beynnon's RCT (2006) reported the following comparisons:

- Grade I sprain: an Air-Stirrup returned patients to normal stair climbing in 5.5 days vs 12 days for elastic wrap only
- Grade II sprains: an elastic air wrap plus an Air-Stirrup returned patients to normal stair climbing in 11.7 days compared to 28 days for those wearing a cast.

Kerkhoffs (2012) also reported a quicker return to work by an average of 4.2 days (95% CI 2.4-6.1) for semi-rigid braces compared to elastic bandages based on 2 RCTs (N=159).

In the case of competitive athletes and military service members serving in the field, semi rigid ankle bracing is recommended, particularly if there are also multiple risk factors for recurrence, (McCriskin 2015).

In general, lace up braces offer more specific fit and compression than Velcro type fasteners. Lace -up semi-rigid braces typically allow plantar/dorsi-flexion movement while minimizing or eliminating inversion/eversion. Braces are very convenient to apply by the wearer. They have the added benefit of generally being more comfortable and better tolerated for longer periods than taping. In terms of brace selection, metal inserts are very rigid and may injure the wearer or other players in active movements or contact sports. Plastic composites may be a better choice.

Elastic wrap and taping

There may be situations when a semi-rigid brace is not immediately available or deemed unnecessary because of the mildness of the injury. In these and in chronic cases, an elastic wrap or taping remains an option. The prophylactic use of both taping and braces has been found to reduce first time injuries and recurrent injuries (Kaminski 2012). (See prevention on pp 37.) Elastic wraps do not provide significant support and are more effective at simply providing compression.

In the acute phase, traditional ankle taping procedures which incorporate anchors, stirrups, taping horseshoes (different than the pad mentioned above), figure of eights, heel locks and general closures should be reserved until all edema has subsided. This procedure is usually applied to prevent further injury/re-injury when the patient feels the need to return to stressful/athletic activities. One option is to use the "open Gibney" taping procedure in a" basket weave pattern" to enhance the stability of this taping application. This approach offers custom fit with minimal bulk

and is best for short term sports activities. However, this taping does not accommodate edema and is difficult to self-apply. (See Appendix A.)

Taping can be used for a variety of other purposes. It may be used initially as part of a lymphatic drainage technique for acute ankle sprains with the intent of reducing edema. Although this has not been tested for ankle sprains specifically, some studies have shown that kinesiotaping may have an effect on post-surgical edema (Ristow 2014, Pekyavas 2014). Other types of taping may be used to facilitate proprioception as a part of a rehabilitation program and to provide some minimal support. (See Appendix A.) One case study reported significant improvement of a chronic (3 years) grade 2 deltoid sprain with just the daily application of inversion kinesiotaping for two months (Lee 2015).

If an elastic wrap is used temporarily, the compression can be better targeted to a specific area by using orthopedic felt cut into a horseshoe/"U" shape underneath the wrap in the submalleolar area. This felt horseshoe may be applied under tape also.

Caution: It is important that the brace is not tight enough to decrease circulation. If possible, it is preferable to have patients totally remove elastic wraps and braces (or at minimum reduce the tightness of the brace) when sleeping to eliminate the chance of vascular compromise.

Choosing an option

Mild injury (able to bear weight/walk/with edema): 3-4" elastic bandage wrap, semi-rigid brace, or "open" Gibney/basket weave taping.

Moderate injury (marginally able to bear weight/walk/with edema): semi-rigid brace to rigid brace (air cast stirrup type brace). Taping can be done temporarily until a brace can be procured.

Severe injury (unable to bear any weight, rule out fracture as part of the diagnosis):

- Significant edema/questionable ability of patient to manage edema use posterior splint/crutches (accommodates edema and allows for cold application)
- Mild-moderate edema/good ability of patient to manage edema: use short leg walking cast (5-10 days of wear averaging 7 days, remove cast by bi-valve method to retain posterior portion as splint if necessary)

Functional Rehabilitation

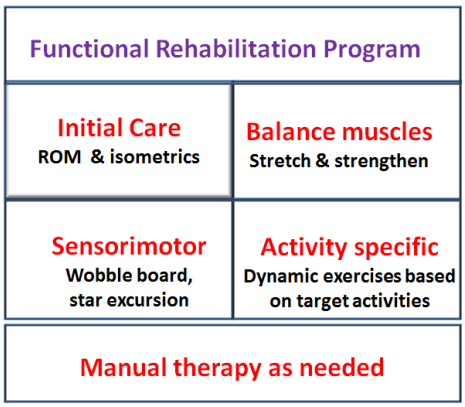
Initial goals: Prevent further loss of range of motion, minimize atrophy, maintain "muscle memory"
Intermediate goals: Facilitate healing, restore ranges of motion, increase strength, and re-establish motor control, return to work
Final management goals: Return to play, prevent re-injury, prevent instability
Outcome measures: (See Outcome measures p 23.)

The overarching strategy for a functional rehabilitation program is to stabilize and protect the ankle with bracing or taping while enhancing strength, motion, and motor control. In addition, addressing biomechanical deficits in the kinetic chain, especially the knee and hip, may also be necessary especially the in case of athletes. Treatment of these more proximal structures are outside the scope of this protocol, although a number of the ankle rehabilitation exercises will address these joints as well.

THERAPEUTIC EXERCISE

The rehabilitation program can be conceptualized into having 5 major components.

1. The initial goals of the exercise program focus on maintaining motion by doing active or passive range of motion exercises and preventing atrophy and loss of muscle memory by initiating isometric exercises.
2. As the patient enters the subacute phase, the emphasis shifts to re-instating a more efficient muscle balance by stretching or relaxing tight/overactive muscles and strengthening the key stabilizers. To these ends, resistance exercises are introduced to the ankle stabilizing muscles to build strength and endurance; the calf muscle may also be targeted for both strengthening and stretching; and the gluteal muscles facilitated and strengthened to address potential reflex inhibition from the ankle injury.
3. As soon as the patient can weight bear with minimal pain, proprioceptive activities on stable and then unstable surfaces are incorporated and can be performed throughout the rehabilitation program.
4. Lastly, more dynamic exercises and sports-specific exercises are prescribed.
5. Mobilization, manipulation, and soft tissue procedures can be used as needed throughout the program to normalize joint play and to help promote increase in ankle dorsiflexion.



Clinical Tip: When introducing various exercises to the patient as they progress through a functional rehabilitation program, it is useful to explain the purposes of the different exercises using the four main components of this model: initial care to maintain and improve range of motion and muscle activity, eventually balancing their muscles by strengthening the weak ones and stretching/lengthening the tight ones, retraining the sensorimotor system and finally doing graded activities that mimic the activities that they are going back to pre-injury.

RATIONALE AND EVIDENCE

Lateral Ankle Sprains

Ankle injuries can potentially alter function through a number of mechanisms including an alteration of proprioceptive input from the damaged ligaments, alteration in the of the sensory motor loop above the level of the spinal reflex, delayed response time of the peroneal/fibularis muscles, secondary damage to the peroneal nerve, and perhaps peripheral sensitization* (Kerkhoffs 2012). Functional rehabilitation is more effective than immobilization for grade I and II lateral ankle sprains and is generally considered the standard of care (based on category A evidence, Kaminski 2013).

Sensorimotor training in the form of incorporating balance and proprioceptive exercises has become "an integral part of rehabilitation programs." Thus, balance training is a near-mandatory clinical intervention for athletes who have sustained an ankle sprain (Kaminski 2013). It is especially important for high-risk activities (e.g., football, basketball, soccer, volleyball). (Hupperets 2009)

* Injury to the joints and muscles may result in changes to the peripheral receptor membranes such that even sub-threshold nociceptive stimuli can continue to trigger the experience of pain until the tissue heals and inflammation subsides.

Kerkhoffs 2012 Dutch national guidelines recommend that rehabilitation programs for athletes should include proprioceptive training, strength training of the ankle extensor muscles, and coordination exercises.

There is some research evidence suggesting these interventions can reduce recurrent injury rates and instability.

- An RCT demonstrated that a 12-week wobble-board training program begun 1 week after injury reduced the functional instability rate from 54% to 25%. In addition, none of the patents participating in the balance training reported a subjective sense of instability, compared to 25% of those in the control group. (Wester 1996)

- Another RCT reported reducing re-injury rates from 16% in the controls down to 3% for those participating in a balance training program composed of 1 hour of supervised rehabilitation 2 times per week. (Holme 1999) The NNT for preventing one new reinjury was 5. (Kaminski 2013).

- Another RCT, this time of an 8 week *unsupervised home-based* sensorimotor training program, included more severe injuries that kept athletes from completion. It also demonstrated reduced re-injury rates (NNT = 11). The authors suggested that at least a minimum of 6 weeks of proprioceptive training seemed necessary. (Hupperets 2009)

Manual therapy also has been recommended in evidence-based guidelines. Kaminski et al. (2013) recommended applying both passive joint mobilizations and mobilizations with movement to increase ankle dorsiflexion and improve function based on category B evidence.[4] Soft tissue manipulation can also be introduced. Pin and stretch (e.g., applied to the fibularis muscles), instrument assisted soft tissue manipulation (e.g., Graston), transverse massage to the injured ligaments (for parameters, see CSPE protocol Transverse Friction), and post-isometric relaxation (PIR) can be performed. (Dubin 2011).

Chronic Ankle Sprains

A 2014 systematic review reported that there was limited to moderate level evidence suggesting that training programs outperformed control groups for chronic ankle complaints in both subjective and objective outcomes as well as preventing re-injuries. Moderate evidence was reported for improved function at 4 to 6 weeks of follow-up. There was also moderate evidence that at long-term follow-up proprioceptive training reduced recurrence rates from 33% to 22%. (Van Ochhten 2014)

[4] Based on patient-oriented, inconsistent or limited quality evidence.

PROGRAM PRESCRIPTIONS

Optimal program parameters in terms of duration, numbers of sets, number of repetitions etc. have not been determined.

Program Length
Programs generally range from 4-12 weeks. There is limited evidence that 4 weeks of wobble board training is superior to a two-week program for patients with chronic ankle sprain (Van Ochhten 2014). On the other hand, Hupperets et al (2009) suggested that at least a minimum of 6 weeks of proprioceptive training seemed necessary. In one study of both acute and chronic sprains, a mix of manual therapy and supervised exercises were done twice a week for 4 weeks. Home exercises were performed daily. (Cleland 2013)

Sets and Reps
Below are examples of various recommended sets and repetitions based on type of exercise.

- AROM exercises: 1-3 sets, 10-15 repetitions, 1-3 times per day.
- Stretches: 15 second-3 minute holds, 3-5x/day.
- Resisted exercises: 3 sets of 15.
- Balance: activities 1-5 minutes, twice per day.

SAMPLE FUNCTIONAL REHABILITATION PROGRAM FOR LATERAL SPRAIN

Below is a sample of general treatment program for a lateral ankle sprain (based on Hammer 2007, Hyde 2007, Hupperets 2008, Dubin 2011, Cleland 2013, Souza 2016). This program would need to be individualized for a patient based on the severity of the sprain and the physical demand of the patient's normal activities. This program may also require further changes based on the type of sprain (i.e., high ankle sprains, eversion sprains or chronic ankle pain/instability). (See pp. 28-37.)

Functional rehabilitation programs are often divided into 3 or 4 phases of care. Progression through the phases is partly based on time but more importantly on the speed of a patient's improvement. Each phase has a cluster of recommended exercise and interventions; however, the timing of the introduction of a particular exercise and how it is progressed can cross phases and is determined in part by the patient's ability to successfully perform the activity/exercise with minimal pain.

ACUTE CARE (targets the immediate symptoms and tissue damage; for more details, see pp 3-11)

- **RICE**[5] (ice and compress while maintaining elevation as much as possible until swelling/bruising begins to subside)
- **Motion** (initially ankle pumps)
- **Manual mobilization/manipulation**
- **Bracing & support** (Crutches may be necessary for grade II sprains; walking boot for severe grade II or III).

Additional options:

- **Laser** (other modalities may be used to control pain or swelling in the short term but have poor or no supporting evidence for improving recovery).
- **NSAIDs and/or supplements**

REHABILITATION PHASE 1 (immediate post acute)

This phase overlaps with the acute phrase intervention. Generally, an uncomplicated inversion sprain can be progressed through this phase over the span of 3 days. Indicators for going on to the next phase of care are the ability to partially weight bear along with a reduction in pain and swelling**.** (Souza 2016)

Summary

Light weigh bearing
AROM exercise
Provider administered passive ROM
Achilles towel stretch
Pain-free isometrics
Toe crunches (with towel)

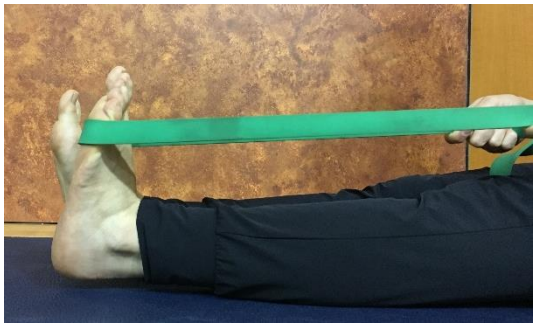
- **Light weight bearing.** In the case of grade II and III sprains, crutches may be necessary for 1-3 days, but light body weight (5-15%) should be transferred to the injured side to help prevent tissue shortening.

- **AROM** (progress from flexion and extension to ankle alphabet) Target: 1-3 sets of 15 repetitions, 3x/day. Note: In severe sprains ROM into plantar flexion and inversion should be avoided until palpatory tenderness over the anterior talofibular ligament has decreased.

- **Provider-administered passive ROM:** 3 sets of 10 with 3-5 second holds at end range with care taken in the direction that will stretch the sprained ligament. (Dubin 2011)

[5] When RICE is combined with bracing and support methods to protect the joint and to ensure optimal loading, it can be referred to as POLICE.

- **Achilles tendon towel stretch** (15 seconds, 5x/day or 30 seconds, 3x/day).



- **Pain-free isometrics.** Begin as soon as patient can tolerate (this may even be in the acute phase of care). For example: press foot against the wall for inversion, eversion, and plantar flexion; use the opposite foot to provide resistance to dorsiflexion (5-second holds, 5 repetitions). Contractions should be pain free even if that means limiting effort to 10-15% of a maximum voluntary contraction (MVC).

- **Toe crunches with a towel (10 reps, 3x/day).** Sometimes this may need to be delayed until the patient can bear 50% of weight without pain.

REHABILITATION PHASE II (early)

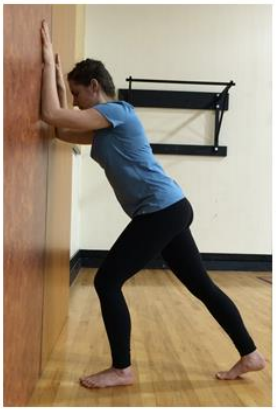
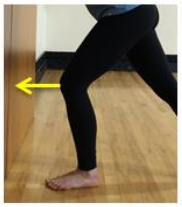
Summary
Continue ROM exercises Manipulate/mobilize ankle Weight bearing Achilles Stretch End range isometrics Side lying resisted abduction exercises

Early phase II care overlaps with the previous phase of care and begins 3-5 days post injury. The patient's goal is to fully weight bear, have little or no evident swelling, and nearly complete active ROM so move on to the last phase of rehabilitation. (Souza 2016) Patients should ice after activities.

Clinical warning: If the patient is still in significant pain and/or still cannot weight bear, the ankle should be re-examined for a possible talar dome fracture often missed on initial radiographs.

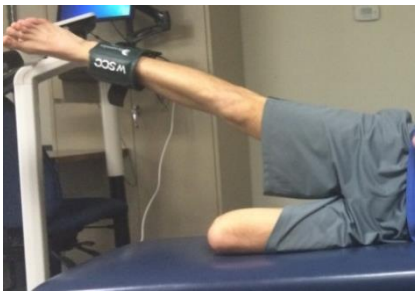
- **Continue ROM exercises**. Add 3-5 second holds at end range, increase hold duration.
- **Manipulate/mobilize ankle** (e.g., talocrural, subtalar, and midtarsal joints)
- **End range isometrics.** The patient can begin to perform isometric contractions more at an end range position if pain permits.
- **Self mobilization of the ankle**. This can be done in a quadruped positon, by rocking back and forth so that the heel touches the floor and then the foot moves back up on toe.


Self mobilization can also be done in a standing positon, maintaining a short foot, bending the knee and passing it between the 3rd and 5th toes toward the wall *without picking up the heel*. The joint is mobilized by rocking back in forth toward and away from the wall.


- **Weight bearing Achilles stretch** (3 minutes, 3-4x/day) Progress to standing stretches for gastrocnemius (leg straight) and soleus (knee bent); 3 stretches of 30 seconds' duration.

- **Side lying resisted hip abduction exercises** (to activate gluteus medius which sometimes becomes inhibited in ankle injuries). (Optional.) If necessary start with clam exercise (hip abduction with both heels on the floor), progress to single leg raises (hip abduction) while lying on side, add resistance with ankle weights (1-3 lbs, 3 sets of 10-15 reps)



- **Heel raises.** When the patient is fully weight bearing, double and single heel raises can be introduced in the following progression:
    - bilateral, hold on to a table or sink (for balance and partly to decrease the load); when 20 repetitions can be performed without pain, got to the next step,
    - single heel raises (holding on to table);

REHABILITATION PHASE II (late)

Summary
Heel raises (single leg), hopping & skipping
Stabilization exercises
Resisted ROM exercises
Proprioceptive training: leg reaches
Sensory motor exercises on unstable surface
Modified activities

- **Continue heel raises, add hopping and skipping activities.** Single heel raises can be introduced in the following progression:
    - single heel raises without support (shift weight to injured ankle and then slowly lower)
    - single heel raises performed on slant board or stair (allowing the heel to drop into a stretch);
    - heel walk and toe walk;
    - 3 to 4 short hops.

- **Stabilization exercises.** A weight bearing tubing exercise is added to target the stabilizing role of the ankle muscles. The <u>non-injured</u> ankle pulls the tubing through hip flexion, extension, abduction and adduction while the injured ankle (circled in the picture below) maintains its position.

HIP FLEXION (starting position)

HIP FLEXION (ending position)

HIP EXTENSION (starting position)

HIP EXTENSION (ending position)

- **Resisted ROM exercises** with tubing/elastic band (inversion, eversion, dorsiflexion, plantar flexion). Non-weight bearing: 3 sets of 10-15 repetitions with the goal of achieving muscle fatigue at the end of 3 sets. Progressively increase range of movement, duration of holds at the end range, and resistance level of the elastic band over time. Increase the resistance (e.g., strength of elastic band) when 3 sets of 15 repetitions are completed in the full range.


EVERSION


INVERSION


PLANTAR FELXION

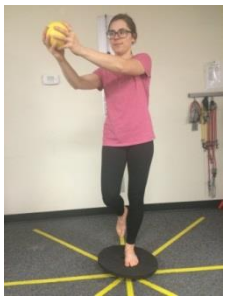
- **Proprioceptive training: leg reaches.** Once fully weight bearing, training should begin with single leg balance and progress to opposite leg reaching out to points on the clock.

- **Sensorimotor training on unstable surface.** The unstable training surface can be a pillow, disc, balance pad, air filled cushion, rocker or wobble board. Each exercise should incorporate progressively more complex arm and leg movements. When the patient can balance on the injured ankle with minimal pain (often about a week after the injury), the progressions can be done a variety of ways, but generally progress from a more stable platform (e.g., the ground to a balance pad to rocker board to wobble board), two legged balance on an unstable surface to single leg balance, and eyes open activities to eyes closed. Along each step of the progression, perturbations can be incorporated to train balance response. The patient can be taught to do these exercises using the "short foot." (See Appendix E). Six weeks of training is postulated to be the minimal dose to attain a useful clinical effect. (Hupperets 2009)

Sample progression

  - Start on <u>stable</u> surface, single leg standing on the injured limb, hold on to counter or sink if necessary, eyes open; 3 sets of 30 seconds duration. When this can be successfully performed, progress to eyes closed.

- Double leg standing on the injured limb on unstable surface, arms abducted, and eyes open; 3 sets of 30 seconds' duration quickly progressed to single leg stand.
- Progress from arms abducted to arms across chest, 3 × 30 seconds.
- Progress from eyes open to eyes closed, 3 × 30 seconds
- Options for progression: decrease the standing base, throwing and catching a ball.

- **Modified activity.** A sample workout would be a 5 minute warm up walk, then a 3 minute run at easy intensity, then a 2-minute walk, repeat these cycles for a total of 20-30 minutes. When this can be done without stopping and no noticeable increase in pain or swelling, the mileage and/or intensity can be slowly increased (e.g., 10% per week) (Dubin 2011)

REHABILITATION PHASE III

This phase can usually begin approximately 2-3 weeks after initial care. The patient should be able to run and hop without pain, though there may be pain at end range inversion. Training may extend another 3-9 weeks based on degree of injury and sports or work demand.

Summary

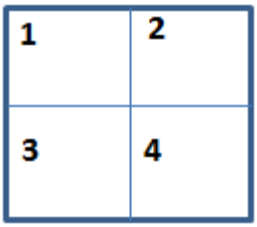
Continue strengthening exercises
Progress to running & jumping
Continue balance training; add sports specific drills
Sports specific exercises

- **Continue strengthening exercises.** Increase tubing repetitions and/or resistance.

- **Progress to running and jumping activities.** When strength, range of motion, and balance exercises have been progressed fully as outlined above, progress from walking to running (forward, then backward, then zigzags and figure 8's), skipping, and hopping, an/or jumping rope based on patient's activities and recreational demands. Running and jumping activities must be multidirectional. The following are examples of progressive jumping exercises:

    - Jump forward and backward over a line
    - Jump laterally over a line

- Box drills: jump in the center of 4 boxes (jumping in various combinations: clockwise, counter clockwise, diagonals).



- **Continue balance training and add sports specific drills** on stable and unstable surfaces (wear brace or tape).
  - Begin with mimicking sports activity (e.g., kicking a ball, catching a ball, spiking a ball).
  - Progress to performing activity on unstable surface, keeping the motion shortened and close to the body.
  - Progress to reaching further out, following through with the motion.

- **Sports specific exercise:** Practice stopping, changing directions, running figure 8's, etc. as would be performed during the sport.

Return to Play/Return to Activity

Recommendations for return to work are generally based on the degree of inversion injury. Kerhoffs et al in a 2012 Dutch guideline report that patients with mild sprains should be able to return to light activities at work within two weeks. Temporary work limitations include lifting no more than 10kg and curtailing standing for extended periods as well as walking on uneven surfaces. Full return to work activities should be expected in 3-4 weeks depending on the load demand. For partial tears or total ruptures return to light work could be delayed for 3-6 weeks. In those cases, resumption of full activities may be delayed for 6-8 weeks.

The decision to return to full activity is dependent, in part, on how demanding the activity is and on the patient's symptoms and functional status. To aide in this decision, available validated outcomes measures include both subjective self-assessment questionnaires and functional performance testing (Kaminski 2013). Employing these measures may be particularly helpful for patients with instability, chronic sprains, and/or or severe sprains.

Outcome Measures

A number of tools have been validated for assessing patients with ankle sprains. These include the Foot and Ankle Disability Index (FADI), Foot and Ankle Ability Measure (FAAM), Foot and Ankle Outcome Score, Lower Extremity Function Test (LEFS), and the Sports Ankle Rating System. None of the standard questionnaires have received widespread acceptance as a gold standard. (Kaminisk 2013)

For acute and chronic ankle sprains

Foot and Ankle Outcome Score, Lower Extremity Function Test (LEFS)

Although not specific to the ankle, LEFS accurately identifies functional limitations in patients with acute inversion ankle sprains and is responsive to changes over time Alcock 2002). The questionnaire is composed of 20 items/questions ranging from daily activities (e.g., putting on shoes) to more advanced sport-specific tasks (running and hopping). Each item is scored from 0 (extreme difficulty or unable to perform activity) to 4 (no difficulty). The LEFS is a reliable and valid measure for lower extremity injuries that is sensitive to change. (Binkley 1999, Alcock 2002). The minimum clinically important difference (MCID) for a variety of lower extremity injuries is 9. This questionnaire can be used to establish baseline function, track progress, and set recovery goals. Excellent test-retest reliability has been reported for ankle injuries in general (r = 0.86; 95%, lower limit CI = 0.80) as well as for the subset of patients with more chronic conditions (r = 0.94; 95% lower limit CI = 0.89) Inter-examiner reliability is also excellent (r = 0.84). (Binkley 1999) (See Appendix F.)

The Sports Ankle Rating System.

This questionnaire has two components which can be used individually or in combination: a quality of life self-assessment and a clinical assessment (i.e., the Clinical Rating Score). The Quality of Life measure is a 5-part self-assessment that rates symptoms, work and school activities, recreation and sports, activities of daily living, and lifestyle. Each item is graded from 0 extreme dysfunction) to 4 (normal function). A higher composite score indicates better function. The second component, the Clinical Rating Score, includes both patient-based and clinician-based sections. The patient-based items, measure the severity of pain, swelling, stiffness, giving way, and function using a VAS. The clinician-based section assesses gait, motion, strength, ligamentous stability, postural stability, and function. As a summary component, a final question is asked of the patient (the Single Assessment Numeric Evaluation): ‘‘On a scale of 0 to 100, how would you rate your ankle’s function with 100 being normal?’’ The scale has excellent content validity and test-retest reliability. It effectively differentiates between patients with and without ankle sprains and is responsive to change during recovery.

For chronic ankle instability

Foot and Ankle Disability Index (FADI)

The FADI questionnaire identifies functional limitations related to foot and ankle conditions and has been used especially with chronic ankle pain and/or signs of instability. It has 2 subscales: the main set of 26 items assessing activities of daily life and an additional 8 items (i.e., FADI-Sport) addressing more physical activities. Each item is scored from 0 (unable to do) to 4 (no difficulty at all), and a higher score indicates a higher level of function. The FADI has been reported as reliable and sensitive in detecting injury and change (Hale 2005). Test re-test reliability is excellent for the general questionnaire

(ICC.89) as well as the sports section (ICC .84) (Eechaute 2007). Inter-examiner reliability is also excellent for both portions at 1 and 6 weeks (ranging from ICC 0.84-0.93) (Hale 2005). One potential limitation is that it has been studied primarily in young adults with self-reported unilateral chronic ankle instability who were compared to young healthy controls. Another limitation is that a MCID has not been established. (See Appendix G for the FADI questionnaire.)

Foot and Ankle Ability Measure (FAAM)

Testing and analysis of the FADI questionnaire resulted in the creation of the FAAM shortening the FADI by 5 items. Patients answer each question with a single response that most accurately describes their condition within the past week. If a particular activity is limited by something other than their foot or ankle, the patient is asked to record "N/A." A global question at the end of each subscale has the patient rate their current level of function during their usual activities of daily living and during their sports related activities from 0 to 100 (100 being the prior level of function and 0 being unable to perform their usual daily activities). The FAAM also asks the patient to rate their current level of function as "normal," "nearly normal", "abnormal," and "severely abnormal." In order to score the ADL subscale and the Sports subscale, 20/21 items and 7/8 items must be completed, respectively. Questions for which "N/A" is indicated are not counted. To calculate the score for either subscale, the total number of points are added, divided by the total number of possible points (84 for the ADL subscale and 32 for the Sports subscale), and then multiplied by 100. Therefore, a higher score reflects a higher level of physical function.

The FAAM has construct validity for patients with ankle instability and is considered reliable, responsive, and valid for assessing physical function for individuals with musculoskeletal disorders of the lower leg, foot, and ankle (Martin 2005). The MCID for the FAAM is 8 points for the ADL subscale and 9 for the Sports subscale. It can be applied to ages 6 and above. Test-retest reliability is excellent (ADL Subscale ICC=0.89; Sports Subscale: ICC= 0.87)

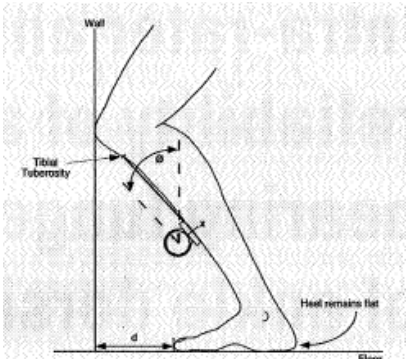
Limitations include the fact that most of this research for this variation of the FADI questionnaire is based on one study, and inter-rater and intra-rater reliability has not been established.

Functional Performance Testing

Using a standardized questionnaire/physical examination process to assess treatment response relative to function is recommended, especially for those with chronic ankle complaints. To assess proprioception and balance, a variety of standardized tests are recommended, measuring different outcomes. (Van Ochhten 2014)

The single leg hop for distance (see Appendix C) and the Star Excursion Balance Test (See Appendix H) can used to help determine return to activities. Before returning to sport-specific tasks, the injured limb should measure *at least 80% of the uninvolved ankle* (based on category B evidence) (Kaminski 2013).

When rehabilitating a sprained ankle, one treatment objective is to restore ankle dorsiflexion. A standardized measure of weight bearing dorsiflexion can be done with a forward lunge.



A strip of tape can be run to and then up a wall at a 90 degree angle to knee height. The patient places their foot on the tape, lining up the heel and second toe. Moving their foot further and further from the wall, the patient slowly lunges forward to touch the line of tape on the wall with the center of their patella while still keeping the entire sole of the foot flat on the ground. When the greatest reach is achieved, one of two measurements can be done. The distance of the second toe from the wall can be measured and used as a baseline or an inclinometer can be placed on the shin 15 cm form the tibial tuberosity and the angle recorded. This maximum lunge method has previously shown high intrarater and interrater reliability. (Backman 2011)

Other tests that can be used as outcome measures and return to sports indicators include the single leg stand (see Appendix I), repeated step up test, the single leg squat, and single legged heel or toe-rising test (performed at a pace of 60 times per minute). (Kaminski 2013)

Prognosis for Lateral Ankle Sprains

Eventually most patients fully recover from lateral ankle sprains. Recovery ranges from 36-85% of patients reported over a 3-year period (van Rinje 2008). Improvement is rapid over the first two weeks and then continues more slowly.

Residual complaints can occur and include joint instability, stiffness, and intermittent swelling, with pain and intermittent swelling being the most common. These are more likely to occur after more extensive cartilage damage. Various studies have reported anywhere from 3-34% of patients will experience some combination of residual pain, swelling, a giving way sensation or activity limitations. As many as 10-20% complain of persistent “instability.” (Van Ochten 2014).

A systematic review (Van Rijn 2008) covering various grades of lateral ankle sprains included 31 studies (24 were of high quality although most had fewer than 100 subjects) reported the following findings:

- 5-33% of patients still experienced pain after 1 year. Even after 3 years some patients still reported pain and/or subjective instability. One study found that training more than 3 times a week is a prognostic factor for residual symptoms.
- 3% to 34% of the patients had re-injuries (i.e., sprains) from 2 weeks to 96 months post injury. Recurrent sprains may accelerate long term degeneration of the ankle joint. (Struijs 2014).
- 0% to 33% reported subjective instability.

Poor Response to Treatment

Tenforde et al (2016) suggest that the patient should be re-assessed for concomitant injuries if there is poor recovery from an inversion sprain. These injuries include a peroneal (i.e. fibularis) muscle tear, an osteochondral lesion of the talar dome, a fracture of the anterior process of the calcaneus or lateral malleolus, and neuritis of the superficial peroneal or sural nerve.

Surgery for Lateral Ankle Sprains

Although most ankle sprains can be treated conservatively, surgery remains an option for individual cases. Peterson's systematic review (2013) recommended surgical consideration for athletes with objective signs of increased instability and for those with extensive grade III sprains, involving all three lateral ankle ligaments and accompanied by significant hematoma. Anderson (2010) suggests surgery for instability with displacement of $\geq$2 mm compared to the uninjured ankle.

Special Topics

Summary

1. Severe Sprains

In cases when a grade III sprain is suspected on the grounds of significant swelling, bruising, and the inability to weight bear, the patient should be given crutches and placed in a functional walking orthesis. When there is significant edema, a posterior splint in the neutral position will better accommodate swelling, allow for icing and eliminate the potential for calf muscle shortening. Bearing weight is allowed only on the uninjured side. Procedures to reduce swelling should be instituted and the ankle re-examined approximately 3 days later. If there is still no noticeable improvement or there are now detectable signs of joint laxity, an MRI should be ordered to assess the degree of injury. Acute treatment should continue another 4 days before functional rehabilitation is introduced. (Dubin 2011)

While immobilization is necessary for these injuries, there is controversy regarding the optimal length of time and type. (Kaminski 2013) A common recommendation is to immobilize grade III sprains for approximately 7-10 days using a rigid stirrup brace or below-knee cast to help protect the area. This is applied in the neutral position (90 degrees). This position is especially helpful when the patient feels the need to return to occupational or other activities that require walking as soon as possible and eliminates the potential calf muscle shortening that may occur with simple wraps and /or using crutches alone. Thorough instruction in edema control is critical in this case.

This approach should be followed by controlled exercise after transitioning to a semi-rigid brace (category B evidence, Kerkhoffs, et al., 2012, Mitchell 2013, McCriskin 2015). Rigid immobilization for an extended length of time in a cast is typically reserved for patients who are sedentary or with lower physical demands. It is worn for no more than 3 weeks followed by a course of muscle strengthening and proprioceptive retraining. (McCriskin 2015)

Functional management of the severe sprain is similar to sprains in general: early mobilization, weight bearing with appropriate bracing, and an exercise program focusing on muscle strengthening, ankle range of motion, and sensorimotor training. Proprioceptive therapy is thought to be crucial. (McCriskin 2015)

Patients with moderate to severe ankle sprains should be re-examined 4-6 weeks after the initial injury to screen for signs of instability. (Tiemstra 2012)

Surgery for Severe Lateral Sprains

Surgical repair is a consideration but may be delayed and reserved for treatment failure or select patients who have high physical demands (McCriskein 2015). McCrisken cites a 2010 RCT which reported that acute grade Ⅲ lateral ankle ligaments surgically repaired within one week of injury had similar recovery results compared to a functional treatment approach. Surgery had the advantage of a lower re-injury rate but a higher rate of post-surgical osteoarthritis. Secondary reconstruction of grade III injuries is possible even years after injury and outcomes are similar to those for primary repair. (Kaminski 2013)

2. Deltoid Sprains (based on McCollum 2013)

Management of deltoid sprains depends largely on whether the there is a partial tear (usually involving just the superficial section of the ligament), a complete tear (which includes the deep portion leading to instability), or whether there are concomitant injuries. Isolated deltoid sprains are rare and so there is little research evidence to guide management of isolated deltoid injuries without fracture. Deltoid sprains which involve only the superficial portion and which are rotationally stable are thought to have a good prognosis and can be treated non-operatively.

The general approach is to immobilize the ankle with a boot and avoid weightbearing for 5-7 days. The rehabilitation program can be introduced when the patient can tolerate it and is similar to treating lateral sprains (see pp 16-22). For the athlete with an isolated deltoid sprain, early stress by returning to too soon activity may lead to the ligament healing in a stretched position, contributing to instability. Return to light training should be delayed to about 6-8 weeks.

There is less agreement concerning whether complete ruptures of both sections should be managed surgically or not. Musculoskeletal ultrasound or MRI can confirm the diagnosis of the sprain and the degree of tearing.

Most deltoid sprains, however, are associated with fibular or lateral malleolar fractures and other injuries. Large tears and ruptures affecting both layers are almost always associated with high ankle sprains, lateral malleolar fractures, lateral sprains, or high fibular fractures. The tibialis posterior, flexor hallucis longus, and saphenous nerves may also be injured. Generally, pain, swelling and hematoma occur rapidly, although instability may be initially difficult to appreciate until later.

The presence of a fracture extends the period of limited weight bearing which may actually provide additional time for the deltoid ligaments to heal. An RCT (Stromsoe 1995) reported that whether the deltoid ligament was sutured or not there was no difference in outcome in those patients with displaced ankle fractures (providing the talus was reducible into the mortise).

Post-surgical management can include the following:

- Plaster cast for 6 weeks.
- Passive and active mobilization of the ankle joint, muscle training, and wearing a removable boot when walking,
- A walker or stabilizer shoe is recommended for 4-6 weeks after the cast removal, then continued to be used on uneven ground, during high risk sports and demanding outdoor work environments.

3. High Ankle Sprains

There is agreement that recovery from high ankle sprains takes longer than from lateral sprains. (Kaminski 2013) There are currently, however, no RCTs or consensus on how best to manage these sprains, although early recognition and immobilization are important components. Immobilization is achieved by non-weight bearing, employing a walking boot, casting or bracing. (Williams 2010, Kaminski 2013) Ankle braces that limit *external rotation* and *extreme dorsiflexion and plantar flexion* may be helpful. Ankle stirrups, athletic tape and lace up ankle braces provide less stabilization and are not recommended. (Williams 2010).

Acute, stable sprains (i.e., no significant widening of the mortise radiographically upon external rotation) are candidates for non-operative management.

(Mulligan 2011) A conservative management program includes protecting the injury, treating symptoms and increasing strength, ROM and strength and proprioception. (Kaminski 2013)

A Sample Conservative Management Program for High Ankle Sprains

Clinical tip: As treatment progresses the pace of rehabilitation can be guided in part by the level of posterior tibiofibular pain. (Mulligan 2011)

Phase I: Day 1–4.

- **Complete non-weightbearing.** Use crutches. Premature load on the syndesmotic ligaments and membrane may induce heterotrophic ossification along the membrane. (Dubin 2011)
- **Posterior splint** with ankle at neutral (optional) (Williams 2010)
- **Cryotherapy** for pain and inflammation. (See p. 3.)
- **Manual isometric exercises**, performed at 30° of plantar flexion.
- **AROM exercises.** Note that dorsiflexion exercises should be introduced cautiously; when doing the exercises begin by limiting the degree of dorsiflexion by initiating movement starting from a plantar flexed position, extending back only to neutral. Also avoid end range eversion (i.e. external rotation). (Mulligan 2011)

  A cycle ergometer and other machines can also be an effective means to mobilize the joint. (Williams 2010) Dorsi-flexion can continued to be managed by carefully manipulating the seat position on an exercise bicycle by setting it higher or on a leg press by setting the seat further back. (Mulligan 2011)

SEAT TOO CLOSE INCREASES ANKLE DORSIFLEXION

SEAT FURTHER BACK DECREASES ANKLE DORSIFLEXION

Clinical tip: Because end range dorsiflexion and plantar flexion creates a shear load on the ligament and syndesmotic membrane, these extremes should be minimized throughout the recovery process, especially when added resistance is provided.

- **Non-weight bearing resisted dorsiflexion.** Initially limit the amount of dorsiflexion.
- **Light passive dorsiflexion** stretching with a towel.

Phase II: Day 4–5

- **Continue AROM.** Full range, pain free dorsiflexion can be encouraged but forceful or ballistic dorsiflexion should be avoided. (Williams 2010)
- **Daily wear of ankle brace**.
- **Manual resistive exercises.** Full range of dorsi/plantar flexion can be added cautiously with provider resistance in office.
- **Resistance exercises.** Home tubing exercises, focusing on calf muscles and peroneal muscles, but eventually targeting each of the major muscle groups around the ankle. (Williams 2010)
- **Initiate weightbearing exercises** (as tolerated), walking, and double toe raises.
- **Light proprioceptive exercises**. Double leg stance on surfaces that are minimally unstable. As the patient demonstrates good control with minimal pain, the balance challenges can be increased (see next phase).
- **Stretching calf muscles.** Low load, longer duration especially if muscles are stiff. (Williams 2010)

Phase III: Day 6+

- **Full weightbearing.** Note that in more severe cases some providers will maintain non-weightbearing ambulation with the ankle in a cast or boot for as much as 2-6 weeks. (Williams 2010). Progression toward full weight bearing will be based on the patient's tolerance and the results of examination. Full weight bearing is initiated when patients can walk on various surfaces and up and down stairs with minimal discomfort. (Williams 2010) Weight bearing exercises should avoid the ankle placed in an everted (i.e., toes pointed outward) position. (Mulligan 2011)
- **Begin with squat exercises** on a decline board with heels higher than toes to limit the amount of ankle dorsiflexion while allowing for deeper knee flexion. (Mulligan 2011)

- **Continue manual resistive exercises** with inversion/eversion added.

- **Functional exercises:** progress from double toe raises to double-legged hopping, single toe raises, and single-leg hopping. The external rotation test and stabilization test (see Appendix D) can be used to assess the patent's readiness to progress to activities like jogging and hopping. (Williams 2010) Progress to lunges and lateral step up exercises. Extreme dorsi-flexion can be controlled by emphasizing retro lunges initially and short step ups. Progress cautiously to more dynamic sport-specific drills. (Mulligan 2011)
- **Proprioceptive exercises:** single leg stance on rocker board, balance pad progressions (see progression in Lateral Ankle sprain p. 21). Single leg balance can be done with the knee near full extension to focus the balance strategy down to the ankle. (Williams 2010).
- **Walk, jog, run, cutting, explosive maneuvers**. These include running figure 8's and carioca drills*. (Williams 2010)
- **Ankle brace/taping for return.**

Recovery period is extremely variable, depending both on the extent of injury and the individual patient. Disability ranges from days to 4-5 months. (Tiemstra 2012, Kaminski 2013) But there is general agreement that recovery is much longer than for lateral ankle sprains. (Williams 2010)

High Ankle Sprains: Return to Work/Play

A variety of indicators have been suggested regarding return to work/sport. An athlete may return to activity when able to complete 15 single-legged hop off toes (Anderson 2010), has passed functional testing, and is mentally ready to return. Mulligan (2011) suggests the following functional indicators: comfort with push off and cutting maneuvers, 80-90% symmetry in single leg forward hop (see Appendix XX), and a normal FADI score.

For grade I or II distal tibiofibular injuries, 4-6 weeks may be required before returning to unrestricted competition (Mulligan 2011). Others report an average of 45 -55 days (with a very wide range of 6-137 days) --twice as long as for grade III lateral sprains (Williams 2011).

Chronic pain, instability, and functional impairment are considered to be common sequelae. (Williams 2010). The provider should continue to monitor for possible complications for a minimum of 6 months (e.g., heterotopic ossification, syndesmotic calcification, anterior impingement syndrome). (Mulligan 2011)

A 1992 (Taylor) study reported that at an average of 4 years out, the following were the outcomes for 44 syndesmotic sprains in football players: 36% still had mild to moderate stiffness, 23% mild to moderate pain with activity, 18% had mild to moderate persistent swelling. Ankle function, however, was rated as good to excellent in 86% with none reporting poor results. (Mulligan 2011)

* In a carioca drill one quickly moves sideways, the leading leg crossing behind the stance leg (which then steps sideways), then the leading leg crosses in front of the stance leg which then steps sideways. The leading leg continues to alternate crossing behind then in front of the stance leg, propelling the person in a straight line sideways. The drill should be run in both directions.

Surgery for High Ankle Sprains

In the case of high ankle sprains, surgery is recommended for obvious diastasis of the tibiofibular space on x-rays. Common cut points are a tibiofibular clear space < 6mm (as seen on AP and mortise views) and tibiofibular overlap of ≥ 6mm or 24% for the fibular width. On the AP view an overlap of 1mm on the mortise view also is an indicator. (Harper1989). There is some controversy as to whether these radiographic measurements are sufficient on their own or whether they need to be accompanied by additional indicators such as presence of fracture requiring fixation, evidence of other surgical treatable lesions such as repairable syndesmotic tear, latent instability, scarring or calcification of the syndesmosis since these have been correlated with chronic ankle pain. Surgical success rates are considered to be excellent (Williams 2010).

Surgical fixation is also recommended for increased ankle mortise widening (greater than 2mm) or joint incongruity seen on standard or stress radiographs (Kaminski 2013). Finally, surgery is indicated when there is a fibular fracture at least 2 inches above the ankle joint in the presence of a deltoid rupture or complete diastasis. (Mulligan 2011)

4. Chronic ankle pain or instability

Summary of Interventions
Manual therapy
Balance exercises
Taping
Resistance exercises
Manually resisted PNF cross patterns

Patients with moderate to severe ankle sprains should be re-examined 4-6 weeks after the initial injury to screen for signs of instability. (Tiemstra 2012) Patients may also present to the clinic for the first time with a complaint of chronic ankle pain or a feeling of instability.

Tools used to identify chronic instability include the Foot and Ankle Ability Measure [FAAM] and the Ankle Instability Instrument. These tools are also used to assess severity and measure progress (Kaminski 2013).

Kinetic chain complicators and contributors should be assessed including increased ankle laxity, impaired dorsiflexion, leg and hip weakness, and diminished postural control. (Kaminski 2013, Tenforde 2016). Manual therapy techniques should be used to restore motion and restore dorsiflexion (see appendix B). Rehabilitation should focus on balance and strength and should incorporate dynamic movements with changes in direction to reduce the risk of re-injury (based on category B evidence, (Kaminski 2013). Clinical consensus suggests that both open and closed chain exercises should be used (Kaminski 2013).

Participants with functional instability who were involved in a 6-week progressive rehabilitation program (10 minutes, 3 times per week) consisting of resisted ankle exercises in 4 directions improved their ankle dorsiflexion, eversion strength, and ankle-joint positon sense. (Docherty 1998)

Taping

One chronic residual effect of an acute lateral sprain may include pain anterior to the lateral malleolus when dorsiflexing as when squatting. There has been some suggestion that inversion sprains sometimes result in anterior displacement of the distal fibula (Mulligan 2011, Hubbard 2008). If during a functional assessment of this area, pushing the distal fibula posteriorly relieves the pain, leukotape can be applied to pull the distal fibula into a posterior direction. Application starts in front of the lateral malleolus, the tape is pulled from A-P and spiraled behind the Achilles tendon and once around the crest of the tibia. Leukotape can be a good choice because it doesn't stretch and is very moisture resistant. Patients can easily be taught this technique for self- help during aggravating activities.

Resistance exercises

Below is a sample of a 6-week resistance band exercise program for chronic instability. (Hall 2015)

This was a supervised program, 3 times/week for 6 weeks consisting of dorsiflexion, plantar flexion, inversion and eversion exercises. Patients were instructed to exercise at a consistent pace of 3-5 seconds per repetition and to go through full range of motion.

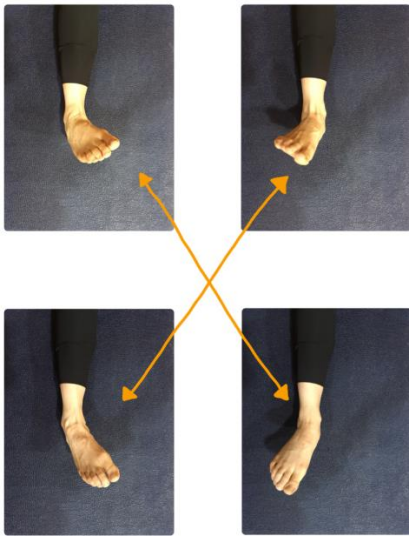
Week	Tubing	Prescription
1	Heavy	3 sets, 10 reps
2	Heavy	4 sets, 10 reps
3	Super heavy	3 sets, 10 reps
4	Super heavy	4 sets, 10 reps
5	Ultra-heavy	3 sets, 10 reps
6	Ultra-heavy	4 sets, 10 reps

In-Office PNF Treatment

The Hall 2015 RCT compared the same strengthening exercise program (see above) to a PNF in-office treatment plan and found similar benefits. Treatment consisted of resistance through D1 and D2 patterns.

The D1 pattern consists of a diagonal movement of dorsiflexion-inversion (an up and in motion) followed by plantar flexion-eversion (down and out). The D2 pattern consists of dorsiflexion-eversion (up and out) followed by plantar flexion-inversion (down and in). Throughout the

movement, patients exert maximal effort for each repetition, taking approximately 3 to 5 seconds to complete each direction.



The practitioner applies manual resistance to the foot at the metatarsal heads, either at the superior or inferior aspect depending on which direction of movement is being resisted. The patient rests for 60-seconds between sets, but there is no rest between repetitions.

To see a video, go to https://www.youtube.com/watch?v=D8OxRf3T0_E

The treatment prescription is outlined below:

Week	Prescription
1	3 sets, 10 reps
2	4 sets, 10 reps
3	3 sets, 10 reps
4	4 sets, 10 reps
5	3 sets, 10 reps
6	4 sets, 10 reps

Surgery for Chronic/Recurrent Ankle Pain & Instability

Van Ochhten's systematic review (2014) reported that for patients with *chronic ankle pain*, good to excellent clinical outcomes were found for surgery in most of the studies. However, in four of the studies, no comparison was made with a control or usual-care group.

For patients with second-stage *ankle instability,* the evidence in favor of surgery over a functional training program is limited at long-term follow-up in patients (Van Ochhten 2014). However, for chronic lateral ankle instability unresponsive to conservative treatment, surgical repair or reconstruction is recommended and can restore active patients to full athletic function. (McCriskin 2015)

Tenforde et al (2016) suggest a surgical consultation for patients with *recurrent ankle sprains* (e.g., ≥ 3). Clinical research studies report that surgery had good results in patients with recurrent ankle sprains, as expressed in subjective scoring scales (high percentage of good to excellent results); however, the superiority of surgery over continued conservative care has not be assessed due to the lack of comparison to a nonsurgical control group. (Van Ochhten 2014)

5. Prevention Programs

Although Kerhoffs (2012) reports that there is no evidence that prevention programs can decrease the rate of first time ankle sprains, there is evidence that they can minimize the chances of re-injury by about 35% with an NNT of 7-9 (Kaminski 2013) and perhaps as high as 50% in Huppert's 2009 study. Evidence-based programs emphasize single-leg balance activities with pertubation challenges and upper extremity tasks incorporated as well as dynamic jumping activities. Although there is less direct evidence for strengthening and ROM exercises, deficits in these areas have been implicated as possible risks. In terms of duration and frequency, program prescriptions differ widely. One recommendation is an injury prevention program lasting at least 3 months that focuses on balance and neuromuscular control (based on category A evidence) (Kaminski 2013).

Athletes with a history of previous ankle sprains should wear prophylactic ankle supports (e.g., taping or bracing during practice and games). Lace-up and semi-rigid braces and traditional ankle taping can reduce the re-injury rate (based on category B evidence) (Kaminski 2013)

Evidence suggests that both bracing (lace up, semi-rigid) and taping can help prevent both first time and recurrent injuries (Kaminski 20123). In terms of footwear, the evidence is less clear. Although wearing hiking boots or other high-top, lace-up shoes has generally thought to be helpful, two systematic reviews (3 RCTs, N=3140) could demonstrate no difference between high vs low fitted shoes in terms of reducing recurrence rates. (Kerkhoffs 2012).

Programs include strengthening lower extremity muscles (evertors, invertors, dorsi and plantar flexors) as well as hip extensors and abductors. An additional goal is to increase dorsiflexion ROM. (Kaminiski 2013)

A sample proprioceptive program preventing ankle sprain recurrence (Hupperts 2008)

- Begin 8 weeks after completing usual care and when sports activity is possible. Give both written and verbal instructions.
- Assign 3 training sessions per week.
- The program can be performed as part of the warm up for their sport.
- This program should be coupled with a balance program which incorporates perturbations. (See next page.)

For the sample program below, the letters (A-F) indicate the type of exercise; the first row of numbers indicate sessions 1-24; the numbers in the columns denote the progressive levels of difficulty (1-3) for each exercise.

	Week 1			Week 2			Week 3			Week 4			Week 5			Week 6			Week 7			Week 8		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
A	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3
B	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
C	1	1	1	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
D	1	1	1	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
E	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	4	4	4	4	4	4	4	4
F	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2

Postural “faults” should be observed and corrected as much as possible. For example, “valgus collapse” of the weight-bearing extremity while adopting the running pose or one legged stance may be simply habitual or may be secondary to inhibited/weak hip abductors or ankle pronation. Core stability should be encouraged by holding a neutral pelvis and performing abdominal bracing while performing the exercises.

A: Single leg knee flexion/squat

- **Level 1** on even surface (sessions 1-8, into week 3)
- **Level 2** even surface eyes shut (sessions 9-16, into week 6)
- **Level 3** balance board (see picture) (sessions 17-24, to end of week 8)

B: Toe stand and heel raise

- **Level 1** on high surface with handhold (sessions 1-12, into week 4)
- **Level 2** without handhold (see picture) (sessions 13-24, to end of week 8)

C: Single leg stance (lunge)

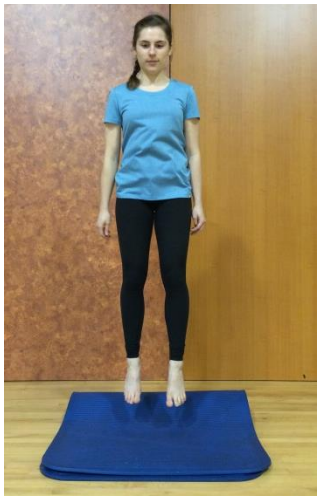
- **Level 1** on even surface (sessions 1-8, into week 3)
- **Level 2** even surface eyes shut (sessions 9-16, into week 6)
- **Level 3** balance board (see picture) (sessions 17-24, to end of week 8)

D: Single leg runner's pose

- **Level 1** on even surface (sessions 1-4, into week 2) (see picture)
- **Level 2** even surface eyes shut (sessions 5-8, into week 3)
- **Level 3** balance board (sessions 9-24, to end of week 8) (see picture)

E: Cross leg sway.

- **Level 1** on even surface with handhold (sessions 1-6, week 2)
- **Level 2** even surface without handhold (sessions 7-12, end of week 4)
- **Level 3** even surface eyes shut (without handhold) (sessions 13-16, into week 6)
- **Level 4** on balance surface (sessions 17-24, end of week 8)



F: Toe walk

- **Level 1** on even surface walking
  (sessions 1-12, end of week 4)
- **Level 2** on even surface jumping
  (sessions 13-24, end of week 8)

Appendix A: General Ankle Taping

The following are step by step instructions for taping an inversion sprain or other ligamentous injury.

Step 1: Skin Prep and heel/lace pads

Prep skin by treating any cuts/abrasions, shaving hair, spraying with tough-skin (skin protectant), applying skin lube and heel/lace pads to friction prone areas (e.g., Achilles and anterior/dorsal extensor tendons).

Step 2: Underwrap

Thin foam wrap is applied to areas between anchors to protect skin from tape irritation.

Step 3: Anchor strips

Two anchor strips are placed on skin. The proximal edge of one anchor strip is placed just inferior to the calf muscle and the distal edge of the other proximal to the metatarsal heads.

Step 4: Stirrups

Apply U shaped loops to support ligaments in a direction opposite to the motion you want to limit. Stirrups are taped to each anchor strip with the posterior edge starting at the heel. Three are commonly applied: One anterior, one central to and one posterior to the malleoli.

Step 5: Horseshoe strips

These horizontal strips are applied next, attached to the distal anchors (stirrups, but not anchor strips are shown here).

OR

Step 6: Basket Weave

Stirrups and horseshoe strips are laid down in alternating layers. Start applying stirrups from the posterior aspect and inferior horseshoe strips from the inferior aspect, alternating between them and working towards anterior and superior directions.

Overlapping strips are applied all the way to the back of the leg (partially seen in picture). Superior anchor strip not shown. In the open Gibney, the anterior foot and ankle are left open to accommodate swelling.

Step 6: Figure 8

1-2 figure of eights are laid down around the ankle and foot and over all of the taping in the above pictures for general ankle support (the underlying taping is not shown in the picture).

Step 7: Double heel lock

The first lock is a continuous strip starting at the top of the foot, winding under the sole, wrapping around and locking the heel, then back to the other side, up the lower leg, and finally back around the circumference of the leg. These are attached to the anchor strips and applied over the top of all of the previous taping.

Step 8: Closures

To secure and clean up the taping procedure and eliminate any remaining gaps or open windows to prevent blisters and space for swelling to occur.

Appendix B Manipulation & Mobilization

The following are examples of various manipulation and mobilization approaches from published studies. There is currently no evidence that these procedures are more or less effective than other specific manipulations. When using a mobilization technique, the length of time or number of oscillations vary, typically about 15 impulses are delivered (Hubbard 2008).

A-P Mobilization (**Hoch 2010, Cosby 2010, Green 2001)**

The distal tibia and fibula are stabilized and the talus (in an open joint position or with the ankle dorsi-flexed) is mobilized into a posterior direction up to the end feel of restriction (grade III mobilization) for 30 to 60 seconds at 1 oscillation per second. Pause for 10 seconds and then repeat the treatment two more times. Periodically check with the patient to make sure that the mobilization continues to be relatively pain free.

Manipulation and soft tissue treatment package in an ER setting (Eisenhart 2003)

In this study, the following procedures were all performed as a standard treatment package.

- Posterior proximal fibula treated by low force techniques
- Manipulate dropped (inferior) cuboid
- PIR for fibularis muscle

Below are two common methods manipulating the cuboid:

Double Thumb
Inferior Cuboid Contact

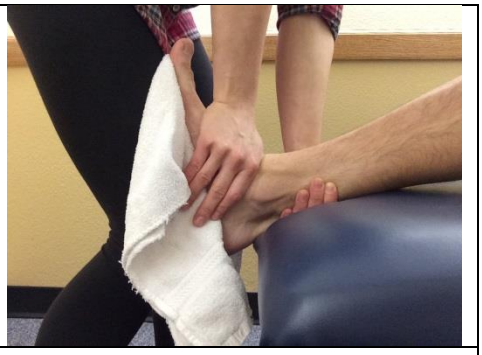
Hypothenar Covered Thumb
Inferior Cuboid Contact

Mortise separation thrust adjustment (Pellow 2001)

The mortise separation adjustment for subacute inversion ankle sprains. The patient is supine. Firmly grasping the foot from both sides, the provider places their thumbs on the sole of the foot and fingers over the dorsum. The entire lower extremity is then internally rotated with the ankle everted. Then a sharp impulse is applied to the ankle, distracting the joint. (See high velocity distraction on the next page.)

From Cleland (2013)

This is a treatment approach to grade 1 and 2 lateral ankle sprains. The number of days post-injury was not restricted. When low velocity mobilizations were performed, they were repeated 5 times for 30 seconds each (modified based on patient's tolerance).

Talocrural A-P mobilization*	Stabilize lower extremity just above the malleoli, grasp the talus firmly, mobilize with low force oscillations. Progressively increase the amount of dorsiflexion and alter the degree of pronation and supination. The thigh can be used to stabilize the ankle into dorsiflexion.	
Talocrural A-P mobilization (weight bearing)**	Place the indifferent hand over the top of the foot to stabilize it and to prevent any anterior movement of the talus. Loop a belt just above the ankle and around your posterior pelvis. As the patient leans forward dorsiflexing at the ankle, you lean backward into a squat pulling the distal lower leg toward you, creating a slow P-A force across the joint.	
Talocrural glide	While the indifferent hand stabilizes the malleoli, place the thenar eminence of the treatment hand on the talus, fingers reaching around the foot. The thenar eminence imparts an oscillating mobilization to the talus. The forearm can be pressed along the lower extremity to help stabilize.	

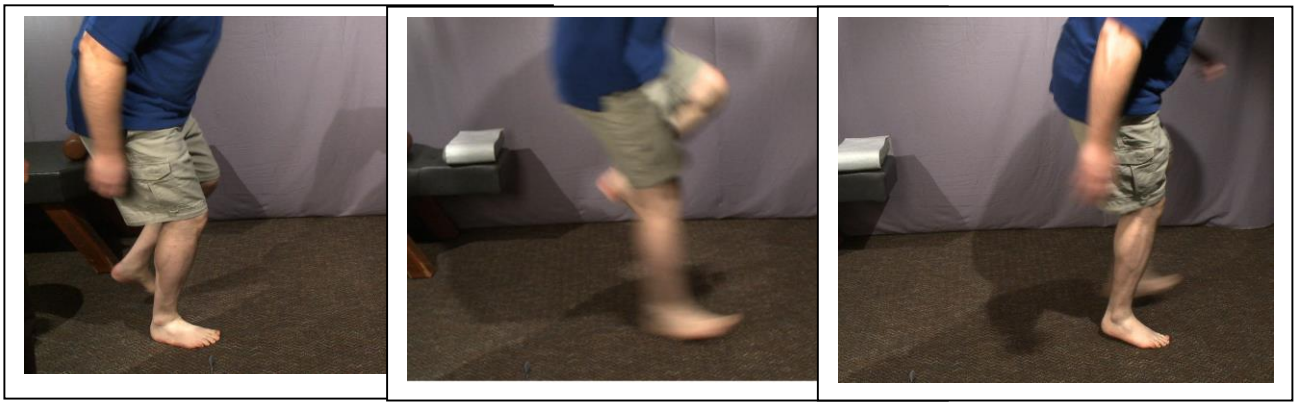
* Although not used in the Cleland study, this procedure can be done as a high velocity, low amplitude thrust adjustment.

** A variation of this method (not used in the Cleland study) is to vary the orientation and angle of pull of the belt (e.g., pulling the lower extremity lateral, medial or posterior) while stabilizing the foot until a pain free direction is discovered and then mobilizing the ankle in that direction.

Subtalar glide:	With one hand stabilize the talus and place the thenar eminence of the treatment hand on the medial aspect of the calcaneus. The thenar eminence imparts an oscillating mobilization to the calcaneus.	
Proximal tib-fib manipulation	The indifferent hand is place behind the knee with the index finger firmly stabilizing the posterior aspect of the proximal fibula. The treatment hand grasps the distal tibia, externally rotates the ankle, and flexes the knee to the barrier and then imparts a high velocity, low amplitude thrust at the ankle forcing the knee into further flexion. *	
Distal tib-fib mobilization	The indifferent hand stabilizes the distal tibia and the thenar eminence of the treatment hand imparts an A-P oscillatory mobilization to the distal fibula.	
High velocity distraction	Grasp dorsum of foot with inter-laced fingers and thumbs press firmly against the sole of the forefoot. Pronate, dorsiflex, and traction to get to the barrier and then apply a shallow, high velocity tug.	

* A common alternative is to flex the knee over the contact hand and using to the thenar eminence of the contact hand to apply a medial to lateral thrust.

Appendix C: Single legged hop

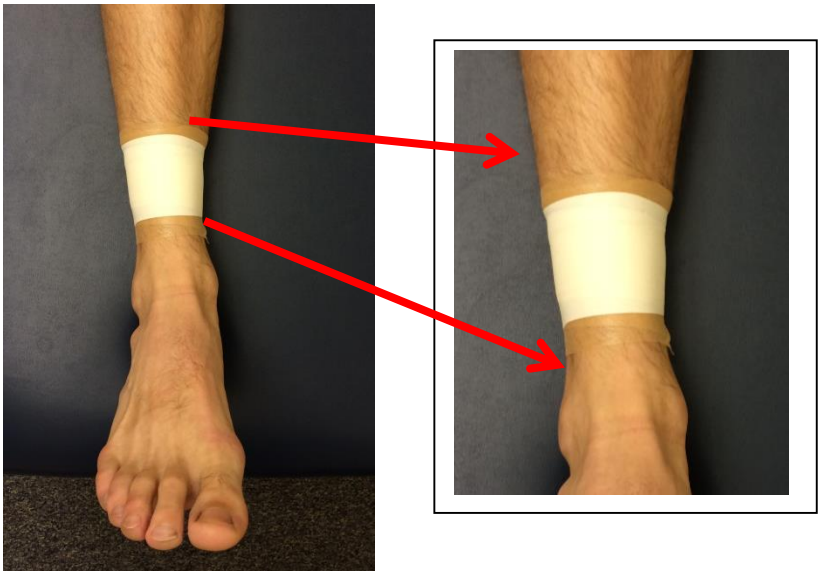


Indication: This is a not a test leading to a diagnosis of the patient's pain generator. It is a functional test of strength and coordination and is done only after the patient is out of the acute phase and transitioning into the rehabilitation and recovery phases of treatment.

Procedure: Mark a starting position on the floor. The patient stands on one leg and hops forward as far as possible. Start with the uninjured extremity. The patient gets 2 practice hops followed by 2 test hops. Measure the distance of each test hop and average. If the initial hop is painful, consider waiting to do this assessment. A brace is recommended when performing the test post injury and up to 1 year post-surgical. Variations include the cross over hop and triple hop.

Interpretation: This is a dynamic test assessing ankle stabilizers strength and motor control. An abnormal finding is the injured side hopping < 85% of the distance of the uninjured extremity. A target for rehabilitation in an active patient would be 92-96%. (Logerstedt 2010)

Appendix D: Syndesmosis Stabilization and External Rotation tests



Syndesmosis stabilization test. Patients perform each of the following functions if possible: walk, heel raises, run and hop vertically. The athletic tape is then applied to stabilize the syndesmosis and the functions are repeated. Relief of pain and/or improved performance or sense of stability is considered a positive test.

External rotation test. The lower leg is externally rotated and a positive test is pain in the area of the syndesmosis.

Appendix E: Short Foot

The “short foot” or “small foot” are terms used to describe an exercise in which the plantar intrinsic foot muscles are contracted pulling the metatarsophalangeal joints together and toward the calcaneus in order to accentuate the longitudinal and transverse arches McKeon 2015, Liebensen 2007). When done properly, this exercise shortens and narrows the foot. Its purpose is to activate and strengthen the intrinsic foot muscles.

The intrinsic foot muscles are the local stabilizing foot muscles that both originate and insert within the foot. While there are intrinsic muscles on both the dorsal and plantar aspects of the foot, the plantar intrinsic muscles are most commonly targeted due to their functional link with the longitudinal and transverse arches of the foot. They consist of four layers of muscles deep to the plantar fascia. Some muscles (abductor hallucis, flexor digitorum brevis, abductor digiti minimi, quadratus plantae and lumbricals) have configurations which align with the medial and lateral longitudinal arches of the foot whereas others (adductor hallucis oblique and transverse heads, flexor hallucis brevis) align more with the transverse arch. Studies have shown that diminished function of the intrinsic foot muscled leads to deleterious alterations in foot posture (Fiolkowski 2003, Headlee 2008) and that training of the intrinsic foot muscles enhances foot posture (Drewes 2008, Mulligan 2013).

Exercises prescribed for activation and strengthening of the plantar intrinsic foot muscles have often included toe flexion exercises such as towel curls and marble pick-ups. While these exercises activate some of the plantar intrinsic muscles, they also involve substantial activation of the flexor hallucis longus and flexor digitorum longus muscles. (McKeon 2015). Short foot exercise may isolate contraction of the plantar intrinsic muscles better than toe curls. One study found the short foot exercise to be a more useful strengthening exercise than toe curling in activating the abductor hallucis muscle and in preventing lowering of the medial longitudinal arch. Another found the short foot to be more effective than towel curling at training the intrinsic foot muscles to maintain the height of the medial longitudinal arch during dynamic-balance task (Lynn 2012). A comprehensive rehabilitation program should include both types of exercises.

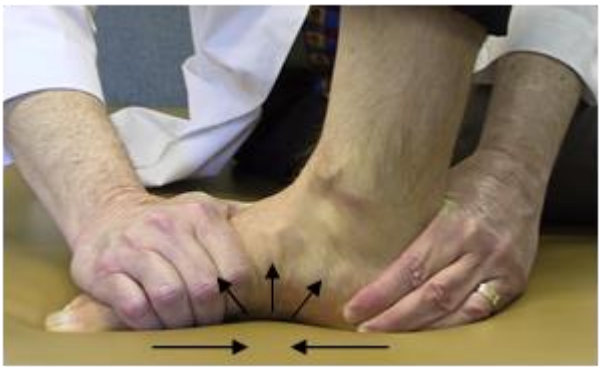
The rationale for performing short foot exercises is based on the concept that creating a stable base at the foot will improve biomechanical function throughout the body when standing and ambulating. The short foot helps to increase afferent input from the sole of the foot, improves the position of the body segments and improves stability of the body in upright position (Liebenson, 2007). It has also been shown to improve dynamic balance (Moon 2014). The short foot exercise can be viewed as a foundational exercise for foot and ankle rehabilitation similar to how abdominal bracing is foundational to lumbopelvic stability exercise programs. Vladimir Janda proposed implementing the short foot exercise as the first step in a sensory motor training program (Liebenson 2007).

Teaching the Short Foot

Before teaching the short foot to the patient it will likely be beneficial to mobilize the joints and soft tissue of the foot as needed in order to promote unrestricted motion. Since the exercise can initially be fairly difficult for most patients to perform, especially in weight bearing, it is advisable to begin with the patient sitting. Janda outlines a three step process for teaching the short foot which includes passive modeling by the therapist, active assisted modeling and finally active modeling by the patient (Liebenson 2007).

Passive Modeling

The patient is seated with the entire sole of the foot on the floor, toes and knee pointing forward, and the lower leg vertical to the ground. The therapist cups one hand behind the patient's heel and the other hand grasps the forefoot, gently squeezing the first and fifth metatarsals together and then, with vibratory movements, the therapist shortens and lengthens the sole of the foot. This is repeated several times, followed by relaxation. By this helps to stimulate the intrinsic muscles helps the patient to feel and see the motion that is desired.



Active Assisted Modeling

With the patient in the same position and the therapist with the same contacts, the patient is the instructed to push slightly with the plantar surface of the stretched toes against the floor, without curling the toes, and then tries to narrow the forefoot and pull it toward the heel, increasing both the longitudinal and transverse arch of the foot. The therapist helps to correct the movement with slight pressure on the toes from above to prevent flexion of the toes.

Active Modeling

In the same position, the patient voluntarily creates the short foot by narrowing the forefoot and pulling it toward the heel without contact by the therapist. Each trial is followed by relaxation of the foot muscles.

Alternatively, the patient can be coached to distribute his/her weight over a three-point tripod consisting of the heel and 1st and 5th metatarsal heads. While the weight is balanced in this fashion, the patient pushes off from those points resulting in a more upright standing posture.

Once the patient is able to perform the exercise adequately, it can be given as a home exercise to be done several times per day. Once the patient has mastered the exercise in a seated position, the next step is voluntary forming of the short foot on one leg positioned in front of the other while standing. The aim is to teach the patient to form the short foot on the non-weightbearing/front leg first and then progress to forming it while weight bearing on both feet evenly and eventually to single leg stance.

Appendix F: Lower Extremity Functional Scale (LEFS)

Although not specific to the ankle, LEFS accurately identifies functional limitations in patients with acute inversion ankle sprains and is responsive to changes over time (Alcock 2002). The questionnaire is composed of 20 items/questions ranging from daily activities (e.g., putting on shoes) to more advanced sport-specific tasks (running and hopping). This questionnaire can be used to establish baseline function, track progress, and set recovery goals.

Scoring instructions

Each item is scored from 0 (extreme difficulty or unable to perform activity) to 4 (no difficulty). The columns on the scale are summed to get a total score. The maximum score is 80.

Interpretation of scores

- The lower the score the greater the disability.
- The minimal detectable change is 9 scale points.
- The minimal clinically important difference is 9 scale points.
- % of maximal function = (LEFS score) / 80 * 100

Performance

- The potential error at a given point in time was +/- 5.3 scale points.
- Test-retest reliability was 0.94.
- Construct reliability was determined by comparison with the SF-36. The scale was found to be reliable with a sensitivity to change superior to the SF-36.

Source: Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. North American Orthopaedic Rehabilitation Research Network. Phys Ther. 1999 Apr;79(4):371-83.

The Lower Extremity Functional Scale

We are interested in knowing whether you are having any difficulty at all with the activities listed below **because of your lower limb problem** for which you are currently seeking attention. Please provide an answer for **each** activity.

Today, *do you* or *would you* have any difficulty at all with: Activities	**Extreme difficulty or unable to perform activity**	**Quite a bit of difficulty**	**Moderate difficulty**	**A little bit of difficulty**	**No difficulty**
1. Any of your usual work, housework or school activities.	**0**	**1**	**2**	**3**	**4**
2. Your usual hobbies, recreational or sporting activities.	**0**	**1**	**2**	**3**	**4**
3. Getting into or out of the bath.	**0**	**1**	**2**	**3**	**4**
4. Walking between rooms.	**0**	**1**	**2**	**3**	**4**
5. Putting on your shoes or socks.	**0**	**1**	**2**	**3**	**4**
6. Squatting.	**0**	**1**	**2**	**3**	**4**
7. Lifting an object, like a bag of groceries from the floor.	**0**	**1**	**2**	**3**	**4**
8. Performing light activities around your home.	**0**	**1**	**2**	**3**	**4**
9. Performing heavy activities around your home.	**0**	**1**	**2**	**3**	**4**
10. Getting into or out of a car.	**0**	**1**	**2**	**3**	**4**
11. Walking 2 blocks.	**0**	**1**	**2**	**3**	**4**
12. Walking a mile.	**0**	**1**	**2**	**3**	**4**
13. Going up or down 10 stairs (about 1 flight of stairs).	**0**	**1**	**2**	**3**	**4**

14. Standing for 1 hour.	**0**	**1**	**2**	**3**	**4**
15. Sitting for 1 hour.	**0**	**1**	**2**	**3**	**4**
16. Running on even ground.	**0**	**1**	**2**	**3**	**4**
17. Running on uneven ground.	**0**	**1**	**2**	**3**	**4**
18. Making sharp turns while running fast.	**0**	**1**	**2**	**3**	**4**
19. Hopping.	**0**	**1**	**2**	**3**	**4**
20. Rolling over in bed.	**0**	**1**	**2**	**3**	**4**
Column Totals:					

APPENDIX G: The Foot & Ankle Disability Index Score (FADI)

This questionnaire identifies functional limitations related to foot and ankle conditions and has been used especially with chronic ankle pain and/or signs of instability. One potential limitation is that it has been studied primarily in young adults with self-reported unilateral chronic ankle instability who were compared to young healthy controls.

Scoring instructions

It has 2 subscales: the main set of 26 items assessing activities of daily life and an additional 8 items (i.e., FADI-Sport) addressing more physical activities. Each item is scored from 0 (unable to do) to 4 (no difficulty at all), and a higher score indicates a higher level of function.

Interpretation of scores

The FADI has been reported as reliable and sensitive in detecting injury and change (Hale 2005). Test re-test reliability is excellent for the general questionnaire (ICC.89) as well as the sports section (ICC .84) (Eechaute 2007). Inter-examiner reliability is also excellent for both portions at 1 and 6 weeks (ranging from ICC 0.84-0.93) (Hale 2005).

Performance

One limitation is that a MCID has not been established.

The Foot & Ankle Disability Index Score

Please answer every question with one response that most closely describes your condition within the past week. If the activity in question is limited by something other than your foot or ankle, mark N/A.

Today, *do you or would you* have any difficulty at all with: Activities	**No difficulty at all**	**Slight difficulty**	**Moderate difficulty**	**Extreme difficulty**	**Unable to do**
Standing	**0**	**1**	**2**	**3**	**4**
Walking on even ground	**0**	**1**	**2**	**3**	**4**
Walking on even ground without shoes	**0**	**1**	**2**	**3**	**4**
Walking up hills	**0**	**1**	**2**	**3**	**4**
Walking down hills	**0**	**1**	**2**	**3**	**4**
Going up stairs	**0**	**1**	**2**	**3**	**4**
Going down stairs	**0**	**1**	**2**	**3**	**4**

Walking on uneven ground	**0**	**1**	**2**	**3**	**4**
Stepping up and down curves	**0**	**1**	**2**	**3**	**4**
Squatting	**0**	**1**	**2**	**3**	**4**
Sleeping	**0**	**1**	**2**	**3**	**4**
Coming up to your toes	**0**	**1**	**2**	**3**	**4**
Walking initially	**0**	**1**	**2**	**3**	**4**
Walking 5 minutes or less	**0**	**1**	**2**	**3**	**4**
Walking approximately 10 minutes	**0**	**1**	**2**	**3**	**4**
Walking 15 minutes or greater	**0**	**1**	**2**	**3**	**4**
Home responsibilities	**0**	**1**	**2**	**3**	**4**
Activities of daily living	**0**	**1**	**2**	**3**	**4**
Personal care	**0**	**1**	**2**	**3**	**4**
Light to moderate work (standing, walking)	**0**	**1**	**2**	**3**	**4**
Heavy work (push/pulling, climbing, carrying)	**0**	**1**	**2**	**3**	**4**
Recreational activities	**0**	**1**	**2**	**3**	**4**
General level of pain	**0**	**1**	**2**	**3**	**4**
Pain at rest	**0**	**1**	**2**	**3**	**4**
Pain during your normal activity	**0**	**1**	**2**	**3**	**4**
Pain first thing in the morning	**0**	**1**	**2**	**3**	**4**

FADI-Sport

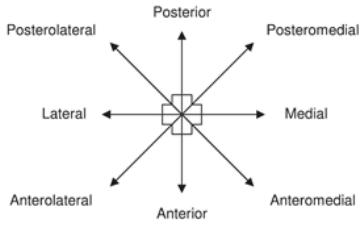
Today, *do you or would you* have any difficulty at all with: Sports	**No difficulty at all**	**Slight difficulty**	**Moderate difficulty**	**Extreme difficulty**	**Unable to do**
Running	**0**	**1**	**2**	**3**	**4**
Jumping	**0**	**1**	**2**	**3**	**4**
Landing	**0**	**1**	**2**	**3**	**4**
Squatting and stopping quickly	**0**	**1**	**2**	**3**	**4**
Cutting, lateral movements	**0**	**1**	**2**	**3**	**4**
Low-impact activities	**0**	**1**	**2**	**3**	**4**
Ability to perform activity with your normal technique	**0**	**1**	**2**	**3**	**4**
Ability to participate in your desired sport as long as you would like	**0**	**1**	**2**	**3**	**4**

Reference:

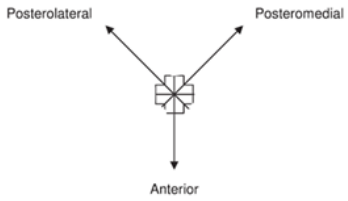
Martin RL, Burdett RG, Irrgang JJ. Development of the Foot and Ankle Disability Index (FADI) J Orthop Sports Phys Ther. 1999; 29: A32-A33

APPENDIX H: Star Excursion Balance Test (SEBT)

The SEBT consists of multiple, single leg stance, reaching tasks on a star grid (modified after Gribble 2012). 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.



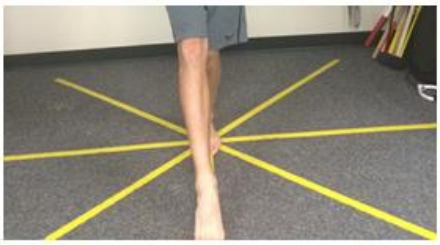
8 arms: each arm is at a 70° angle

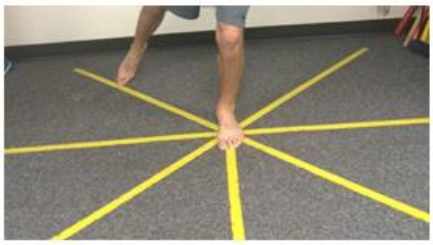


3 arms: the posterior arms are 90° to each other and both are 135 ° from the anterior line.

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.

- 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).

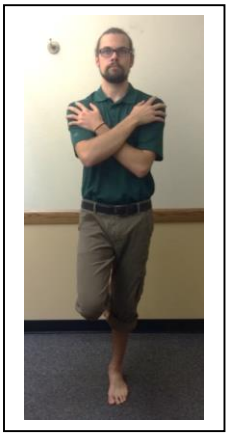
Reliability & Validity: Most, but not all, studies conducted have demonstrated that the test can differentiate normal controls from those patients with chronic instability. Traditional test validity values (sensitivity, specificity, LRs) have not been reported, but effect sizes reflecting a statistical 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. (Kaminski 2013)

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

APPENDIX I: Single Leg Balance Test (SLBT)

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)

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