Acute ankle sprains: A review of literature

Bryan L. Witt, DO, Sharon Lee Witt, DO

From 1395 Lake Shore Dr Unit C, Columbus, OH.

KEYWORDS:
Ankle sprain

Acute ankle sprains are one of the most common musculoskeletal injuries evaluated and treated by primary care physicians. Ankle sprains are common in adolescents and young adults and typically occur during athletic activity. Risk factors include a previous ankle sprain and body mass index greater than 25. There are 3 common types of ankle ligamentous injuries: lateral ankle, deltoid, and syndesmotic ligamentous injuries, with the lateral ankle sprain being the most common. A thorough history and physical examination including special tests (the anterior drawer, talar tilt, and squeeze or external rotation tests) would aid in the diagnosis of these ankle ligamentous injuries. Furthermore, using the Ottawa foot and ankle rule would help determine the need for diagnostic imaging to supplement the physical examination in making an accurate diagnosis. Once a diagnosis is obtained, appropriate medical treatment can be administered including nonsteroidal antiinflammatory drugs, cryotherapy, osteopathic manipulative medicine, activity modification with external support devices, and physical therapy. In the acute inflammatory phase, an acronym of RICES (rest, ice, compression, elevation, and support) can be used as a basic treatment guide.

Epidemiology

Acute ankle sprains are one of the most common musculoskeletal injuries encountered by primary care physicians. There are approximately 2 million acute ligamentous ankle injuries per year in the United States with an associated healthcare cost of $2 billion.[1] Among these, half occur during athletic activity including basketball, football, and soccer.[2] There are 3 major classifications of ligamentous ankle injuries including lateral, medial (deltoid), and syndesmotic ankle sprains. Lateral ankle sprains account for 88.2% of all ligament ankle injuries, whereas deltoid and syndesmotic ankle injuries account for 6.7% and 5.1%, respectively.[3]

Ligamentous ankle injuries are more commonly seen in adolescents and young adults, 15-19 years of age.[1] Overall, there appears to be no difference in occurrence of ankle injuries between men and women.[1,4] When comparing races, there is a slight preponderance of ankle injuries in Caucasians and African Americans matched with other ethnicities.[1]

The most common intrinsic risk factor associated with acute ligamentous ankle injuries is a history of a prior ankle sprain.[5,6] De Noronha et al. demonstrated that subjects who sustained a prior ankle sprain were 2 times more likely to sustain another ankle sprain than those without a prior injury.[5] Similarly, in high school football players, there was a 6.6 time increased incidence of lateral ankle sprains in those players who had sustained a previous injury. In this same cohort, there was a 3.9 time increased incidence of ankle sprains in those who were near overweight and overweight by body mass index (BMI) (BMI >25). In fact, there is an additive effect in those individuals who had an elevated BMI and a prior ankle sprain resulting in a 19 times greater incidence of suffering a ligamentous injury in the study participants.[7]

Increased postural sway, poor balance, and deficient proprioceptive capabilities have also been linked to elevated

Corresponding author: Sharon Lee Witt, DO, 1395 Lake Shore Dr Unit C, Columbus, OH 43204.
E-mail address: sllwittdo@gmail.com.

risks of acute ligamentous ankle injuries.[8] In collegiate and high school athletes, there was an association between a positive single-leg balance (SLB) test and occurrence of lateral ankle sprains. The SLB test is performed by having the patient stand on 1 foot with the contralateral knee bent and not touching the weight-bearing leg; the eyes are then closed for 10 seconds. A positive test is defined as the patient reporting a sense of imbalance or failure to remain balanced. The relative risk of sustaining an acute lateral ankle sprain with a positive SLB test is 8.82.[9]

Anatomy

The talocrural joint is composed of 3 major ligamentous complexes: lateral, deltoid, and syndesmotic ankle ligaments. These 3 ligamentous complexes as well as the surrounding musculotendinous structures provide dynamic stability to the ankle joint. Furthermore, the distal tibia including the medial malleolus as well as the lateral malleolus comprises the ankle mortise and provides static stability to ankle joint.

The lateral ankle ligamentous complex is composed of the anterotalofibular (ATFL), calcaneofibular (CFL), and posterotalofibular (PTFL) ligaments. The ATFL attaches to the anterior border of the lateral malleolus and inserts onto the lateral aspect of the body of the talus. This ligament is approximately 15-20-mm long, 6-8-mm wide, and 2-mm thick. The ATFL ligament is taut in plantar flexion and loose in dorsiflexion where the shape of the ankle mortise provides bony stability. It prevents internal rotation and adduction of the talus. This ligament has the lowest load to failure compared with other lateral ankle ligaments and is thus the most commonly injured ankle ligament.

The CFL is an extracapsular ligament and is confluent with the peroneal tendon sheath. The CFL attaches to the anterior border of the distal lateral malleolus and inserts onto the lateral aspect of the calcaneus. The CFL is slack in plantar flexion and tense in dorsiflexion preventing adduction of the talus within the talocrural joint.

The PTFL is a capsular ligament and attaches to the posteromedial aspect of the lateral malleolus and inserts onto the posterolateral aspect of the talar body. The PTFL has maximal tension in dorsiflexion of the ankle and prevents external rotation of the ankle in dorsiflexion.

The deltoid ligaments, most notably the tibiocalcaneal ligament, prevent abduction of the talocrural joint. Furthermore, the deep deltoid ligaments assist in the prevention of ankle external rotation. This ligamentous complex also helps inhibit lateral translation of the talus when the lateral ankle ligaments have been completely disrupted. Finally, the deltoid ligament halts valgus tilting of the talus. The superficial fibers of the deltoid attach to the inferior colliculus of the medial malleolus; however, there are many insertions sites including the navicular bone, talus, and the sustentaculum tali. The deep portion of the deltoid ligament originates on the medial malleolus and inserts onto the talus.

This portion of the deltoid ligament is contiguous with the medial ankle joint capsule.

The syndesmotic ligamentous complex connects the tibia and fibula through 4 stout ligamentous structures. Furthermore, the interosseous membrane, which runs the length of the tibia and fibula, contributes to the stability of the syndesmosis.

History and physical examination

The history and physical examination is the most important portion of the evaluation process in diagnosing acute ankle sprains. The history of present injury begins with the mechanism of injury. The most common mechanism of injury for lateral ankle ligament sprains is an inversion-type injury to the ankle. More specifically, added plantar flexion or dorsiflexion predisposes ATFL or CFL to the injuries, respectively. The deltoid ligament is injured with forced eversion or a combination of forced eversion with external rotation. The mechanism of injury of syndesmotic injuries is proposed to be dorsiflexion, eversion, and external rotation of the ankle on an axially loaded foot.[10]

The physician should ask the patient to localize and describe the pain, including the onset and severity. Lateral ankle sprains would have pain over the lateral aspect of ankle over the ATFL, CFL, and PTFL. Whereas pain located over the medial aspect of the ankle or between the tibia and fibula should raise suspicion for a deltoid or syndesmotic injury. The acute pain is often described as sharp and does not radiate. Paresthesia is not typical in ankle sprains; however, swelling or stretching of the local sensory nerves may cause temporary paresthesias in the foot and ankle. Questions should be asked regarding the location, onset, and amount of swelling. In addition, the patient should describe any audible or sensations of a "pop" or "snap" during the incidence. The physician should inquire about the ability to ambulate after the injury. Finally, questions concerning prior injuries can help guide diagnosis and treatment.

Observation

The observation portion of the examination begins when the patient presents to the office. The physician should inspect the gait and document the use of crutches or assistive devices. Furthermore, the patient should remove necessary clothing, shoes, and socks to fully evaluate the foot, ankle, and lower leg of the injured extremity as well as the noninjured limb for comparison. Once adequate visualization of the limb has been achieved, the physician should inspect the lower extremity for any soft tissue or bony deformities documenting and inspecting any open wounds, blisters, swelling, ecchymosis, or erythema.

A standing examination of the patient should be attempted if able to bear weight. On standing examination, the physician should inspect the foot posture including

inspection of the arches. Looking from the anterior vantage point, the foot should be evaluated for any forefoot varus or valgus deformities, and then, inspecting the patient posteriorly, the foot should be evaluated for any hindfoot varus or valgus deformities that may predispose the patient to deltoid or lateral ankle ligament complex injuries, respectively.

The physician should inspect any footwear, orthotics, or braces the patient wears. The wear pattern should be identified and would provide information about the foot structure and potential deformities. Pes cavus (hindfoot varus) or pes planovalgus (hindfoot valgus) deformities may predispose the patient to lateral ankle ligament complex injuries and deltoid ligamentous injuries, respectively.

Palpation

Palpation should always begin away from the area of maximal tenderness to avoid patient apprehension throughout the remaining examination. The joint above and below the ankle joint should be evaluated to rule out any other associated pathology or differential diagnoses. It is important to palpate the proximal fibula to rule out any bony tenderness, somatic dysfunction, or potential fracture. Furthermore, palpation distally about the foot should be performed to the base of the fifth metatarsal as well as to the navicular bone. Palpation along the course of the peroneal longus and brevis tendons may rule out any pathology associated with these tendons. After palpation above and below the ankle has been performed, the physician should now focus on palpation of the ankle joint. Palpation of the medial and lateral malleolus may identify bony injuries. Lastly, the ligamentous structures of the ankle including the deltoid, syndesmotic, and lateral ankle ligament complexes should be palpated.

Range of motion (ROM)

After performing the palpatory examination, the ROM should be assessed. Depending on the severity of the pain, the active and passive ROM of the foot, ankle, and knee should be assessed in addition to muscle strength testing. Ankle dorsiflexion, plantar flexion, inversion, and eversion should be assessed for any limitations. Normal ankle ROM in dorsiflexion and plantar flexion is approximately 30° and 45°, respectively. In addition, normal inversion and eversion ankle ROM measures 35° and 25°, respectively. Active inversion and eversion is typically restricted secondary to pain in lateral ankle and ligamentous deltoid injuries, respectively. Furthermore, passive ankle ROM in inversion and eversion would be restricted and painful with lateral ankle and deltoid sprains. Acutely, patients may have apparent weakness with muscle strength testing of the ankle secondary to pain.

Neurovascular examination

When evaluating any musculoskeletal injury, a neurovascular examination should be performed to rule out any limb-threatening emergencies. The dorsalis pedis and posterior tibial pulses should always be assessed. Furthermore, capillary refill of the toes should be inspected. Any change in temperature, coloration, capillary refill, and pulses may require further evaluation for vascular injury or disease.

Sensation about the foot and ankle should be assessed during injury evaluation. The L4-S2 dermatomes provide sensation about the foot and ankle. Any altered sensation could represent irritation or damage to the nerves supplying the foot and ankle. The L4 nerve root supplies sensation to the skin over the dorsomedial aspect of the lower leg, foot, and entire great toe. The L5 nerve root supplies sensation to the dorsolateral aspect of the lower leg, dorsomedial and plantomedial aspect of the foot, and second through fourth toes. The S1 nerve root supplies sensation to the skin over the dorsolateral aspect of the foot and ankle and small toe. Finally, the S2 nerve root supplies sensation to the skin about the posterior aspect of the lower leg. Two-point discrimination as well as altered pain, temperature, and light touch sensation should be evaluated for each dermatome.

Special tests

After a thorough history and physical examination is performed, specialized testing of the ankle joint should be performed. These tests can provide vital information regarding the diagnosis of ankle pain and the severity of injury.

The anterior drawer test evaluates the patency of the anterior talofibular ligament and to some extent the CFL. However, the accuracy of what degree these ligaments are compromised is difficult to ascertain.[11] This test is performed with the patient seated with the knee in 90° of flexion. The physician grasps the posterior aspect of the heel with a cupped hand while the opposite hand is placed on the anterior aspect of the lower leg just above the ankle joint. With the foot in a relaxed position (10°-20° of plantar flexion), an anterior force is applied to the heel while the opposite hand stabilizes the lower leg.[12,13] The physician inspects the ankle joint for laxity by determining the amount of anterior translation of the talus within the ankle mortise. This test may elicit pain over the ATFL. In addition, the physician may also hear or feel a "clunk" as the talus is translated forward.

The talar tilt test assesses the stability of the CFL. Similar to the anterior drawer test, the ability to determine the extent of ligamentous damage may be difficult to quantify.[11] The physician grasps the posterolateral aspect of the heel with the ankle in neutral dorsiflexion. The physician's other hand is placed on the medial aspect of the lower leg for stability, and then the physician passively inverts the ankle with the hand grasping the heel. The physician inspects the ankle joint for laxity and pain over the CFL representing a positive test.

The squeeze test is performed by compressing the tibia and fibula together at the level of the middle one-third of the lower leg. Pain elicited during squeezing the tibia and fibula together is a positive test and is indicative of a syndesmosis injury. However, this test has variable reliability. A more reliable test to evaluate the competency of the syndesmotic ligament is the external rotation test. This test is performed with the patient in the supine position and the ankle dorsiflexed. The foot is externally rotated stressing the syndesmotic ligaments. Pain elicited during this examination represents a positive test.

Ankle sprain grading

Determining the severity of ankle sprains is somewhat arbitrary, and the clinical usefulness may not change the treatment protocol. There are several terms used to describe lateral ankle injuries; these include grade, degree, and severity. Dedicated classification schemes for medial or deltoid ligament sprains and syndesmotic injuries have not been well established.

There are 2 common grading systems classically employed in classifying lateral ankle sprains and instability. The first system, developed by Nicholas, is based upon the ligamentous pathology. Grade I, first-degree or mild sprain, represents microscopic tearing of the lateral ankle ligaments. A grade II, second-degree or moderate lateral ankle sprain, is described as being a partial disruption of the ligament, whereas a grade III, third-degree or severe sprain, is a complete tear or rupture of the ligament. The second classification system is based on clinical signs and symptoms described by McKonkey. Grade I lateral ankle sprain is described as having little swelling, localized tenderness, mild pain, and minimal function loss. Grade II injuries have diffuse tenderness and swelling, difficulty performing a toe raise and walking as well as moderate functional loss. Finally, a grade III sprain is associated with marked tenderness, swelling, and decreased ROM with a need for crutches.

Radiologic examination

The diagnosis of an acute ligamentous ankle injury is most often made with history and physical examination. However, radiologic evaluation can be utilized to help delineate a differential diagnoses such as ankle fractures and osteochondral lesions of the talus. Radiographs, ultrasound, and magnetic resonance imaging have been employed to further delineate the pathology of acute ankle pain.

The Ottawa foot and ankle rules help primary care physicians to determine the need for radiographic evaluation in patients with acute ankle pain. The ankle rules include the following: pain over the posterior aspect of the distal 6 cm of the medial and lateral malleolus, and inability to bear weight immediately after injury or in the emergency department.[14,15] Any positive finding on the ankle rules warrants radiographs to aid in the diagnosis. The Ottawa

foot and ankle rules have 100% sensitivity for ruling out foot and ankle fractures.[14,15] However, these rules are only 40.1% and 36.0% specific for detecting foot and ankle fractures, respectively.[14] The use of these rules have drastically reduced the number of ankle radiographs, decreased patient healthcare costs, and decreased missed foot and ankle fractures.[16]

Radiographic examination includes anteroposterior, lateral, and mortise views of the ankle.[17] Other radiographic examinations less commonly utilized are the talar tilt and anterior drawer stress radiographs. These stress examinations can help identify the degree of ligamentous injury.[18]

Treatment

Physical therapy

The treatment of ankle sprains in the acute phase of injury includes rest, ice, compression, elevation, and support (RICES). Depending on the severity of the injury and the ability of the patient to bear weight without altered gait mechanics, crutches and nonweight bearing can be employed. However, the discontinuation of crutches and return to full weight-bearing status should be achieved as soon as possible so that a functional rehabilitation program can be initiated. Furthermore, the use of immobilization can be utilized for a brief period of time in select few patients with significant pain, disability, and swelling. In a systematic review composed by Jones et al., an earlier return to preinjury activities was demonstrated with a functional rehabilitation when compared with ankle immobilization.[19] The implementation of functional rehabilitation in a randomized control trial demonstrated an increased activity level in regards to step count, time spent walking, and time spent in light-intensity activity when compared with conventional RICES protocol.[20]

The use of formal physical therapy may have merit in a faster return to recovery when compared with conventional unsupervised rehabilitation of acute ankle injuries. In 2 systematic review articles, the utilization of supervised physical therapy had a limited to moderate benefit in a quicker return to sport and work when compared with a home-based rehabilitation program.[21,22] In addition, neuromuscular or proprioceptive exercises in the later stages of the rehabilitation process have a protective effect on recurrence of ligamentous ankle injuries and an overall reduction risk of 35% for ankle sprain recurrence.[23]

External support devices

The use of an external support device in the acute phase of a ligamentous ankle injury is often employed to aid in the reduction of pain and swelling.[24-26] Furthermore, the use of ankle supports also provides stability to the ankle joint allowing earlier functional capabilities. These devices include ankle braces, walking boots, and elastic bandages.

Cryotherapy

Cryotherapy or ice is commonly employed as a treatment in acute ankle injuries to subside initial pain and swelling. However, in a recent review of literature looking at the benefits of cyrotherapy on acute soft tissue injuries to the ankle demonstrates a lack of quality studies demonstrating its effectiveness.[27] Furthermore, there is a lack of data to advise on the type and duration of cyrotherapy treatment in acute ankle injuries.[27]

Osteopathic manipulative medicine

The use of osteopathic manipulative treatment for acute ankle sprains is useful to decrease edema and pain.[28] Multiple researchers have sought to confirm the usefulness of manipulative treatment in patients with acute ankle sprains. In 2003, a study involving 55 patients reported in the Journal of the American Osteopathic Association showed improvement in edema and pain after a single session of osteopathic manipulative treatment provided in the emergency setting. The treatment varied based on the patient-specific findings and included various soft tissue techniques.[29] The techniques, as described by Blood in a much earlier Journal of the American Osteopathic Association publication in 1980, included the treatment outlined for the initial stage of injury. This initial stage of treatment should be performed as soon as possible before swelling starts. At this stage, obvious subluxations and strains should be corrected, including those at the talotibial and fibulotalar joints of the ankle and the talocalcaneal, talonavicular, and calcaneocuboid joints of the foot.[30] One key technique to help restore ROM on a locked talocalcaneal joint is the "talar tug" during which the talus is distracted from the calcaneus allowing a resetting of the articular forces.[28] In addition to correcting obvious somatic dysfunctions, at the initial stage of treatment, soft tissue and passive movement to the affected areas should be applied to reduce early swelling.[30] A later publication in the Journal of Manual and Manipulative Therapy in 2011 resulted in a significant decrease in pain at a 24-hour follow-up after a single application of talocrural joint mobilization performed by a physical therapist on an acute ankle sprain.[31] In 2012, a review of literature from 2008-2011 found fair evidence for the short term from manipulative therapy for ankle sprains.[32] Furthermore, Blood outlined a second phase of osteopathic treatment for ankle sprains, the rehabilitative phase. During this phase, treatment of the lumbar vertebrae, pelvis, upper thoracic spine, and ribs is emphasized to restore neural flow to the affected tissues of the ankle and promote venous and lymphatic drainage.[30]

Medications

Nonsteroidal antiinflammatory drugs (NSAIDs) are commonly used in the treatment of acute ankle sprains to alleviate pain and inflammation. Owing to the potential for long-term adverse effects of NSAIDs, selected medications should be used in the lowest dose for the shortest duration necessary. Other effective medications such as acetaminophen and opioid analgesics are less commonly used secondary to perceived ineffectiveness and opioid dependence. The results of a randomized control trial comparing the effectiveness of paracetamol (acetaminophen) vs diclofenac demonstrated similar outcomes in regards to the reduction of ankle pain and edema 10 days post injury.[33] Another randomized controlled trial comparing the effectiveness of acetaminophen vs ibuprofen demonstrated similar results. Both medications had similar results in decreasing ankle pain, swelling and ecchymosis, and increasing ROM and walking ability after 9 days of treatment.[34] Notably, the daily dosage of ibuprofen in this study was 1200 mg, whereas the acetaminophen dosage was 3900 mg.

Gastrointestinal symptoms such as dyspepsia, gastric ulcers, and gastrointestinal bleeding are common side effects of oral COX-1 inhibitors such as ibuprofen and naproxen. Selective COX-2 inhibitors were developed to decrease the gastrointestinal side effects of nonselective COX inhibitor antiinflammatories. A randomized control trial comparing the effectiveness of Celebrex to naproxen in acute ankle sprains demonstrates similar reduction in pain after 8 days of treatment with the 2 medications. Celebrex had significantly less gastrointestinal side effects when compared with naproxen.[35]

Topical antiinflammatory medications are another option to treat acute ligamentous ankle injuries. These topical medications provide antiinflammatory and analgesic properties similar to those of oral antiinflammatory medications. Moreover, these topical antiinflammatories act directly on the injured tissues with little systemic absorption and side effects. In a recent study comparing diclofenac gel with placebo, a statistically significant decrease in pain and swelling after 8 days of treatment with diclofenac gel was demonstrated.[36] Furthermore, diclofenac gel had no gastrointestinal side effects throughout the duration of the treatment protocol.[36] Ketoprofen patch was compared with placebo in a recent randomized controlled study. Ketoprofen patch provided statistically significant reduction in pain and swelling when compared with placebo.[37] Furthermore, a recent meta-analysis concluded that topical diclofenac, ibuprofen, ketoprofen, and piroxicam were of similar effectiveness compared with indomethacin and benzydamine which were no better than placebo. Comparison of effectiveness among the different available topical NSAIDs could not be adequately assessed.[38] Overall, topical NSAIDs are a good option to treat acute musculoskeletal pain when compared with oral antiinflammatories and have the advantage of not having gastrointestinal side effects.

Therapeutic modalities

The use of therapeutic modalities has been used extensively in physical therapy regimens to assist in pain relief and swelling. Therapeutic modalities including ultrasound,

phonophoresis, iontophoresis, neuromuscular electrical stimulation, and cryotherapy have been utilized to expedite the return to function in ankle injuries.

The use of therapeutic ultrasound has been employed to decrease pain and inflammation after acute ankle ligamentous injuries. However, a recent review article comparing ultrasound with placebo in the treatment of pain and swelling demonstrated that ultrasound was no better than placebo at decreasing ankle pain and swelling after 1-4 weeks of treatment.[39]

Neuromuscular electrical stimulation has also been used in the treatment of acute ankle injuries to aid in the reduction of pain and swelling. A randomized control trial comparing neuromuscular electrical stimulation with a placebo group showed no differences in pain, inflammation, and functional improvement in ankle injuries.[40] Similar to the use of ultrasound, neuromuscular electrical stimulation has no benefits in the rehabilitation of ankle sprains.

Prevention

In the primary care setting, it is extremely important to participate in the prevention of acute ligamentous ankle injuries. The economic burden, exuberant healthcare costs, and days lost to work are significant issues for those individuals who sustain acute ankle sprains. Furthermore, the prevention of ankle injuries in athletic participants would reduce the time loss at practice and games. Moreover, primary prevention of these injuries would decrease the risk of chronic ankle instability, ankle osteoarthritis, and decreased quality of life. Measures to prevent these injuries include balance or coordination training, taping or bracing, sports-specific technical training, orthotics, footwear, and strengthening or stretching exercises.

The role of external support devices in the prevention of ankle sprains has been well established. The use of ankle supports has been associated with a decrease risk of ankle sprains in those who had prior ankle injuries.[41-43] Moreover, a systematic review looking at the benefits of external supportive devices and the prevention of ankle sprains in elite and recreational players demonstrated a reduction of ankle sprains by 69% and 71% with the use of ankle bracing and taping, respectively.[44] However, there is no clear advantage of ankle taping vs bracing in the prevention of ankle injuries.[41] The use of ankle bracing has however also demonstrated a reduction in the severity of ankle sprains.[45] For those patients who have not sustained a prior injury, the use of prophylactic devices is not well established in the prevention of ankle injuries.[41,45]

Similar to the use of external support devices, the implementation of balance or neuromuscular training to decrease the risk of ligamentous ankle injuries in patients with a history or at high risk of sustaining an ankle sprain has been well documented.[46-48] Moreover, these coordination activities are more effective at preventing injuries in those patients who have already sustained a previous ankle injury.[41,46,49] The longer the activities are implemented into a daily routine, the more effective the preventative measures.[41] This training typically involves single-leg stance activities including balance boards, foam pads, dynamic hopping exercises, and sports-specific training.[41]

References

1. Soboroff SH, Pappius EM, Komaroff AL. Benefits, risks, and costs of alternative approaches to the evaluation and treatment of severe ankle sprains. *Clin Orthop Relat Res*. 1984;183:160–168

2. Waterman BR, Owens BD, Davey S, et al: The epidemiology of ankle sprains in the United States. *J Bone Joint Surg Am*. 2010;92:2279–2284

3. Waterman BR, Belmont PJ, Cameron KL, et al: Risk factors for syndesmotic and medial ankle sprain: role of sex, sport, and level of competition. *Am J Sports Med*. 2011;39:992–998

4. Beynnon BD, Vacek PM, Murphy D, et al: First-time inversion ankle ligament trauma: the effects of sex, level of competition, and sport on the incidence of injury. *Am J Sports Med*. 2005;33(10):1485–1491

5. de Noronha M, França LC, Haupenthal A, et al: Intrinsic predictive factors for ankle sprain in active university students: a prospective study. *Scand J Med Sci Sports*. 2012. [Epub ahead of print]

6. McHugh MP, Tyler TF, Tetro DT, et al: Risk factors for noncontact ankle sprains in high school athletes: the role of hip strength and balance ability. *Am J Sports Med*. 2006;34(3):464–470

7. Tyler TF, McHugh MP, Mirabella MR, et al: Risk factors for noncontact ankle sprains in high school football players: the role of previous ankle sprains and body mass index. *Am J Sports Med*. 2006;34(3):471–475

8. McGuine TA, Greene JJ, Best T, et al: Balance as a predictor of ankle injuries in high school basketball players. *Clin J Sport Med*. 2000;10:239–244

9. Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. *Br J Sports Med*. 2006;40:610–613

10. Wei F, Post JM, Braman JE, et al: Eversion during external rotation of the human cadaver foot produces high ankle sprains. *J. Orthop Res*. 2012;30:1423–1429

11. Bahr R, Pena F, Shine J, et al: Mechanics of the anterior drawer and talar tilt tests: a cadaveric study of lateral ligament injuries of the ankle. *Acta Orthop Scand*. 1997;68(5):435–441

12. Tohyama H, Yasuda K, Ohkoshi Y, et al: Anterior drawer test for acute anterior talofibular ligament injuries of the ankle: how much load should be applied during the test? *Am J Sports Med*. 2003;31(2):226–232

13. Tohyama H, Beynnon BD, Renström PA, et al: Biomechanical analysis of the ankle anterior drawer test for anterior talofibular ligament injuries. *J Orthop Res*. 1995;13(4):609–614

14. Stiell IG, Greenberg GH, McKnight RD, et al: A study to develop clinical decision rules for the use of radiography in acute ankle injuries. *Ann Emerg Med*. 1992;21:384–390

15. Stiell IG, Greenburg GH, McKnight RD, et al: Decision rules for the use of radiography in acute ankle injuries: refinement and prospective validation. *J Am Med Assoc*. 1993;269:1127–1132

16. Stiell IG, McKnight RD, Greenburg GH, et al: Implementation of the Ottawa ankle rules. *J Am Med Assoc*. 1994;27:827–832

17. Marsh JL, Saltzman CL. Ankle fractures. In: Bucholz RW, Heckman JD, Court-Brown C, eds. *Rockwood and Green's Fractures in Adults*, 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2006:2147–2247

18. Lentell G, Desch RJ, Tracz SM, et al: Self-stress vs manual stress in talar tilt radiology. *Radiol Technol*. 2010;82(1):14–21

19. Jones MH, Amendola AS. Acute treatment of inversion ankle sprains: immobilization versus functional treatment. *Clin Orthop Relat Res*. 2007;455:169–172

20. Bleakley CM, O'Connor SR, Tully MA, et al: Effect of accelerated rehabilitation on function after ankle sprain: randomised controlled trial. *Br Med J*. 2010;340:c1964

21. van Rijn RM, van Ochten J, Luijsterburg PA, et al: Effectiveness of additional supervised exercises compared with conventional treatment alone in patients with acute lateral ankle sprains: systemic review. *Br Med J*. 2010;341:c5688

22. van Os AG, Bierma-Zeinstra S, Verhagen AP, et al: Comparison of conventional treatment and supervised rehabilitation for treatment of acute lateral ankle sprains: a systemic review of the literature. *J Orthop Sports Phys Ther*. 2005;35(2):95–105

23. Hupperets M, Verhagen E, van Mechelen W. Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomised controlled trial. *Br Med J*. 2009;339:b2684

24. Boyce SH, Quigley MA, Campbell S. Management of ankle sprains: a randomized controlled trial of the treatment of inversion injuries using an elastic support bandage or an Aircast ankle brace. *Br J Sports Med*. 2005;39:91–96

25. Beynnon BD, Renström PA, Haugh L, et al: A prospective, randomized clinical investigation of the treatment of first-time ankle sprains. *Am J Sports Med*. 2006;34(9):1401–1412

26. Guskiewicz KM, Riemann BL, Onate JA. Comparison of 3 methods of external support for management of acute lateral ankle sprains. *J Athl Train*. 1999;34(1):5–10

27. Bleakley C, McDonough S, MacAuley D. The use of ice in the treatment of acute soft-tissue injury: a systemic review of randomized controlled trials. *Am J Sports Med*. 2004;32(1):251–261

28. Brolinson PG, Heinking K, Kozar AJ. An osteopathic approach to sports medicine. In: Ward RC, ed. *Foundations for Osteopathic Medicine*, 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2003:534–550

29. Eisenhart AW, Gaeta TJ, Yens DP. Osteopathic manipulative treatment in the emergency department for patients with acute ankle injuries. *J Am Osteopath Assoc*. 2003;103(9):417–421

30. Blood SD. Treatment of the sprained ankle. *J Am Osteopath Assoc*. 1980;79(11):61–73

31. Cosby NL, Koroch M, Grindstaff TL, et al: Immediate effects of anterior to posterior talocrural joint mobilizations following acute lateral ankle sprain. *J Man Manipulative Ther*. 2011;19(2):76–83

32. Brantingham JW, Bonnefin D, Perle SM, et al: Manipulative therapy for lower extremity conditions: update of a literature review. *J Manipulative Physiol Ther*. 2012;35(2):127–166

33. Lyrtzis C, Natsis K, Papadopoulos C, et al: Efficacy of paracetamol versus diclofenac for grade II ankle sprains. *Foot Ankle Int*. 2011;32 (6):571–575

34. Dalton JD, Schweinle JE. Randomized controlled noninferiority trial to compare extended release acetaminophen and ibuprofen for the treatment of ankle sprains. *Ann Emerg Med*. 2006;48:615–623

35. Petrella R, Ekman EF, Schuller R, et al: Efficacy of celecoxib, a COX-2-specific inhibitor, and naproxen in the management of acute ankle sprain: results of a double-blind, randomized controlled trial. *Clin J Sport Med*. 2004;14:225–231

36. Predel HG, Hamelsky S, Gold M, et al: Efficacy and safety of diclofenac diethylamine 2.32% gel in acute ankle sprain. *Med Sci Sports Exerc*. 2012;44(9):1629–1636

37. Mazières B, Rouanet S, Velicy J, et al: Topical ketoprofen patch (100 mg) for the treatment of ankle sprain: a randomized, double-blind, placebo-controlled study. *Am J Sports Med*. 2005;33(4):515–523

38. Massey T, Derry S, Moore RA, et al: Topical NSAIDs for acute pain in adults (review). *Cochrane Database Syst Rev*. 2010;6

39. van den Bekerom M, van der Windt D, ter Riet G, et al: Therapeutic ultrasound for acute ankle sprains (review). *Cochrane Database Syst Rev*. 2011;6

40. Man I, Morrissey MC, Cywinski JK. Effect of neuromuscular electrical stimulation on ankle swelling in the early peroid after ankle sprain. *Phys Ther*. 2005;87:53–65

41. McKeon PO, Mattacola CG. Interventions for the prevention of first time and recurrent ankle sprains. *Clin Sports Med*. 2008;27:371–382

42. McGuine TA, Brooks A, Hetzel S. The effect of lace-up ankle braces on injury rates in high school basketball players. *Am J Sports Med*. 2011;39:1840–1848

43. Pedowitz DI, Reddy S, Parekh SG, et al: Prophylactic bracing decreases ankle injuries in collegiate female volleyball players. *Am J Sports Med*. 2008;36(2):324–327

44. Dizon JM, Reyes JJ. A systematic review on the effectiveness of external ankle supports in the prevention of inversion ankle sprains among elite and recreational players. *J Sci Med Sport*. 2010;13(3):309–317

45. Verhagen E, van Mechelen W, de Vente W. The effect of preventive measures on the incidence of ankle sprains. *Clin J Sport Med*. 2000;10:291–296

46. Hübscher M, Zech A, Pfeifer K, et al: Neuromuscular training for sports injury prevention: a systematic review. *Med Sci Sports Exerc*. 2010;42(3):413–421

47. Emery CA, Rose MS, McAlliser JR, et al: A prevention strategy to reduce the incidence of injury in high school basketball: a cluster randomized controlled trial. *Clin J Sport Med*. 2007;17:17–24

48. McHugh MP, Tyler TF, Mirabella MR, et al: The effectiveness of a balance training intervention in reducing the incidence of noncontact ankle sprains in high school football players. *Am J Sports Med*. 2007;8:1289–1294

49. Verhagen E, van der Beek A, Twisk J, et al: The effect of a proprioceptive balance board training program for the prevention of ankle sprains: a prospective controlled trial. *Am J Sports Med*. 2004;32(6):1385–1393