ROBROY L. MARTIN, PT, PhD • **TODD E. DAVENPORT,** DPT • **STEPHEN PAULSETH,** DPT, MS
DANE K. WUKICH, MD • **JOSEPH J. GODGES,** DPT, MA

Ankle Stability and Movement Coordination Impairments: Ankle Ligament Sprains

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Orthopaedic Section of the American Physical Therapy Association

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REVIEWERS: Roy D. Altman, MD • Anthony Delitto, PT, PhD • John DeWitt, DPT
Amanda Ferland, DPT • Helene Fearon, PT • Joy MacDermid, PT, PhD • James W. Matheson, DPT
Thomas G. McPoil, PT, PhD • Stephen Reischl, DPT • Leslie Torburn, DPT • James Zachazewski, DPT

 Address correspondence to: Joseph Godges, DPT, ICF Practice Guidelines Coordinator, Orthopaedic Section, APTA, Inc, 2920 East Avenue South, Suite 200, La Crosse, WI 54601. E-mail: icf@orthopt.org

Recommendations*

RISK FACTORS – ACUTE LATERAL ANKLE SPRAIN: Clinicians should recognize the increased risk of acute lateral ankle sprain in individuals who (1) have a history of a previous ankle sprain, (2) do not use an external support, (3) do not properly warm up with static stretching and dynamic movement before activity, (4) do not have normal ankle dorsiflexion range of motion, and (5) do not participate in a balance/proprioceptive prevention program when there is a history of a previous injury. (Recommendation based on moderate evidence.)

RISK FACTORS – ANKLE INSTABILITY: Clinicians should recognize the increased risk for developing ankle instability in patients who (1) have an increased talar curvature, (2) are not using an external support, or (3) did not perform balance or proprioception exercises following an acute lateral ankle sprain. (Recommendation based on weak evidence.)

DIAGNOSIS/CLASSIFICATION – ACUTE LATERAL ANKLE SPRAIN: Clinicians should use the clinical findings of level of function, ligamentous laxity, hemorrhaging, point tenderness, total ankle motion, swelling, and pain to classify a patient with acute ankle ligament sprain into the International Statistical Classification of Diseases and Related Health Problems (ICD) category of sprain and strain of ankle (S93.4), and the associated International Classification of Functioning, Disability and Health (ICF) impairment-based category of ankle stability (b7150 stability of a single joint) and movement coordination impairments (b7601 control of complex voluntary movements). (Recommendation based on moderate evidence.)

DIAGNOSIS/CLASSIFICATION – ANKLE INSTABILITY: Clinicians may incorporate a discriminative instrument, such as the Cumberland Ankle Instability Tool, to assist in identifying the presence and severity of ankle instability associated with the ICD category of disorder of ligament, instability secondary to old ligament injury, ankle and foot (M24.27), and the associated ICF impairment-based category of ankle stability (b7150 stability of a single joint) and movement coordination impairments (b7601 control of complex voluntary movements). (Recommendation based on moderate evidence.)

DIFFERENTIAL DIAGNOSIS – ACUTE LATERAL ANKLE SPRAIN: Clinicians should use diagnostic classifications other than an acute lateral ankle sprain when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline. Particularly, the Ottawa and Bernese ankle rules should be used to determine whether a radiograph is required to rule out a fracture of the ankle and/or foot. (Recommendation based on strong evidence.)

DIFFERENTIAL DIAGNOSIS – ANKLE INSTABILITY: Clinicians should use diagnostic classifications other than ankle instability when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline. (Recommendation based on expert opinion.)

EXAMINATION – OUTCOME MEASURES: Clinicians should incorporate validated functional outcome measures, such as the Foot and Ankle Ability Measure and the Lower Extremity Functional Scale, as part of a standard clinical examination. These should be utilized before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with ankle sprain and instability. (Recommendation based on strong evidence.)

EXAMINATION – ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION MEASURES: When evaluating a patient in the postacute period following a recent or recurring lateral ankle sprain, assessment of activity limitation, participation restriction, and symptom reproduction should include objective and reproducible measures, such as single-limb hop tests that assess performance with lateral movements, diagonal movements, and directional changes. (Recommendation based on moderate evidence.)

EXAMINATION – PHYSICAL IMPAIRMENT MEASURES: When evaluating a patient with an acute or subacute lateral ankle sprain over an episode of care, assessment of impairment of body function should include objective and reproducible measures of ankle swelling, ankle range of motion, talar translation and inversion, and single-leg balance. (Recommendation based on strong evidence.)

INTERVENTION – ACUTE/PROTECTED MOTION PHASE – EARLY WEIGHT BEARING WITH SUPPORT: Clinicians should advise patients with acute lateral ankle sprains to use external supports and to progressively bear weight on the affected limb. The type of external support and gait assistive device recommended should be based on the severity of the injury, phase of tissue healing, level of protection indicated, extent

Recommendations* *(continued)*

of pain, and patient preference. In more severe injuries, immobilization ranging from semi-rigid bracing to below-knee casting may be indicated. (Recommendation based on strong evidence.)

INTERVENTION – ACUTE/PROTECTED MOTION PHASE – MANUAL THERAPY: Clinicians should use manual therapy procedures, such as lymphatic drainage, active and passive soft tissue and joint mobilization, and anterior-to-posterior talar mobilization procedures, within pain-free movement to reduce swelling, improve pain-free ankle and foot mobility, and normalize gait parameters in individuals with an acute lateral ankle sprain. (Recommendation based on moderate evidence.)

INTERVENTION – ACUTE/PROTECTED MOTION PHASE – PHYSICAL AGENTS: Cryotherapy: clinicians should use repeated intermittent applications of ice to reduce pain, decrease the need for pain medication, and improve weight bearing following an acute ankle sprain. (Recommendation based on strong evidence.) Diathermy: clinicians can utilize pulsating shortwave diathermy for reducing edema and gait deviations associated with acute ankle sprains. (Recommendation based on weak evidence.) Electrotherapy: there is moderate evidence both for and against the use of electrotherapy for the management of acute ankle sprains. (Recommendation based on conflicting evidence.) Low-level laser therapy: there is moderate evidence both for and against the use of low-level laser therapy for the management of acute ankle sprains. (Recommendation based on conflicting evidence.) Ultrasound: clinicians should not use ultrasound for the management of acute ankle sprains. (Recommendation based on strong evidence.)

INTERVENTION – ACUTE/PROTECTED MOTION PHASE – THERAPEUTIC EXERCISES: Clinicians should implement rehabilitation programs that include therapeutic exercises for patients with severe lateral ankle sprains. (Recommendation based on strong evidence.)

INTERVENTION – PROGRESSIVE LOADING/SENSORIMOTOR TRAINING PHASE – MANUAL THERAPY: Clinicians should include manual therapy procedures, such as graded joint mobilizations, manipulations, and non–weight-bearing and weight-bearing mobilization with movement, to improve ankle dorsiflexion, proprioception, and weight-bearing tolerance in patients recovering from a lateral ankle sprain. (Recommendation based on strong evidence.)

INTERVENTION – PROGRESSIVE LOADING/SENSORIMOTOR TRAINING PHASE – THERAPEUTIC EXERCISE AND ACTIVITIES: Clinicians may include therapeutic exercises and activities, such as weight-bearing functional exercises and single-limb balance activities using unstable surfaces, to improve mobility, strength, coordination, and postural control in the postacute period of rehabilitation for ankle sprains. (Recommendation based on weak evidence.)

INTERVENTION – PROGRESSIVE LOADING/SENSORIMOTOR TRAINING PHASE – SPORT-RELATED ACTIVITY TRAINING: Clinicians can implement balance and sport-related activity training to reduce the risk for recurring ankle sprains in athletes. (Recommendation based on weak evidence.)

*These recommendations and clinical practice guidelines are based on the scientific literature accepted for publication prior to April 2012.

Introduction

AIM OF THE GUIDELINES

The Orthopaedic Section of the American Physical Therapy Association (APTA) has an ongoing effort to create evidence-based practice guidelines for orthopaedic physical therapy management of patients with musculoskeletal impairments described in the World Health Organization's *International Classification of Functioning, Disability and Health* (ICF).[286]

The purpose of these clinical guidelines is to:

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention, and assessment of outcome, for musculoskeletal disorders commonly managed by orthopaedic physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization's terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, ac-

Introduction *(continued)*

tivity limitations, and participation restrictions associated with common musculoskeletal conditions

- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of the individual
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payers and claims reviewers regarding the practice of orthopaedic physical therapy for common musculoskeletal conditions
- Create a reference publication for orthopaedic physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of orthopaedic physical therapy

STATEMENT OF INTENT

These guidelines are not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made in light of the clinical data presented by the patient; the diagnostic and treatment options available; and the patient's values, expectations, and preferences. However, we suggest that significant departures from accepted guidelines should be documented in the patient's medical records at the time the relevant clinical decision is made.

Methods

Content experts were appointed by the Orthopaedic Section of the APTA as developers and authors of clinical practice guidelines for musculoskeletal conditions of the ankle and foot that are commonly treated by physical therapists. These content experts were given the task to identify impairments of body function and structure, activity limitations, and participation restrictions, described using ICF terminology, that could (1) categorize patients into mutually exclusive impairment patterns on which to base intervention strategies, and (2) serve as measures of changes in function over the course of an episode of care. The second task given to the content experts was to describe the supporting evidence for the identified impairment-pattern classification as well as interventions for patients with activity limitations and impairments of body function and structure consistent with the identified impairment-pattern classification. It was also acknowledged by the Orthopaedic Section, APTA content experts that only performing a systematic search and review of the evidence related to diagnostic categories based on International Statistical Classification of Diseases and Related Health Problems (ICD)[286] terminology would not be sufficient for these ICF-based clinical practice guidelines, as most of the evidence associated with changes in levels of impairment or function in homogeneous populations is not readily searchable using the ICD terminology. Thus, the authors of this guideline independently performed a systematic search of MEDLINE, CINAHL, and the Cochrane Database of Systematic Reviews (1967 through April 2012) for any relevant articles related to classification, examination, and intervention strategies for ankle sprains. Additionally, when relevant articles were identified, their reference lists were hand searched in an attempt to identify other relevant articles. Articles from the searches were compiled and reviewed for accuracy by the authors. This guideline was issued in 2013 based on publications in the scientific literature prior to April 2012. This guideline will be considered for review in 2017, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Orthopaedic Section, APTA website: www.orthopt.org.

LEVELS OF EVIDENCE

Individual clinical research articles were graded according to criteria described by the Centre for Evidence-Based Medicine, Oxford, UK (http://www.cebm.net) for diagnostic, prospective, and therapeutic studies.[198] If the 2 content experts did not agree on a grade of evidence for a particular article, a third content expert was used to resolve the issue. An abbreviated version of the grading system is provided on the next page.

Methods *(continued)*

I	Evidence obtained from high-quality diagnostic studies, prospective studies, or randomized controlled trials
II	Evidence obtained from lesser-quality diagnostic studies, prospective studies, or randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, less than 80% follow-up)
III	Case-control studies or retrospective studies
IV	Case series
V	Expert opinion

GRADES OF EVIDENCE

The overall strength of the evidence supporting recommendations made in these guidelines was graded according to guidelines described by Guyatt et al,[101] as modified by MacDermid et al[160] and adopted by the coordinator and reviewers of this project. In this modified system, the typical A, B, C, and D grades of evidence have been modified to include the role of consensus expert opinion and basic science research to demonstrate biological or biomechanical plausibility.

GRADES OF RECOMMENDATION BASED ON		STRENGTH OF EVIDENCE
A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation
C	Weak evidence	A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies
E	Theoretical/foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic science/bench research supports this conclusion
F	Expert opinion	Best practice based on the clinical experience of the guidelines development team

REVIEW PROCESS

The Orthopaedic Section, APTA also selected consultants from the following areas to serve as reviewers of the early drafts of these clinical practice guidelines:

- Basic science in ligament pathology and healing
- Claims review
- Coding
- Rheumatology
- Foot and Ankle Special Interest Group of the Orthopaedic Section, APTA
- Medical practice guidelines
- Orthopaedic physical therapy residency education
- Orthopaedic physical therapy clinical practice
- Orthopaedic surgery
- Physical therapy academic education
- Sports physical therapy residency education
- Sports rehabilitation

Comments from these reviewers were utilized by the authors to edit these clinical practice guidelines prior to submitting them for publication to the *Journal of Orthopaedic & Sports Physical Therapy*.

CLASSIFICATION

The primary ICD-10 codes associated with ankle stability and movement coordination impairment are **S93.4 sprain and strain of ankle** and **M24.27 instability secondary to old ligament injury, ankle and foot**.

The corresponding ICD-9-CM codes include **845.00 sprain of ankle, unspecified site**, **845.02 sprain of calcaneofibular ligament**, **845.03 sprain of tibiofibular (ligament), distal of ankle**, and **718.87 other joint derangement, instability of joint, ankle and foot**.

The primary ICF body-function codes associated with ankle ligament sprain are **b7150 stability of a single joint** and **b7601 control of complex voluntary movements**.

The primary ICF body-structure codes associated with ankle stability and movement coordination impairments are **s75023 ligaments and fasciae of ankle and foot**, **s75012 muscles of lower leg**, **s75002 muscles of thigh**, and **s7402 muscles of pelvic region**.

The primary ICF activities and participation codes associated with ankle stability and movement coordination impairments are **d450 walking**, **d4552 running**, **d4553 jumping**, **d4558 moving around, specified as direction changes while walking or running**, and **d9201 sports**.

Methods *(continued)*

This guideline has chosen to classify individuals with lateral ankle sprain into 2 categories: (1) acute lateral sprains and (2) ankle instability. The evidence related to the classification of acute lateral sprain generally includes studies that enrolled subjects within 72 hours following injury, or subjects who demonstrated significant swelling, pain, limited weight bearing, and overt gait deviations (ie, limited stance time, abbreviated/omitted terminal stance phase). Ankle instability relates to the postacute period and includes studies that enrolled subjects with primary concerns of instability, weakness, limited balance responses, and intermittent swelling. Chronic ankle instability is a term commonly applied to individuals with these complaints. However, definitive and uniformly applied criteria to diagnose chronic ankle instability have not been developed. Therefore, the classification of "instability" is the best label for these individuals and will be used throughout this guideline.

CLINICAL GUIDELINES

Impairment/Function-Based Diagnosis

INCIDENCE

A review of emergency department records in the United States between 2002 and 2006 estimated the incidence rate of an ankle sprain to be 2.15 per 1000 person-years in the general population.[266] The incidence of ankle sprain was highest in those between 15 and 19 years of age (7.2 per 1000 person-years). The overall incidence rate ratio for ankle sprain did not differ between males and females. However, males between 14 and 24 years of age and females older than 30 years of age had a higher incidence rate compared to their respective counterparts.[266] The black and white races were associated with higher rates of ankle sprain compared with the Hispanic race.[266] Nearly half of all ankle sprains (49.3%) occurred during athletic activity, with basketball (41.1%), football (9.3%), and soccer (7.9%) being associated with the highest percentage of ankle sprains.[266] Physically active individuals, particularly those who participate in court and team sports,[86] such as basketball,[177] are at a higher risk than the general population.[265] The ankle joint was found to account for 10% to 34% of all sport-related injuries, with lateral ankle sprain comprising 77% to 83% of these injuries.[86] In prospective studies that included physically active subjects, 20% of females[281] and 18% of males[280] sustained an inversion ankle sprain. In the United States Armed Services and Academies, the incidence rate is also higher than the general population and has been reported to vary between 35 and 58 per 1000 person-years.[35,265]

The rate of lateral ankle sprain reinjury is noteworthy.[243] A systematic review noted that reinjury occurred in 3% to 34% of patients. This review found the time between initial injury and a second injury to vary greatly, with a time frame ranging from within 2 weeks to 96 months.[259] A recent prospective study of track-and-field athletes noted a reinjury rate of 17% within 2 years.[162] However, the reinjury rate may be greater in high-risk sports such as basketball, in which a reinjury rate of 73% was reported.[177] The overall incidence of lateral ankle sprain may be underestimated because approximately 50% of those sustaining an ankle sprain do not seek medical attention after injury.[12,177,224]

PATHOANATOMICAL FEATURES

The hindfoot is composed of the distal tibiofibular syndesmosis, talocrural joint, and subtalar joint. The 3 major contributors to stability of the ankle joint are (1) osseous congruity and fit of the articular surfaces when the joints are loaded, (2) static ligamentous and capsular restraints, and (3) surrounding musculotendinous units.[109] The lateral ligaments of the ankle complex are potentially injured with an inversion or supination mechanism. The most common mechanism of injury occurs with forefoot adduction, hindfoot internal rotation, ankle inversion in plantar flexion, and external rotation of the leg beyond anatomical constraints. This injury mechanism may result when landing from a jump, stepping into a hole, and/or landing on a competitor's foot during sports. A lateral ankle sprain consists of partial or complete disruption of the lateral ankle ligaments. These ligaments consist of the anterior talofibular ligament, calcaneofibular ligament, and posterior talofibular ligament. Up to 73% of lateral ankle sprains involve isolated anterior talofibular ligament injuries.[86] Injury to the posterior talofibular ligament rarely occurs in isolation with an inversion mechanism of injury.

Combined subtalar, medial, and/or syndesmotic sprains can occur concurrently with lateral ankle sprain but are reported less often in the literature. Following an excessive ankle inversion injury, structures other than the lateral ligaments can be injured and may contribute to chronic concerns regarding pain, instability, and limitation in activities and participation. These structures include the lateral subtalar ligaments, fibular (peroneal) tendon, nerve injury, extensor and peroneal retinaculum, inferior tibiofibular ligament, osteochondral lesions of the talus or tibial plafond, and neuromuscular elements of the lower extremity.

Anterior Talofibular Ligament

The anterior talofibular ligament is an extra-articular ligament of the talocrural joint.[219] Its fibers course laterally from the talus in the transverse plane and superiorly between the sagittal and frontal planes to attach on the anterior distal tip of the lateral malleolus.[250] The anterior talofibular ligament can have single (38%), bifurcated (50%), or trifurcated (12%) fiber bundles.[183] The anterior talofibular ligament provides the primary restraint to inversion movement when the ankle is in a plantar-flexed position.[250] Maximal displacement of the talus from an applied anteriorly directed force was found to occur with the ankle in 10° of plantar flexion when compared to 0° or 20° of plantar flexion.[240] Approximately half of the sprains involving the anterior talofibular ligament are avulsions from the fibula, with the other half being midsubstance tears.[250] Damage to the ligaments is dependent on the ankle and foot position at the time of injury and the velocity of the mechanism of injury. The anterior talofibular ligament demonstrates lower maximal load tolerance before failure as compared with the posterior talofibular ligament, calcaneofibular ligament, anterior inferior tibiofibular ligament, and deltoid ligament. The anterior talofibular ligament has the lowest modulus of elasticity, and injury to adjacent muscles (fibularis brevis, longus, and tertius) leaves the lateral ankle somewhat unprotected dynamically.[8,83,208]

Calcaneofibular Ligament

The calcaneofibular ligament is an extra-articular ligament of the talocrural joint that courses from the anterior distal tip of the fibula obliquely downward and backward to the lateral calcaneus. The location of the calcaneal insertion of the calcaneofibular ligament is highly variable.[31] The fibers of the calcaneofibular ligament cross both the ankle and subtalar joints. The ligament is stronger and thicker than the anterior talofibular ligament and may be fan shaped in less than 2% of the population. Because the calcaneofibular ligament crosses the subtalar joint and parallels its axis, subtalar joint motion can affect calcaneofibular ligament tension.[219] Although tension within the ligament increases with dorsiflexion, it resists ankle inversion throughout the full range of ankle motion.[119,122] Because the calcaneofibular ligament crosses both the ankle and subtalar joints, injury to this ligament may have a more profound functional effect on the ankle complex than isolated injuries to the anterior talofibular ligament.[269]

Posterior Talofibular Ligament

The posterior talofibular ligament runs from the posterior-medial portion of the fibula to the lateral tubercle on the posterior aspect of the talus. The posterior talofibular ligament is intracapsular but extrasynovial.[250] It is the strongest of the lateral ligaments[222] and primarily functions to provide transverse plane rotatory stability.[232] Along with the calcaneofibular ligament, anterior talofibular ligament, and medial collateral ligaments, the posterior talofibular ligament assists to couple movements between the lower extremity and foot.[119] Although the posterior talofibular ligament is rarely involved in a typical lateral ankle sprain, movements that involve extreme ankle dorsiflexion, foot external rotation and pronation, along with limb internal rotation may cause injury to the posterior talofibular ligament.[32,219]

Lateral Subtalar Ligaments

The fibers of the lateral talocalcaneal ligament are parallel to and blend in with the posterior fibers of the calcaneofibular ligament. The lateral talocalcaneal ligament crosses the posterior subtalar joint and is considered weaker and smaller than the calcaneofibular ligament.[31] The lateral subtalar joint is further stabilized by the deep interosseous ligament located in the sinus tarsi and cervical ligaments, which are located laterally and insert on the inferolateral talar neck.[227] The fibers of these ligaments run obliquely between the talus and calcaneus, subdividing the subtalar joint into posterior and anterior chambers. These ligaments have a large modulus of elasticity and are considered stabilizers of the subtalar joint throughout the entire range of motion.[136,210] The ligament of Rouvière, or fibulotalocalcaneal ligament, lies distinctly posterior to the calcaneofibular ligament and assists in resisting excessive supination.[122] A combined injury of the anterior talofibular ligament and the interosseous talocalcaneal ligament can induce anterolateral rotatory instability of the ankle joint. After dissection of the interosseous talocalcaneal ligament, dorsiflexion of the talocalcaneal joint increased by 43%, with little effect on ankle supination motion.[28,269] Subtalar ligament sprains are reported after inversion injuries,[14] with subtalar instability noted in 10% to 25% of those with lateral ankle instability.[112,269] Unlike the anterior talofibular ligament, calcaneofibular ligament, and posterior talofibular ligament, the lateral talocalcaneal ligament does not cross the ankle joint. However, with recurrent ankle sprains, greater loads may be placed on the lateral subtalar ligaments and contribute to chronic ankle symptoms, including instability.[112]

Extensor and Fibular Retinacula

The extensor and fibular (peroneal) retinacula contribute to ankle and hindfoot stability primarily due to their anatomical orientation. The inferior extensor retinaculum courses from the tip of the lateral malleolus to insert on the lateral calcaneus and sinus tarsi. The inferior extensor retinaculum also blends with the inferior fibular retinaculum and may improve evertor muscle function.[94] Surgical augmentation of the inferior extensor retinaculum has been shown to provide protection to an anterior talofibular ligament repair in cadaveric[9] and in clinical studies of the modified Broström procedure.[82,155] The superior fibular retinaculum runs from the lateral malleolus to the calcaneus, parallel with the posterior fibers of the calcaneofibular ligament. The actual prevalence of injury to the retinacula is not well defined. However, the fibular and extensor retinacula may be injured in conjunction with lateral ankle sprains and potentially contribute to chronic pain, instability, and peroneal tendon subluxation.[62]

Lower-Limb Neuromuscular Structures

A lateral ankle sprain may result in injuries to the lateral musculotendinous structures, resulting in tendon tearing, intramuscular strain, or tendon subluxation.[68] Dynamic stabilization of the ankle complex is dependent on the adjacent musculature and laterally includes the fibularis (peroneus) longus and brevis. The tibialis anterior and extensor digitorum longus and brevis are thought to eccentrically control ankle plantar flexion. Because lateral ankle sprains commonly occur in plantar flexion, these muscles are also thought to protect against injury. However, both peripheral and central reactions of a muscle response are likely too slow to protect against a sudden inversion force.[149] Therefore, anticipatory muscle contraction may be more important to protect against inversion ankle injuries than a reflexive response. Anticipatory muscle action may increase active muscle stiffness, and hence joint stiffness, while simultaneously increasing the sensitivity of the muscle spindle to stretch.

A lateral ankle sprain not only affects local musculature but may also lead to proximal muscle weakness of the bilateral gluteus maximus, biceps femoris, and lumbar erector spinae.[30] Abnormal hip muscle activation has been found after ankle inversion movements in those with ankle hypermobility after injury.[18] Local sensory changes may also occur after a lateral ankle sprain.[237] Sensory changes can occur in the joint receptors and cutaneous nerves, such as the sural nerve and distal superficial peroneal nerve. Nerve damage can alter afferent cutaneous feedback receptors.[119,149] This not only creates local neurological changes but may also involve central neuromuscular pathways.[30,237] Muscle spindles located within the adjacent lateral ankle muscles are involved in proprioception at the ankle and therefore may be involved in those with instability.[121] Abnormal signals from the central nervous system could be present in individuals with chronic ankle symptoms and affect postural control. The role of the neuromuscular elements in chronic pain and subjective instability is controversial and needs further study.

CLINICAL COURSE

The clinical course of acute lateral ankle sprains was investigated in a systematic review that included 31 prospective studies.[259] These studies generally noted a rapid decrease in pain and improvement in function the first 2 weeks after the injury. However, 5% to 33% of patients continued to have pain at 1-year or longer follow-up, with 5% to 25% still experiencing pain after 3 years.[259] Residual problems included pain (30%), instability (20%), crepitus (18%), weakness (17%), stiffness (15%), and swelling (14%).[85] The percentage of individuals with a subjective report of full recovery ranged between 50% and 85% at approximately 3 years after the injury and seemed to be independent of sprain severity.[259] When symptoms of instability continue after a lateral ankle injury, patients are commonly diagnosed as having ankle instability.

Acute lateral ankle sprains can vary greatly in their presentation with respect to the amount of edema, pain, range-of-motion limitation, and loss of function. In addition, those with acute lateral ankle sprains can present with sensorimotor deficits. Freeman and colleagues[90] were among the first to describe a clinical presentation consistent with sensorimotor deficits associated with ligamentous disruption in individuals with lateral ankle sprains. These sensorimotor functions have been outlined by Hertel[110] to include proprioception, postural control, reflex reactions to inversion perturbation, alpha motor neuron pool excitability, and muscle strength. Proprioception allows for the detection of body movement or position and is purely an afferent phenomenon.[110] Postural control or balance requires the integration of somatosensory, visual, and vestibular afferent information with an efferent response to maintain an upright posture.[110] Proprioceptive[148] and postural control deficits[178] have been identified in those with acute ankle sprains. A systematic review noted balance is not only impaired on the injured extremity but may also be impaired on the uninjured extremity after an acute lateral ankle sprain.[275] Decreased ankle eversion strength, noted shortly after injury, seems to resolve over time.[123,148] Weakness after an acute sprain has also been identified in the gluteal muscles.[30,91] No impairments have been identified in fibularis (peroneal) muscle reaction time,[148] and no studies have examined motor pool excitability after an acute ankle sprain.[110]

Once the acute symptoms have resolved, patients are categorized as being in the subacute phases of tissue healing, which include fibroplasia and remodeling. During these phases, patients often experience weakness, impaired balance response, stiffness, swelling, decreased function, and instability. These symptoms and signs can continue past the subacute phase, often for several years, and contribute to suboptimal outcomes. Individuals with these postacute clinical findings commonly receive the diagnosis of ankle instability. Symptoms reported to be associated with ankle instability vary greatly in the literature. As noted above, recurrent sprains have been reported to occur in as high as 73% of athletes.[177,288] However, in high-quality studies, continued reports of instability were noted in 0% to 33% of patients in follow-up periods of 3 years or less.[259]

Individuals with long-term symptoms and signs after acute lateral ankle injuries are commonly characterized as either having mechanical or functional ankle instability.[109] Mechanical ankle instability has been used to describe those who have excessive joint motion, whereas functional ankle instability describes those who report instability but seem to have normal joint motion. Those with mechanical ankle instability may not only have laxity in the talocrural joint but also the subtalar joint, with both contributing to symptoms of instability.[112] In contrast, it has been hypothesized that functional ankle instability results from sensorimotor and/or neuromuscular deficits.[88,110] However, defining what constitutes ankle instability and, furthermore, categorizing individuals into mechanical ankle instability or functional ankle instability have not been consistently performed in the literature.[50] It has been hypothesized that ankle instability may be an interaction between mechanical ankle instability and functional ankle instability, leading to multiple subgroups of individuals with ankle instability.[114]

The sensorimotor functions (ie, proprioception, postural control, reflex reactions to inversion perturbation, alpha motor neuron pool excitability, and muscle strength) in those with ankle instability have been investigated. A recent systematic review noted impaired postural control when standing with eyes closed on unstable surfaces, prolonged time to stabilize after a jump, and decreased concentric inversion strength in those with chronic ankle instability.[115] No differences were noted in ankle evertor muscle strength. This review[115] also noted conflicting results for passive joint position sense, with no impairments in passive movement detection, reflex reactions to inversion perturbation, and fibularis reaction time. Impaired postural control has also been identified in other systematic reviews[7,188,274] and is consistent with recently completed research.[206,272,276] The literature has noted altered alpha motor neuron pool excitability in not only the muscles that cross the ankle but also in the proximal limb muscles.[110] Decreased hip abduction and trunk strength[91] and altered proximal lower extremity muscle activation patterns were also found in those with chronic ankle instability.[254]

The residual symptoms of pain after a lateral ankle sprain may be associated with concurrent pathology. Studies identified that 64% to 77% of individuals with chronic ankle instability had current extra-articular conditions, most commonly associated with fibularis (peroneal) tendon disorders.[62,233] Residual symptoms have also been associated with chondral damage.[39,120,234,236,255] Because of this chondral damage, it has been hypothesized that repetitive ankle sprains may lead to the early onset of posttraumatic ankle arthritis.[100,234,246]

The factors that determine prognosis following an ankle sprain have largely been undefined. Only 1 study was identified in a systematic review that investigated prognostic factors in determining the clinical course after an acute lateral ankle sprain.[259] This study found that having a high level of activity, defined as training 3 times or more per week, increased the likelihood for residual symptoms. Similar findings were noted in a more recent study that noted that the number of individuals with ankle instability and reinjury was significantly greater in the high-activity group when compared to low-activity groups.[106] Prognosis may also be related to not receiving appropriate treatment after injury, including bracing and rehabilitation.[11,63,128,175,184,261,268]

When nonsurgical intervention is ineffective to address symptoms and disablement following lateral ankle sprain, surgical intervention may be indicated. Patients with mechanical instability may undergo repair or reconstruction of the lateral ligament complex. Although those who sustain an acute lateral ankle sprain are commonly recommended to undergo conservative intervention, research supporting this practice is lacking. A review comparing conservative versus surgical interventions was able to pool outcomes from 12 trials.[140] A statistically significantly higher incidence of instability in conservatively treated patients was identified. There was some limited evidence for longer recovery times, and higher incidences of ankle stiffness, impaired ankle mobility, and complications in the surgical treatment group. The overall conclusion was that there was insufficient evidence available from randomized controlled trials to recommend surgical or conservative treatment for those with acute lateral ligament sprains.[140] A recent study[200] compared surgery to functional treatment for acute grade III (severe) lateral ligament injuries. Physically active males (mean age, 20.4 years) with acute grade III injuries were randomly allocated to surgical (n = 25) or functional (n = 26) treatment. Long-term follow-up (mean, 14 years) found that both groups had recovered to preinjury activity level. The prevalence of reinjury was 1 of 15 in the surgical group and 7 of 18 in the functional treatment group. Stress radiographs revealed no difference between groups with anterior drawer or talar tilt tests. Grade II osteoarthritis was observed on magnetic resonance images in 4 of the 15 surgically treated patients.[200] This study concluded that the long-term results of surgical treatment of acute lateral ligament rupture of the ankle are comparable with functional treatment. Surgery appeared to decrease the prevalence of reinjury, potentially at the expense of increasing the risk of developing posttraumatic osteoarthritis.[200]

RISK FACTORS

Risk factors for acute lateral ankle sprain are categorized as being intrinsic or extrinsic. Intrinsic factors describe the characteristic of an individual that increases their risk for a lateral ankle sprain and include the history of previous sprains, age, gender, physical characteristics (ie, height, weight, and body mass index), and musculoskeletal characteristics (ie, balance, proprioception, range of motion, strength, anatomic alignment, and ligament laxity). Extrinsic factors describe features outside/external to the individual that may put an individual at risk for lateral ankle sprain, and generally include the use of external support, sport, level of competition, and participation in neuromuscular training. The risk factors for an acute lateral ankle sprain may be different from the risk factors for developing ankle instability, and therefore will be described separately. Following a prospective cohort of subjects from preinjury, or even after an acute lateral ankle sprain, to the development of ankle instability has not been well demonstrated in the literature.

Acute Lateral Ankle Sprain: Intrinsic Risk Factors

Previous Injury

I Previous ankle sprains have been identified as a risk factor for a future sprain in the majority of prospective cohort studies.[6,11,56,77,79,118,145,146,177,182,229,235,244,245,262] This includes a subanalysis in a level I intervention study that included 765 high school–aged male and female soccer and basketball athletes.[175] In this prospective cohort, the risk of sustaining an ankle sprain was twice as high (risk ratio = 2.14) in those with a previous sprain.[175] Some of the studies that have not found previous injury as a risk factor[81,102,176,241] were noted to have deficiencies, such as small number of injured subjects[102] and subjects having their ankle taped during the study.[241]

Physical Characteristics

II Generally, age[6,11,56,79,145,175-177,229,280,281] and gender[11,77,175-177,262] were not found to be risk factors for an ankle sprain. However, in the United States Military Academy[35] and Armed Services,[265] females were noted to be at higher risk for an ankle sprain. Conversely, a study by Lindenfeld et al[158] found male soccer players to be at higher risk for injury than females. It may be that age, gender, and grade of injury are interrelated. It was noted that males between the ages of 15 and 24 and females older than 30 years of age were found to have a higher incidence of ankle sprain than their respective counterparts.[266] Additionally, females had a higher risk for grade I (less severe) injury, whereas no gender difference was noted for grade II or grade III (more severe) injuries.[124]

II Studies have mostly noted height[6,17,20,56,79,102,145,175,177,229,280] and weight[6,17,20,56,79,102,175,177,280] not to be risk factors for an ankle sprain. However, 2 studies did find male cadets who were taller and heavier to be at greater risk.[182,265] The evidence for body mass index is less definitive, as there is evidence both for[96,176,245,265] and against[79,145,175,280,281] body mass index as a risk factor for an acute lateral ankle sprain.

Musculoskeletal Characteristics

II Two systematic reviews have investigated postural control as a predictor for an ankle sprain.[58,178] Although McKeon and Hertel[178] noted disagreement in the literature, their consensus was that poor postural control (as assessed through instrumented force plate testing) was generally associated with an increased risk of ankle sprain. A review by de Noronha et al[58] found methodological differences and flaws in studies and therefore noted that conclusions regarding postural sway as a predictor for future ankle sprains should be interpreted with caution. Studies completed since this review have had inconsistent findings. Some have noted deficiencies in postural sway and ability to balance as predictors,[56,176,241] whereas others have found these not to be predictors,[79,118,265] for future ankle sprains. de Noronha et al[58] noted that conflicting evidence and methodological flaws were substantiated in studies assessing proprioception as a predictor for future ankle sprains. In addition, an association between reaction time and future ankle sprain has not been identified.[20,280,281]

II Potential roles for range of motion and strength as risk factors for ankle sprain also have been investigated in the systematic review by de Noronha et al.[58] This review noted that limited dorsiflexion was a predictor for a lateral ankle sprain.[58] The study with the best quality score in the systematic review by de Noronha et al[58] noted that individuals with an inflexible ankle (average dorsiflexion of 34° measured in weight bearing) were 5 times more likely to suffer an ankle sprain compared to those with an average dorsiflexion range of motion of 45°.[203] However, this finding was not supported in a recent study where the average dorsiflexion measured in weight bearing was 44.9° and 43.7° for those who sustained and those who did not sustain an ankle sprain, respectively.[56] Findings related to subtalar[17,20,118,280,281] and first metatarsophalangeal extension range of motion[118,280,281] as predictors for an ankle sprain have been inconsistent. The systematic review by de Noronha et al[58] noted strength not to be a predictor for an ankle sprain. It should be noted that a study not included in the review by de Noronha et al[58] also found hip strength not to be a predictor of future ankle sprains.[176]

II Characteristics related to anatomic alignment, including tibial varum,[17] foot type,[20,79] arch type,[175] forefoot position,[17,20] rearfoot position,[17,20,79,280,281] and toe deformity,[79] have not been identified as risk factors in prospective cohort studies. The exceptions to these findings noted that tibial varum in females[20] and a mobile foot type (as measured with computerized assessment)[279] were associated with ankle sprains. Additionally, a wider foot has been associated with lateral ankle sprains in male military recruits.[182]

III Foot type (visually classified as pronated, supinated, or neutral),[47] Q angle,[195] and tibiofemoral angle[194] were not associated with an ankle sprain.

II General ligament laxity,[17,20,118,176] ankle ligament laxity,[17,79,118] and functional instability[56,118] were not found to be predictors of a future ankle sprain. However, Beynnon et al[20] identified increased talar tilt as a risk factor in males but not females.

II Better cardiovascular condition as assessed through functional performance was found to be a predictor of ankle sprains in males[265,280] but not females.[265] In contrast, Arnason et al[6] found that maximal oxygen consumption was not a predictor of ankle sprains.

Acute Lateral Ankle Sprain: Extrinsic Risk Factors

I Athletes who did not use a lace-up ankle brace when participating in high school football[174] or basketball[173] had a higher incidence of ankle injuries, irrespective of previous injury.

II Systematic reviews by Aaltonen et al[1] and Dizon and Reyes[63] have also noted that the use of external supports, including both taping and bracing, reduces the incidence of ankle sprains. Most of the evidence presented in these reviews indicated that external support is most effective in those with previous injuries.[1,63]

I High school–aged basketball and soccer players with a history of previous ankle sprain who did not participate in a balance training program were at greater risk for ankle sprain.[175] Similarly, athletes who had a previous injury were found to have a higher rate of ankle sprains when they did not participate in a proprioception program when compared to those who completed the program.[128,184] Balance and proprioceptive prevention programs have generally consisted of ankle disc or wobble board activities.

II An increased risk of injury has been noted in athletes with a previous injury who did not perform a balance program[261] and in those who did not participate in a general stretching program as part of their pregame warm-up.[177] There is also an increased rate of injury in athletes who did not participate in a proprioceptive exercise program[11,268] and in those who did not participate in neuromuscular warm-up activities.[150] Two studies[77,78] did not support the use of a neuromuscular prevention program to reduce the incidence of ankle sprains. In these studies, a clinically significant reduction in ankle sprains may have been observed, but statistical significance was not achieved secondary to underpowered research designs.[77,78]

II Wearing an air-cell shoe was identified as a risk factor for ankle sprain,[177] whereas no difference in injury rate was noted when comparing high- versus low-top shoes.[15]

II An increased risk of ankle injury when playing on third- and fourth-generation artificial turf was noted in the systematic review by Williams et al.[283]

B Clinicians should recognize the increased risk of acute lateral ankle sprain in individuals who (1) have a history of a previous ankle sprain, (2) do not use an external support, (3) do not properly warm up with static stretching and dynamic movement before activity, (4) do not have normal ankle dorsiflexion range of motion, and (5) do not participate in a balance/proprioceptive prevention program when there is a history of a previous injury.

Ankle Instability: Risk Factors

III A systematic review by Hiller et al[115] identified a larger talar curvature, inverted heel at heel strike of gait, decreased foot clearance when walking, prolonged time to stabilize after jumping, increased postural sway, and decreased concentric ankle inversion strength as characteristics associated with ankle instability. Additionally, laxity with anterior and inversion ankle testing has been associated with ankle instability in a separate systematic review.[45] Studies not included in these reviews have supported osseous characteristics, including increased talar curvature,[161,248] anterior positioning of the talus,[161,273] and decreased dorsiflexion range of motion during jogging,[69] as potential risk factors for developing ankle instability.

II Based on the information presented for acute lateral ankle sprain, a risk for developing ankle instability could include not wearing an external support or not performing balance and proprioception activities as part of an appropriate rehabilitation program following an acute lateral ankle sprain.

Most studies have compared those with ankle instability to normal individuals. Therefore, it is unclear if some of the characteristics associated with ankle instability are true risk factors for developing recurrent ankle sprains or consequences of a previous ankle sprain, regardless of whether it is a recurrent injury. The authors of this clinical guideline suggest that neuromusculoskeletal characteristics, such as prolonged time to stabilize after jumping, increased postural sway, and decreased concentric ankle inversion strength, are associated with ankle instability and are likely a consequence of a previous ankle sprain. In contrast, the authors of this guideline suggest that the osseous characteristics identified through imaging, such as increased talar curvature and anterior positioning of the talus, may represent true risk factors.

C Clinicians should recognize the increased risk for developing ankle instability in patients who (1) have an increased talar curvature, (2) are not using an external support, or (3) did not perform balance or proprioception exercises following an acute lateral ankle sprain.

DIAGNOSIS/CLASSIFICATION

Acute Lateral Ankle Sprain

Acute lateral ankle sprains are often characterized based on the severity of the injury. Traditionally, lateral ankle sprains are graded I, II, and III to represent the extent and severity of ligament damage, with grade I being the least and grade III being the most severe type of injury. Grading scales can incorporate multiple static and dynamic measures to describe the severity of injury.[85] Static measures include an assessment for the presence of ligament laxity, hemorrhaging, swelling, and tenderness. Dynamic measures have included range of motion, strength, and ability to perform functional tests. These grading scales do not have evidence to support their use. Tests to assess ligament stability (ie, anterior drawer and talar tilt) have not shown desirable diagnostic accuracy when done in isolation.[112,205,256] Diagnostic testing, including stress radiographs, magnetic resonance imaging, arthrography, computed tomography, ultrasonography, and bone scan, has also been used to define the severity of injury.[85] While intervention strategies and recovery time are often linked to severity of injury,[49,163] clear data on recovery rates in high-quality studies are lacking.[259]

A method to grade acute lateral ankle sprains has been defined as follows[163]:

- Grade I: no loss of function, no ligamentous laxity (ie, negative anterior drawer and talar tilt tests), little or no hemorrhaging, no point tenderness, decreased total ankle motion of 5° or less, and swelling of 0.5 cm or less.
- Grade II: some loss of function, positive anterior drawer test (anterior talofibular ligament involvement), negative talar tilt test (no calcaneofibular ligament involvement), hemorrhaging, point tenderness, decreased total ankle motion greater than 5° but less than 10°, and swelling greater than 0.5 cm but less than 2.0 cm.
- Grade III: near total loss of function, positive anterior drawer and talar tilt tests, hemorrhaging, extreme point tenderness, decreased total ankle motion greater than 10°, swelling greater than 2.0 cm. Grade III injuries have been further divided according to stress radiograph results, with anterior drawer movement of 3 mm or less being IIIA and greater than 3 mm of movement being IIIB.

II This grading method was used in a prospective study with 272 track-and-field athletes grouped according to the grade of their lateral ankle sprain.[163] Those with grades I, II, IIIA, and IIIB were significantly different with respect to total ankle range-of-motion loss and volume of edema. A significant difference was noted between stress radiographs with IIIA and IIIB. The groups could also be differentiated in the length of time it took to return to full athletic activity. Those with grades I, II, IIIA, and IIIB required a mean $\pm$ SD of 7.2 ± 1.6, 15.0 ± 2.1, 30.7 ± 3.1, and 55.4 ± 4.9 days, respectively, to fully recover.[163]

III A function score was developed to describe the severity of an acute ankle sprain and predict the outcome of subjects.[49] This score developed from the Lysholm knee scale[239] consists of 5 items: pain, instability, ability to bear weight, swelling, and gait pattern, each with multiple responses. Scores range from 0 (worst) to 100 (best). An initial score greater than 35 was able to predict a "cured" outcome, whereas 35 or less predicted an "injured" outcome at 2 weeks postinjury, with a sensitivity and specificity of 0.97 and 1.0, respectively.[49]

V Systems to grade those who sustained a lateral ankle sprain have been reviewed.[85] Many of these systems incorporate static and/or dynamic measures with criteria to assist in score interpretation. Clinical findings of tenderness are felt to be important. Grade III injuries frequently have tenderness along the medial malleolus, as a complete tear of the anterior talofibular ligament is accompanied by a capsule tear, sprain of the posterior deltoid ligament, and/or impaction of the talus and medial malleolus.

B Clinicians should use the clinical findings of level of function, ligamentous laxity, hemorrhaging, point tenderness, total ankle motion, swelling, and pain to classify a patient with acute ankle ligament sprain into the ICD category of sprain and strain of ankle (S93.4), and the associated ICF impairment-based category of ankle stability (b7150 stability of a single joint) and movement coordination impairments (b7601 control of complex voluntary movements).

Ankle Instability

When symptoms of instability continue after a lateral ankle injury, patients are commonly diagnosed as having mechanical or functional ankle instability. However, there has been discrepancy on how to objectively categorize individuals into these 2 groups.[50] Discriminative instruments have been recommended to help identify individuals with mechanical and/or functional forms of ankle instability.[50]

I The Cumberland Ankle Instability Tool is a 9-item questionnaire with multiple responses designed to evaluate the severity of functional ankle instability.[116] Eight of the 9 items ask individuals to describe their instability or "rolling over" of their ankle during sport and daily activities. The other item queries when individuals have pain. Scores range from 0 (worst) to 30 (best). Evidence for reliability and validity has been provided.[116] The test-retest intraclass correlation coefficient (ICC) was 0.96. Evidence for discriminative validity identified a score of 28 or higher as having a sensitivity and specificity of 85.5 and 82.6, respectively, in differentiating between those who had experienced an ankle sprain or not. A score of 28 or higher also had a sensitivity and specificity of 82.9 and 74.7, respectively, in differentiating between individuals with and without functional ankle instability.[116]

II The Ankle Instability Instrument consists of 12 items, 9 of which are scored in a yes/no fashion.[65] The instrument was developed to identify and determine the severity of functional ankle instability using exploratory factor analysis of 4 items relating to the severity of injury, 5 items relating to the history of ankle instability, and 3 items relating to instability during activities of daily living. Test-retest reliability ranged from 0.70 to 0.98 for the individual items and 0.95 for the instrument overall.[65] No information was given on score interpretation.

IV The Functional Ankle Instability Questionnaire contains 10 items, answered in a yes/no fashion. Eight of these items are used to identify individuals with functional ankle instability.[125] To be categorized as having functional ankle instability, subjects need to answer "yes" for the 3 items related to a feeling of instability and the 1 item related to the need for immobilization or crutches after injury. They also need to answer "no" to the 4 items that indicate a more severe injury.[125]

B Clinicians may incorporate a discriminative instrument, such as the Cumberland Ankle Instability Tool, to assist in identifying the presence and severity of ankle instability associated with the ICD category of instability secondary to old ligament injury, ankle and foot (M24.27), and the associated ICF impairment-based category of ankle stability (b7150 stability of a single joint) and movement coordination impairments (b7601 control of complex voluntary movements).

DIFFERENTIAL DIAGNOSIS

In addition to the lateral ligaments, there are many structures around the ankle complex that may be traumatized with an inversion force, including osseous, chondral, neural, muscular, and vascular structures. Each of these structures may be injured depending on the magnitude of the force, the direction of the force, and the position of the lower extremity during the injury. Because of the nature of chronic ankle instability, history, concerns, and differential diagnosis are generally different from those associated with an acute lateral ankle sprain.

Acute Lateral Ankle Sprain

I The Ottawa ankle rules have become well established for determining the appropriate level of concern for excluding fracture without the use of radiographs. The Ottawa ankle rules state that radiographs are indicated if there was pain in the malleolar zone and any of the following criteria are met: (1) tenderness along the tip of the posterior edge of the distal 6 cm of the lateral malleolus, (2) tenderness along the medial malleolus, and/or (3) an inability to bear weight for 4 steps.[231] Also, the Ottawa ankle rules state that radiographs are indicated if there was pain in the midfoot area and any of the following criteria are met: (1) tenderness at the base of the fifth metatarsal, (2) tenderness over the navicular bone, and/or (3) an inability to bear weight for 4 steps.[231] A meta-analysis of 27 studies demonstrated a negative likelihood ratio of less than 1.4%, indicating that very few fractures are missed with the application of these rules.[10] Specificity, however, was found to be low to modest.

I The Bernese ankle rules were developed to improve on the specificity of the Ottawa ankle rules in identifying a fracture after low-energy malleolar and/or midfoot trauma. This examination consists of 3 consecutive steps: indirect fibular stress applied 10 cm proximal to the fibular tip, direct medial malleolar stress, and simultaneous compression of the midfoot and hindfoot. In a prospective cohort of 364 patients who had sustained a low-energy supination-type injury, sensitivity and specificity were 1.0 and 0.91, respectively.[74]

IV Syndesmotic sprains[4] and cuboid syndrome[130] have been described in 2 separate case series. Diagnosis and grading of a syndesmosis sprain include an assessment of the pain and extent of edema between the distal tibia/fibula and posteromedial ankle regions. The palpation, external rotation, squeeze, and dorsiflexion-compression tests can be used for diagnosis and help determine prognosis.[4] Female dancers with hyperpronated feet have been reported to be at the greatest risk for developing cuboid syndrome,[130] which often results in pain and localized swelling on the dorsolateral foot region, adjacent to the cuboid. Those with cuboid syndrome may also have limited weight-bearing ability and a positive midtarsal adduction test.[130]

V In addition to fractures, syndesmotic sprains, and cuboid syndrome, the following should also be considered:

- Fibularis (peroneal) tendon tendinitis/tendinopathy
- Fibularis (peroneal) sensory nerve injury
- Medial collateral ligament ankle sprain
- Lisfranc fracture/dislocation
- Subtalar sprain
- Spring or bifurcate ligament injury
- Achilles tendon rupture
- Lateral talar process injury
- Anterior process of the calcaneus injury

A Clinicians should use diagnostic classifications other than an acute lateral ankle sprain when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline. Particularly, the Ottawa and Bernese ankle rules should be used to determine whether a radiograph is required to rule out a fracture of the ankle and/or foot.

Ankle Instability

V The differential diagnosis for those with ankle instability includes:

- Osteochondral lesions of the talus
- Fibularis (peroneal) tendon pathology
- Accessory ossicles
- Tarsal coalition
- Sinus tarsi syndrome
- Subtalar sprains with or without instability
- Spring or bifurcate ligament injury
- Ankle impingement

F Clinicians should use diagnostic classifications other than ankle instability when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline.

IMAGING STUDIES

History and clinical examination are usually sufficient to diagnose an acute lateral ankle sprain. However, radiographs may be useful in acute cases when indicated by the Ottawa and Bernese ankle rules. Generally, patients with suspected ankle sprains are treated conservatively for 4 to 6 weeks. For those with persistent symptoms, including those consistent with ankle instability, radiographs, stress radiographs, magnetic resonance imaging, arthrography, computerized tomography, ultrasonography, and/or bone scan/scintigraphy can be used to assess the integrity of the soft tissue and/or osseous anatomy. Stress radiographs typically measure the distance from the posterior lip of the distal tibia and the talar dome when anterior stress is applied to the talocrural joint. Magnetic resonance imaging can be a useful tool to assess for integrity of the lateral ligamentous complex and morphological alterations in adjacent tissues. It has been recommended that magnetic resonance imaging be used for differential diagnosis purposes,[36] specifically to rule out osteochondral lesions in patients who have no or limited improvement after 4 to 6 weeks of nonsurgical treatment with concerns regarding persistent pain, instability, crepitus, catching, and/or locking.[36]

CLINICAL GUIDELINES

Examination

OUTCOME MEASURES

Reviews of evaluative outcome instruments to assess change in status over time for those with foot- and ankle-related pathologies have been completed.[33,73,108,167,169] Three instruments have evidence supporting their use after lateral ankle ligament reconstruction: the Foot and Ankle Outcome Score,[212] Karlsson Ankle Function Score,[137] and Kaikkonen score.[133] Out of all instruments identified, 6 have evidence to support their use for individuals with impairments of body function and structure, activity limitations, and participation restrictions associated with lateral ankle sprains.

I The Foot and Ankle Ability Measure (FAAM) is a region-specific instrument designed to assess activity limitations and participation restrictions for individuals with general musculoskeletal foot and ankle disorders.[167] This includes those who sustained an ankle sprain. It consists of the 21-item activities of daily living (ADL) and separately scored 8-item sports subscales. The FAAM has strong evidence for content validity, construct validity, test-retest reliability, and responsiveness with general musculoskeletal foot and ankle disorders.[168] There is also evidence for validity in those with chronic ankle instability.[37] Test-retest ICCs and minimal detectable change values at 95% confidence (MDC_{95}) were 0.89 and 5.7 for the ADL subscale and 0.87 and 12.5 for the sports subscale. The minimal clinically important difference was reported to be 8 and 9 points over a 4-week time frame for the ADL and sports subscales, respectively.[168]

I The Foot and Ankle Disability Index (FADI) is a former version of the FAAM. The 2 instruments are identical, with the exception of an additional 5 items found on the FADI. Four of these items assess pain and the other item assesses an individual's ability to sleep.[166] These 5 items were subsequently removed after factor and item response theory analyses.[168] The FADI, therefore, is composed of a 26-item ADL subscale and an 8-item sports subscale.[166] Evidence for validity, reliability, and responsiveness was reported using subjects with chronic ankle instability.[103] Test-retest ICCs and standard errors of measure (SEMs) were 0.89 and 2.6 for the ADL subscale and 0.84 and 5.3 for the sports subscale. Scores significantly increased after 4 weeks of rehabilitation, demonstrating responsiveness of the scale, with effect sizes of 0.52 and 0.71 for the ADL and sports subscales, respectively.[103]

II The Lower Extremity Functional Scale (LEFS) was created to be a broad region-specific measure appropriate for individuals with musculoskeletal disorders of the hip, knee, ankle, or foot.[21] The LEFS consists of 20 items that assess activity limitations and participation restrictions. Test-retest reliability was r = 0.87, with an MDC_{90} of 9.4 over a 1-week interval with subjects who sustained an acute ankle sprain.[3] A significant difference between changes in scores over a 1-week period was noted when comparing those 6 or more days to those less than 6 days post–ankle sprain.[3] In a group of subjects with hip, knee, ankle, and foot pathologies, the minimal clinically important difference was reported to be 9 points over a 4-week interval.[21] The LEFS also has evidence to support the interpretation of scores with computerized adaptive testing.[264]

II The Chronic Ankle Instability Scale was developed to quantify the multidimensional profile of patients with chronic ankle instability.[70] The Chronic Ankle Instability Scale contains 4 subscales with a total of 14 items. The subscales are defined as impairment, disability, participation, and emotion. Evidence for validity and reliability was reported using subjects with chronic ankle instability. The test-retest ICC was 0.84, with an MDC_{95} of 4.7 points over a 1-week interval.[70]

II The Sports Ankle Rating System was developed as a region-specific measure consisting of both self-reported and clinician-completed outcome measures.[282] This system consists of the quality-of-life measure, clinical rating score, and single-assessment numeric evaluation. The system was developed so that the 3 outcome measures could be either used together or independently. The quality-of-life measure is a self-reported questionnaire designed to assess an athlete's quality of life after an ankle injury. This questionnaire contains 5 items in each of 5 subscales that pertain to symptoms, work/school activities, recreation/sports activities, ADL, and lifestyle. The clinical rating score has both clinician- and patient-completed items. The patient-completed items assess the severity of concerns related to pain, swelling, stiffness, and giving way. The clinician-completed items assess gait, motion, strength, stability, single-limb balance, and lateral hopping distance. In a test-retest assessment using normal subjects, the coefficient of variation was reported to be less than 1%. Scores from the ankle sprain group were reported to be significantly different across the 4-week evaluation interval.[282]

II The Ankle Joint Functional Assessment Tool is a region-specific instrument that contains 6 items generally related to impairment and 6 generally related to activity. Significant score improvement was noted in subjects receiving treatment after an ankle sprain.[217] The test-retest ICC was 0.94, with a SEM of 1.5 points.[215] It was also able to distinguish between those with functional ankle instability and normal individuals.[215]

In summary, evidence for validity, reliability, and responsiveness to assess outcomes in patients with lateral ankle sprains and chronic ankle instability is available for the FADI, FAAM, Sports Ankle Rating System, and LEFS. Values for minimal clinically important difference, which allows one to objectively assess meaningful changes in score over time, have also been reported for the FAAM and LEFS.

A Clinicians should incorporate validated functional outcome measures, such as the FAAM and the LEFS, as part of a standard clinical examination. These should be utilized before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with ankle sprain and instability.

ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION MEASURES

Measures of activity and participation that quantify lower extremity function for individuals who have sustained a lateral ankle sprain integrate neuromuscular control, strength, range of motion, and proprioception as part of the assessment process. Studies evaluating kinematics, kinetics, and muscle function in subjects with ankle instability have identified abnormalities in ankle movement and neuromuscular control during sport-related activities.[51-53,57,117] Often, those with ankle instability function at a high level and only have limitation during sports. Therefore, while measures of activity and performance may be a component of the evaluation process for individuals with acute injuries, these measures may be more relevant in detecting limitations in individuals with ankle instability. For example, in individuals with ankle instability, a key characteristic in determining the usefulness of a test, such as the side hop or the 6-m crossover hop, may relate to whether or not the symptoms of instability are reproduced during the test.

II Following an acute lateral ankle sprain, evidence of validity and responsiveness for lateral hopping for distance has been noted. Over a 6-month period after an ankle sprain, the percentage of subjects who were able to perform lateral hopping within 20% of the distance for their uninvolved limb improved from 77% to 97%. Also, 75% of subjects who could not perform a lateral hop within 80% of their uninjured limb reported a decrease in ankle function or pain with activity.[95] Lateral hopping for distance contributed to predicting scores on the Sports Ankle Rating System[132] and was responsive to change over a 2-week period.[282] The effect sizes of lateral hopping for distance from initial to 2-week evaluations and 2-week to 4-week evaluations were 5.14 and 0.96, respectively.[282]

II In individuals with acute lateral ankle sprains, measures of activities and participation along with a self-report of athletic ability were accurate in predicting time from injury to return to full participation in sports.[285] The measures included in the activity-participation score for the regression model were the 40-m walk time, 40-m run time, figure-of-eight run, single-limb forward hop, crossover hop, and stair hop.[285]

II Tests that were studied and did not demonstrate evidence of usefulness in those with ankle instability included the cocontraction,[54] shuttle run,[54,186] up/down hop,[64] triple crossover hop,[186,277] single-limb hurdle,[27] single-limb forward hop for distance,[64,277,287] single-limb 6-m hop for time,[287] and single-limb 30-m hop for time.[287]

II There is evidence to support the side hop,[34] figure-of-eight hop,[34] 6-m crossover hop,[34] square hop,[34] and hopping course,[27] but only when instability was noted during the test, in those with ankle instability. When comparing individuals with ankle instability to normal individuals or to the uninjured limb, a significant difference was not noted for any of the 5 tests.[27,34,131,277,287] There is additional evidence for the side hop and figure-of-eight hop, as performance on these single-limb hop tests correlated to scores on the Ankle Instability Index.[64]

II In those with ankle instability, there is conflicting evidence to support the use of the agility multiple hop test. Those with ankle instability had more balance errors and needed more time to complete the test when compared to their unaffected limb and normal individuals.[71] The number of balance errors correlated with the time needed to perform the test and the perceived difficulty.[71,72] In contrast, times to complete the hop test were not different when comparing those with ankle instability to healthy controls.[54]

B When evaluating a patient in the postacute period following a recent or recurring lateral ankle sprain, assessment of activity limitation, participation restriction, and symptom reproduction should include objective and reproducible measures, such as single-limb hop tests that assess performance with lateral movements, diagonal movements, and directional changes.

Lateral Hop for Distance

- ICF category: measurement of activity limitation, jumping
- Description: the distance an individual travels laterally in 3 continuous hops on a single limb
- Measurement method: the patient stands on the involved limb and hops as far as possible in a lateral direction with 3 continuous hops on the same leg. The distance between the lateral heel at the starting point and the position of the lateral heel after the third hop is measured.[282] For those with an acute injury, if a patient is unable to perform the test, they are given a score of zero.
- Nature of variable: continuous
- Units of measurement: centimeters
- Measurement properties: no studies have evaluated the reliability of this measure. Seventy-five percent of 104 subjects who could not perform a lateral hop within 80% of their uninjured limb reported a decrease in ankle function or pain with activity.[95]

Side Hop

- ICF category: measurement of activity limitation, jumping
- Description: the amount of time needed to hop laterally back and forth over a 30-cm distance for 10 repetitions
- Measurement method: the patient stands on the involved limb to the side of a starting line. A second line is located 30 cm laterally to the starting line. The patient is instructed to hop as fast as possible on the involved limb laterally back and forth over these lines for 10 repetitions. One repetition is counted when the subject hops from the starting line over the second line, back over the start line. Three practice trials are completed before 3 maximal-effort test trials are timed. The 3 test times are averaged. A trial is discarded if the patient touches down with the contralateral limb or does not completely clear the 30-cm distance.[34]
- Nature of variable: continuous
- Units of measurement: seconds
- Measurement properties: test-retest reliability with an electronic timer: combined group of healthy individuals (n = 30) and individuals with functional ankle instability (n = 30): ICC = 0.84; MDC_{95}, 5.82 seconds.[34] Combined group of nondisabled individuals (n = 24), individuals with chronic ankle instability (n = 24), and individuals with a history of an ankle sprain but who were able to maintain a high level of activity (n = 24): reliability calculated using symmetry ratio of uninvolved and involved sides. ICC = 0.28; SEM, 7.2%.[277]

Figure-of-Eight

- ICF category: measurement of activity limitation, jumping
- Description: the amount of time needed to hop on involved limb twice around a standardized figure-of-eight patterned course
- Measurement method: the patient stands on the involved limb behind a starting line designated by 1 of 2 cones. The second cone is placed 5 m away. Subjects are instructed to hop as fast as possible in a figure-of-eight pattern, twice around the 2 cones. Three practice trials are completed before 3 maximal-effort test trials. The 3 test times are averaged. A trial is discarded if an individual does not complete the pattern or touches down the contralateral limb.[34]
- Nature of variable: continuous
- Units of measurement: seconds
- Measurement properties: test-retest reliability with an electronic timer: combined group of nondisabled individuals (n = 30) and individuals with functional ankle instability (n = 30): ICC = 0.95; MDC_{95}, 4.59 seconds.[34] Combined group of healthy individuals (n = 24), individuals with chronic ankle instability (n = 24), and individuals with a history of an ankle sprain but who were able to maintain a high level of activity (n = 24): reliability calculated using symmetry ratio of uninvolved and involved sides. ICC = 0.21; SEM, 8.3%.[277]

6-m Crossover Hop

- ICF category: measurement of activity limitation, jumping
- Description: the amount of time needed to hop diagonally a distance of 6 m
- Measurement method: the subject stands on the involved limb behind a starting point medial to a line 6 m long and 15 cm wide. The individual is instructed to hop as fast as possible on the involved limb diagonally from side to side over the line for the distance of 6 m. Three practice trials are completed before 3 maximal-effort test trials. The 3 test times are averaged. A trial is discarded if an individual touches down with the contralateral limb or does not completely clear the 15-cm width of the line.[34]
- Nature of variable: continuous
- Units of measurement: seconds
- Measurement properties: test-retest reliability with an electronic timer: combined group of healthy individuals (n = 30) and individuals with functional ankle instability (n = 30). ICC = 0.96; MDC_{95}, 1.03 seconds.[34]

Square Hop

- ICF category: measurement of activity limitation, jumping
- Description: the amount of time needed to hop in and out of a 40 × 40-cm square in a clockwise or counterclockwise direction, depending on if the right or left limb is being tested, respectively, 5 times around the square
- Measurement method: a square 40 × 40 cm is marked on the floor with tape. Starting outside the square, participants are instructed to hop, as fast as possible, in the square and then hop out the side of the square that is clockwise if the right limb is being tested. If the left limb is being tested, the individual would hop out the square to the side that

is counterclockwise to the start side. This is repeated for each of the 4 sides of the square so that the participant will return to the start position in 8 hops. The subject repeats this so that they jump around the square 5 times. Three practice trials are completed before 3 maximal-effort test trials. The 3 test times are averaged. The trial is discarded if an individual touches down with the contralateral limb or does not completely clear the tape outlining the square.[34]

- Nature of variable: continuous
- Units of measurement: seconds
- Measurement properties: test-retest reliability with an electronic timer: combined group of healthy individuals (n = 24) and individuals with functional ankle instability (n = 24). ICC = 0.90; MDC_{95}, 3.88 seconds.[34]

Hopping Course

- ICF category: measurement of activity limitation, jumping
- Description: the amount of time needed to hop through the course of 8 squares
- Measurement method: the course consists of 8 separate 33.02 × 33.02-cm (13-inch) squares positioned in 2 rows of 4. In each row, the first and last squares are level, whereas the middle 2 squares are sloped. The 2 middle squares in the first row are sloped 15° laterally, whereas the middle 2 squares in the second row are sloped at a 15° incline and decline, respectively.[38] The subject is instructed to hop from square to square, moving through 4 squares in row 1 to the 4 squares in row 2 as fast as possible. Three practice trials are completed before 5 maximal-effort test trials. The 5 test times are averaged. A trial is discarded if an individual hops out of sequence, off the course, or touches down the contralateral limb.[27]
- Nature of variable: continuous
- Units of measurement: seconds
- Measurement properties: test-retest reliability with an electronic timer: individuals with functional ankle instability (n = 20): ICC = 0.93; SEM, 0.18 seconds.[27] Healthy individuals (n = 20): ICC = 0.97; SEM, 1.10 seconds.[221]

PHYSICAL IMPAIRMENT MEASURES

Swelling

- ICF category: measurement of impairment of body structure, ankle, and foot
- Description: a measure of the amount of fluid in the leg, ankle, and foot
- Measurement method: the zero end point of a tape measure is positioned at the groove on the edge of the lateral malleolus, midway between the prominence of the lateral malleolus and tibialis anterior tendon. The tape is then drawn medially around the foot to then cross the plantar aspect toward and behind the base of the fifth metatarsal. The tape is then drawn toward and under the medial malleolus, across the Achilles tendon toward and under the lateral malleolus of the fibula, and finally to meet the original zero end point. The ankle is positioned in either neutral, comfortable, or a 20° plantar flexion position. Foot position used for the initial testing should be replicated for future reassessments.
- Nature of variable: continuous
- Units of measurement: millimeters
- Measurement properties: test-retest reliability: 30 patients with observable swelling after unilateral malleolar fracture, measured with the ankle positioned in 20° of plantar flexion. Intratester ICC>0.99; MDC_{95}, 6.8 mm.[211] Twenty-nine subjects with acute lateral ankle sprains, measured with the ankle positioned in neutral. Interrater reliability: ICC = 0.99. Intrarater reliability: ICC = 0.93 to 0.98.[204] Fifteen patients with observable ankle edema from leg injury, measured with the ankle positioned in neutral. Intratester ICC = 0.99.[172] Twenty-nine patients with ankle swelling (83% with the diagnosis of ankle sprain), measured with the ankle in a "comfortable position." Intrarater and interrater ICC = 0.98.[197] Fifty healthy individuals, measured with the ankle in neutral plantar flexion/dorsiflexion. Intratester ICC = 0.99.[238] Validity: patients with observable ankle edema from leg injury, measured with the ankle positioned in neutral. Correlation to volumetric measures: r = 0.90.[172]
- Instrument variations: water displacement volumetry has also been used to quantify the amount of fluid in the leg, ankle, and foot.

Ankle Range of Motion

- ICF category: measurement of impairment of body function, mobility of a single joint
- Description: passive non–weight-bearing goniometric measure of ankle dorsiflexion with the knee extended to 0° and flexed to 45°. Measures with the knee extended are intended to be descriptive of gastrocnemius flexibility, whereas those with the knee flexed are thought to reveal soleus flexibility.
- Measurement method: the patient assumes either a supine or prone position on examination table with ankle and foot suspended over the end of the table. The stationary arm of the goniometer is aligned with the fibular head. The axis of the goniometer is placed just distal to the lateral malleolus and the movable arm of the goniometer is aligned parallel with the plantar aspect of the calcaneus and fifth metatarsal. When measuring ankle dorsiflexion, the subtalar joint should be maintained in neutral.
- Nature of variable: continuous
- Units of measurement: degrees
- Measurement properties: Martin and McPoil[170] published a review of the literature for goniometric ankle measures of dorsiflexion and plantar flexion. Most of the identified works in this review reported intratester reliability measures greater than 0.90, with intertester reliability gener-

ally being around 0.70. The reliability of plantar flexion measurements was consistently lower than that for dorsiflexion.[170] Test-retest reliability ankle dorsiflexion: 22 patients with acute lateral ankle sprain.[289] Intratester ICC = 0.91; MDC_{95}, 6°. Improvement in dorsiflexion range of motion after a 6-week home exercise program was between 16° and 19°.

- Instrument variations: fluid-filled bubble inclinometers have also been used to reliably assess ankle motion, including non–weight-bearing and weight-bearing dorsiflexion[55,189] and posterior talar glide.[55] Weight-bearing dorsiflexion has also been assessed using a tape measure to assess the maximal distance the great toe could be moved from a wall while still maintaining contact of the anterior knee on the wall and heel on the floor during a lunging movement.[263]

Subtalar Joint Range of Motion

- ICF category: measurement of impairment of body function, mobility of a single joint
- Description: passive non–weight-bearing goniometric measure of rearfoot inversion and eversion range of motion
- Measurement method: the stationary arm of the goniometer is held over a bisection of the distal one third of the posterior tibia and fibula. The axis is placed over the subtalar joint while the movable arm is placed over a bisection of the posterior aspect of the calcaneus.
- Nature of variable: continuous
- Units of measurement: degrees
- Measurement properties: test-retest reliability: 37 patients with orthopaedic conditions.[76] Intratester ICC = 0.74 to 0.79. Intertester ICC = 0.17 to 0.32. Twenty patients with ankle pathology.[225] Intertester ICC = 0.42 for inversion and 0.25 for eversion. Thirty healthy individuals (n = 60 ankles).[181] Intratester ICC = 0.83 to 0.94; MDC_{95}, 8° for inversion and 6° for eversion. Intertester ICC = 0.41 for inversion and 0.54 for eversion. Thirty healthy individuals.[257] Intertester ICC = 0.28 for inversion and 0.49 for eversion.

Ankle and Foot Supination and Pronation

- ICF category: measurement of impairment of body function, mobility of multiple joints
- Description: active non–weight-bearing goniometric measure of supination and pronation. These movements are intended to describe the combined motion of inversion, adduction, and plantar flexion and eversion, abduction, and dorsiflexion, respectively. These movements occur to varying extent at the ankle, subtalar, midtarsal, and tarsometatarsal joints.
- Measurement method: the patient assumes a sitting position with the knee flexed to 90°, the leg off the table and unsupported. The stationary arm of the goniometer is aligned with the tibial tuberosity down the anterior midline of the leg. The axis of the goniometer is placed over the anterior aspect of the ankle midway between the malleoli and the movable arm, aligned with the anterior midline of the second metatarsal.
- Nature of variable: continuous
- Units of measurement: degrees
- Measurement properties: 30 healthy individuals (n = 60 ankles).[181] Intratester ICC = 0.82 to 0.96; MDC_{95}, 9° for both inversion and eversion. Intertester ICC = 0.62 to 0.73.

Anterior Drawer

- ICF category: measurement of impairment of body structure, stability of a single joint
- Description: the amount of anterior talar translation in respect to the ankle mortise. A variation of this has been described as the anterolateral drawer test.[207] With intact deltoid ligaments, the anterolateral rotatory motion is specifically assessed as the lateral talus moves in relation to the medial talus in positive testing conditions.
- Measurement method: the patient is positioned sitting in 90° of knee flexion, with the leg relaxed and unsupported. One hand of the examiner is placed on the distal tibia while palpating the articulation between the lateral surface of the talus and the anterior aspect of the distal fibula. The second hand grasps the posterior aspect of the calcaneus. The test is performed by pulling the calcaneus and subsequently the talus in an anterior direction while the distal tibia is stabilized. A number of ankle positions can be used between 10° and 20° of plantar flexion. A variation to this test emphasizes the rotatory component by including an internal rotation force to the talus in addition to the anteriorly directed force. The test has also been described as being performed in full knee extension with the patient positioned supine or prone.
- Nature of variable: ordinal
- Units of measurement: normal: no side-to-side differences. Abnormal: increased motion on the involved side compared to the uninvolved side.
- Measurement properties: 160 subjects with acute injury to the lateral ankle ligaments, of which 122 had surgically confirmed rupture of at least 1 ligament. The remaining 38 had a negative arthrogram and normal ankle at 6-month re-examination.[256]
- Diagnostic accuracy: sensitivity, 0.80 (95% confidence interval [CI]: 0.71, 0.86). Specificity: 0.74 (95% CI: 0.57, 0.85). Positive likelihood ratio = 3.01 (95% CI: 1.71, 5.31). Negative likelihood ratio = 0.28 (95% CI: 0.18, 0.42) (7 subjects with uncertain results were excluded from the calculation). The combination of pain with palpation of the anterior talofibular ligament, lateral hematoma, and a positive anterior drawer on examination 5 days after injury had a sensitivity of 100%, specificity of 75%, positive likelihood ratio of 4.13, and negative likelihood ratio of 0.01 to

identify lateral ligament rupture.[256] Intertester reliability of this examination ranged between 0.5 and 1.0 (moderate to perfect)[153] among 5 investigators.[256] Twelve subjects with a history of more than 1 unilateral ankle sprain and 8 healthy controls were examined.[112] Sensitivity, 0.58 (95% CI: 0.32, 0.80). Specificity, 0.94 (95% CI: 0.63, 0.99). Positive likelihood ratio = 10.39 (95% CI: 0.68, 159.81). Negative likelihood ratio = 0.45 (95% CI: 0.23, 0.86) (using the Altman convention for diagnostic studies with a zero count in the 2-by-2 contingency table, adding 0.5 to all 4 cells). One hundred eighty-eight subjects with acute ankle sprains were included. Arthrography found 55 (29%) normal, 85 (45%) with a rupture of the anterior talofibular ligament, 46 (25%) with a rupture of both the anterior talofibular and calcaneofibular ligaments, and 2 (1%) with an isolated rupture of the calcaneofibular ligament.[205]

- Diagnostic accuracy: sensitivity, 0.67 (95% CI: 0.58, 0.76). Specificity, 0.82 (95% CI: 0.69, 0.91). Positive likelihood ratio = 3.79 (95% CI: 1.99, 7.20). Negative likelihood ratio = 0.40 (95% CI: 0.29, 0.54) (39 subjects with uncertain results were excluded from the calculation).
- Cadaver model: when tested at between 10° and 20° of plantar flexion, anterior talar translation with inversion and internal rotation forces produced the greatest amount of talar translation/ligament laxity.[13,92,122] The anterior drawer performed in 20° of plantar flexion was not able to differentiate between intact and sectioned anterior talofibular ligament or between intact and sectioned anterior talofibular and calcaneofibular ligaments.[93] The anterior drawer test that emphasized rotatory instability had a correlation of 0.93 to direct anatomical measurements.[199]
- Instrument variations: joint arthrometers, such as the LigMaster,[66] Dynamic Anterior Ankle Tester,[139] Quasi-static Anterior Ankle Tester,[139] Telos,[165] and ankle meter,[226] have been developed to quantify the amount of anterior translation.

Talar Tilt

- ICF category: measurement of impairment of body structure, stability of a single joint
- Description: assess the amount of talar inversion occurring within the ankle mortise
- Measurement method: the test is performed with the patient sitting in 90° of knee flexion with the legs relaxed and unsupported. One hand of the examiner grasps the distal tibia and fibula while the second hand grasps the calcaneus, holding the ankle in a neutral position. The test is performed by inverting the calcaneus, and subsequently the talus, relative to the ankle mortise. Variations of this test have been described with the patient in supine and sidelying positions.
- Nature of variable: ordinal
- Units of measurement: normal: no side-to-side differences. Abnormal: increased motion on the involved side compared to the uninvolved side.
- Measurement properties: 12 subjects with a history of more than 1 unilateral ankle sprain and 8 healthy controls were examined.[112]
- Diagnostic accuracy: sensitivity, 0.50 (95% CI: 0.25, 0.75). Specificity, 0.88 (95% CI: 0.53, 0.98). Positive likelihood ratio = 4.00 (95% CI: 0.59, 27.25). Negative likelihood ratio = 0.57 (95% CI: 0.31, 1.07).
- Cadaver model: an inversion movement with the ankle in neutral dorsiflexion produced the greatest tension on the calcaneofibular ligament.[13,42,122,144]
- Instrument variations: joint arthrometers, such as the LigMaster[66] and Telos,[165] have been developed to quantify the degree of talar tilt.

Isokinetic Muscle Strength of Inversion and Eversion

- ICF category: measurement of impairment of body function, power of isolated muscles and muscle groups
- Description: assessment of inversion and eversion force production at a controlled speed
- Measurement method: inversion and eversion torque (both average and peak torque) assessed with an isokinetic dynamometer with the ankle positioned between 0° and 20° of plantar flexion. Velocities of 30°/s, 60°/s, 120°/s, and 180°/s are tested using both concentric and eccentric contractions.
- Nature of variable: continuous
- Units of measurement: Newton meters
- Measurement properties: test-retest reliability: 24 patients with functional ankle instability.[221] Velocity of 120°/s with concentric and eccentric inversion/eversion movements. The ankle was positioned in 10° to 15° of plantar flexion. ICC = 0.91 (range, 0.82-0.98); SEM, 0.7 to 0.8 Nm. Eleven patients with chronic ankle instability: the ankle was positioned in 0° of plantar flexion. ICC = 0.92 and 0.89 at 120°/s and 0.90 and 0.71 at 30°/s for inversion and eversion, respectively.[5] Eight to 35 nondisabled individuals.[135,157,249] Velocities of 30°/s, 60°/s, 120°/s, and 180°/s in 0°, 10°, 15°, or 20° of plantar flexion: ICC = 0.54 to 0.96. Invertor and evertor strength deficits in individuals with chronic ankle instability remain controversial. Some studies have identified invertor strength deficits,[107,187,202,218,278] whereas others have not.[156,180] Evertor strength deficits have also been identified in some studies[107,202,242] but not others.[156,180,218,278]

Single-Limb Balance

- ICF category: measurement of impairment of body function, proprioception function
- Description: maintain balance on 1 limb
- Measurement method: Freeman et al[90] initially described a balance assessment, using a modification of the Rom-

berg test, for individuals with ankle instability. The simple balance test is performed by having an individual stand on 1 leg for 1 minute with eyes open and 1 minute with eyes closed. Each surface contact with the contralateral leg was counted a "touch" or failure point. Alternately, the time the individual is able to maintain balance up to 60 seconds has also been described as the single-limb balance test (SLBT).[40]

- Nature of variable: continuous
- Units of measurement: simple balance test: number of "touches." SLBT: seconds.
- Measurement properties: the SLBT was done in 230 athletes (mean age, 18 years) in a preseason examination. During the course of the study, 28 ankle sprains were noted. A significant association between positive SLBT and ankle sprain was noted (χ^2 = 5.83, P = .016). The relative risk of ankle sprain with positive SLBT was 2.43 (95% CI: 1.15, 5.14).[241] Intertester reliability in this study was high (κ = 0.89).[241]
- Diagnostic accuracy: identifying those at risk for an ankle sprain. Sensitivity, 0.68 (95% CI: 0.49, 0.82). Specificity, 0.56 (95% CI: 0.50, 0.63). Positive likelihood ratio = 1.56 (95% CI: 1.16, 2.10). Negative likelihood ratio = 0.57 (95% CI: 0.33, 0.99). Validity: performances on the simple balance test and SLBT were different between individuals with and without unstable ankles, as well as between injured and uninjured ankles in individuals with ankle instability.[40,87,131,156] Simple balance test scores did not correlate with functional outcome measures in individuals with ankle instability.[60] Normative data: average single-limb balance times for individuals between 20 and 49 years of age ranged between 29.7 and 30.0 seconds with eyes open and between 24.2 and 28.8 seconds with eyes closed. The average times decreased to between 14.2 and 29.4 seconds with eyes open and between 4.3 and 21.0 seconds with eyes closed for those between the ages of 50 and 79 years.[25]
- Instrument variations: postural sway in single-limb balance testing can be measured with a force plate. These force plate measures have been used to detect sensorimotor deficits.[7,178,188]

Balance Error Scoring System Test

- ICF category: measurement of impairment of body function, proprioception function
- Description: maintain balance in 6 conditions: double limb, single limb, and tandem stances on both firm and foam surfaces
- Measurement method: the Balance Error Scoring System (BESS) test consists of counting the number of deviations from a standardized stance position or "errors" in a 20-second time period for each of the 6 conditions. The stance position requires the individuals to stand with their hands on iliac crests, head in neutral, and eyes closed. An "error" is counted when the individual (1) opens their eyes; (2) steps, stumbles, or falls out of test position; (3) removes hands from their hips; (4) moves into more than 30° of hip flexion or abduction; (5) lifts the toes or heels; or (6) remains out of the test position for more than 5 seconds.
- Nature of variable: continuous
- Units of measurement: number of "errors"
- Measurement properties: test-retest reliability, healthy individuals (n = 30-111) for the 6 conditions and total score.[84,209,247] Intratester ICC = 0.50 to 0.98.[84,209,247] Intertester ICC = 0.44 to 0.83.[84] MDC_{95}, 7.3 "errors" for intratester and 9.4 "errors" for intertester assessments.[84] Using generalizability theory analysis with healthy individuals (n = 48): 3 trials were found to provide acceptable reliability.[26] The reliability of 3 trials with 4 conditions (double-limb stance removed) was r = 0.88 with healthy individuals (n = 78).[127] Validity: individuals with functional ankle instability (n = 30) scored more "errors" on the single-limb firm, tandem foam, single-limb foam, and total BESS score than healthy individuals.[67] BESS scores were found to correlate with force plate measures in healthy individuals (n = 111).[209] Normative data: average total BESS scores ranged from 11 to 13 "errors" for those between the ages of 20 and 54 years and 15 to 21 "errors" for those between the ages of 55 and 69 years (n = 589).[129]

Star Excursion Balance Test

- ICF category: measurement of impairment of body function, control of voluntary movement functions
- Description: maintain balance on 1 lower extremity while reaching as far as possible in 8 different directions with the other
- Measurement method: the Star Excursion Balance Test (SEBT) layout consists of 8 lines from a center point arranged at 45° angles. The lines can be labeled according to their position in a counterclockwise direction as follows: anterior, anterolateral, lateral, posterolateral, posterior, posteromedial, medial, and anteromedial. The test consists of having the subject stand with the lower extremity being tested in the center while the maximum reach distance of the contralateral lower extremity achieved along each of the direction lines is measured. Subjects are not allowed to move the support foot and should keep their hand on their hips. The test consists of 6 practice and 3 test trials in each of the 8 directions. Reach distances can be normalized by dividing excursion distance by lower extremity length.[98]
- Nature of variable: continuous
- Units of measurement: centimeters
- Measurement properties: test-retest reliability in healthy individuals (n = 16-20): intratester ICC = 0.67 to 0.96; SEM, 1.77 to 4.78 cm.[113,143] Intertester ICC = 0.35 to 0.94; SEM, 2.27 to 4.96 cm.[113] Validity: individuals with ankle instability had decreased reach distances compared to their

uninvolved side and healthy individuals.[2,99,111,192] Decreased anterior and posteromedial reach distances on the involved side were predictive of ankle instability.[126] Anteromedial, medial, and posteromedial directions were found to represent the best directions to discriminate those with ankle instability from healthy individuals.[111] The posteromedial direction had the highest correlation to overall SEBT performance with factor analysis (α = .96).[111] Individuals with an anterior reach distance difference greater than 4 cm between lower extremities were 2.5 times more likely to sustain a lower extremity injury.[201] Females with a composite reach distance less than 94% of their lower extremity length were 6.5% more likely to sustain a lower extremity injury.[201] Individuals with ankle instability who underwent rehabilitation had improved SEBT reach distances with concurrent improvement in function.[104] Differences in anteromedial, medial, and posteromedial reach distances were not found between those with ankle instability and healthy individuals.[220] A difference in SEBT total score was not found between those with recurrent ankle sprains and a control group.[190]

- Modifications: the Y-balance test is an adaptation of the SEBT that involves performing the reach only for the anterior, posterolateral, and posteromedial directions.[201]

CLINICAL GUIDELINES

Interventions

This synthesis of evidence for interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with lateral ankle sprain is divided into 2 sections. The first section describes the evidence for interventions for patients in the protected motion phase of rehabilitation following a lateral ankle sprain. Studies that enrolled subjects within 72 hours following injury, or subjects who demonstrated significant edema, pain, limited weight bearing, and overt gait deviations (ie, limited stance time, abbreviated/omitted terminal stance phase), are included in this section. The protected motion phase of rehabilitation generally is associated with the acute phase of tissue healing.

The second section discusses the evidence for interventions in the progressive loading and sensorimotor training phase of rehabilitation following a recent or recurring lateral ankle sprain. The progressive loading and sensorimotor training phase generally corresponds to the postacute period of rehabilitation. Studies that enrolled subjects with injuries that were in the postacute period, with primary concerns of instability, weakness, limited balance responses, and intermittent edema, are included in this section. Also, this section includes studies that enrolled subjects with mechanical and/or functional ankle instability.

ACUTE/PROTECTED MOTION PHASE OF REHABILITATION

Early Weight Bearing With Support

I Kerkhoffs et al[141] conducted a systematic review involving 22 studies, which concluded there was a significant benefit to weight bearing as tolerated compared to non–weight-bearing cast immobilization. Crutches or other gait assistive devices are commonly used in the early stages of tissue healing to prevent reinjury and to minimize pain as weight-bearing capacity progresses. The review did not identify any outcome studies that favored non–weight-bearing cast immobilization. Studies generally favored mobilization compared to immobilization in outcome measures that reflect return to sport (weighted mean difference, 4.6 days; 95% CI: 1.5, 7.6 days), return to work (weighted mean difference, 7.1 days; 95% CI: 5.6, 8.7 days), and instability (weighted mean difference, 2.5 days; 95% CI: 1.3, 3.6 days). There also were small effect sizes of treatment that favored the early mobilization group for ankle range of motion and swelling. One study reported that 44% of subjects had persistent symptoms at 1-year follow-up; however, these symptoms did not reduce their ability to work.[59]

I The systematic review by Kerkhoffs et al[141] included 9 studies that specifically compared different types of external support used in conjunction with functional weight bearing. The use of lace-up bracing led to significantly better results for short-term swelling than semi-rigid bracing. However, semi-rigid ankle support was associated with significantly shorter time to return to work and sport, as well as decreased incidence of subjective instability, compared to an elastic wrap. External support from tape was associated with the most complications, such as skin irritation, compared to an elastic wrap.[141]

I Lamb et al[151] noted reduced symptoms and disability in short- and intermediate-term outcomes with below-knee casting and semi-rigid support compared to elastic wrap in individuals with severe ankle sprains. Duration for use of the external support was determined by the brace manufacturer's recommendations and a nationwide practice survey in the UK.[43,152] Subsequently, Cooke et al[44] reanalyzed data from the sample in the study by Lamb et al[151] and established no long-term differences in symptoms, disability, and costs (considering indirect costs) comparing those who received elastic wrap, semi-rigid brace, rigid brace, or below-knee cast. However, in the short term, semi-rigid bracing and below-knee casting appeared most cost-effective.[44]

I Kemler et al[138] recently conducted a systematic review to compare the use of ankle braces with other external supports on symptoms and functional outcomes in patients with acute lateral ankle sprains. Eight studies met inclusion criteria. Data pooling was not possible to assess the study objectives, so qualitative best-practice synthesis was undertaken. The authors' recommendations were that improved functional outcomes and decreased economic expenditures could be attributed to use of an ankle brace compared to other external supports.[138]

III Freeman[89] conducted a cohort study to determine the effectiveness of strapping and mobilization, cast immobilization, and suture of the lateral ankle ligaments in individuals with acute lateral ankle sprains.

Although recovery duration among patients who reported recovery was fastest in the early mobilization group (12 weeks) compared to the immobilization group (22 weeks) and suture group (26 weeks), immobilization and suturing were associated with improved mechanical stability on stress radiography. Subsequently, Smith and Reischl[223] completed a cadaver study to determine the optimal position for immobilization of severe ankle sprains. The authors sectioned the lateral ankle ligaments of 3 nonembalmed human cadaver specimens to simulate a grade III lateral ankle sprain, and then measured the critical angle of ankle dorsiflexion necessary to reduce the resulting anterior subluxation of the talocrural joint according to stress radiography. The authors established that a range of dorsiflexion angles between 5° and 15° reduced the anterior talocrural subluxation. However, the specific dorsiflexion angle varied based on specimen.

A Clinicians should advise patients with acute lateral ankle sprains to use external supports and to progressively bear weight on the affected limb. The type of external support and gait assistive device recommended should be based on the severity of the injury, phase of tissue healing, level of protection indicated, extent of pain, and patient preference. In more severe injuries, immobilization ranging from semi-rigid bracing to below-knee casting may be indicated.

Manual Therapy

II A single session of manual therapy in the emergency department was associated with improvement in edema and pain in individuals presenting with acute ankle sprains.[75] Ankle sprain severity was not carefully described in this study. Manual treatment included soft tissue mobilization, joint mobilization, isometric mobilization, contract/relax, positional release, and lymphatic drainage procedures that were directed to individually identified impairments in body structures and functions. A separate study found significant differences favoring subjects with acute ankle sprains who received low-grade accessory joint mobilization procedures, specifically posterior glide of the talus relative to the tibia and fibula in the pain-free ranges. These subjects achieved full ankle dorsiflexion and step symmetry within the first 2 to 3 treatments.[97]

B Clinicians should use manual therapy procedures, such as lymphatic drainage, active and passive soft tissue and joint mobilization, and anterior-to-posterior talar mobilization procedures, within pain-free movement to reduce swelling, improve pain-free ankle and foot mobility, and normalize gait parameters in individuals with an acute lateral ankle sprain.

Physical Agents

Cryotherapy

I Bleakley et al[22] conducted a systematic review that yielded marginal evidence for the use of ice in addition to exercise for the management of acute-phase healing after lower extremity sprain and minor surgery. The use of ice demonstrated a favorable effect compared to no ice on pain, weight bearing, and use of prescription and nonprescription analgesic medications. A longer duration of icing appeared to be most beneficial. However, the optimal mode and dosage for ice application could not be identified from the reviewed studies.

II Bleakley et al[23] subsequently identified significant improvement in activity at 1 week following intermittent immersion cryotherapy compared to a single 20-minute bout of cryotherapy in individuals with acute ankle sprains.

A Clinicians should use repeated intermittent applications of ice to reduce pain, decrease the need for pain medication, and improve weight bearing following an acute ankle sprain.

Diathermy

II Pasila et al[193] found a significant reduction in edema and examiner's subjective assessment of limping in individuals with acute ankle sprains who received pulsating shortwave diathermy compared to sham control treatment. Neither range of motion nor strength appeared to benefit from shortwave diathermy.

C Clinicians can utilize pulsating shortwave diathermy for reducing edema and gait deviations associated with acute ankle sprains.

Electrotherapy

II Wilson[284] reported greater improvement in clinical grading that considered swelling, pain, and gait deviation in individuals with acute ankle sprains who received pulsed electrical stimulation.

II Man et al[164] found no significant difference in ankle and foot volume, girth, and self-perceived functioning in individuals with acute ankle sprains receiving electrical stimulation at either motor or submotor intensity.

D There is moderate evidence both for and against the use of electrotherapy for the management of acute ankle sprains.

Low-Level Laser Therapy

II — Stergioulas[230] reported a significant decrease in foot and ankle volume at 24, 48, and 72 hours following initiation of low-level laser treatment in individuals during the acute phase of tissue healing after ankle sprains.

II — In a study by de Bie et al,[48] no significant differences were observed in measures of pain and function between individuals with acute ankle sprains who received low-level laser therapy and placebo treatment.

D — There is moderate evidence both for and against the use of low-level laser therapy for the management of acute ankle sprains.

Ultrasound

I — Systematic reviews by van der Windt et al[253] and van den Bekerom et al[251] identified no significant effect among studies comparing active ultrasound treatment to sham ultrasound treatment following ankle sprains.

A — Clinicians should not use ultrasound for the management of acute ankle sprains.

Therapeutic Exercises

I — Bleakley et al[24] found a significant increase in lower extremity function for subjects with acute grade I or II ankle sprains who received exercise in addition to advice for early progressive weight-bearing mobility. Hale et al[104] identified significant improvement in squat reach and self-reported lower extremity functional ability as a result of formal rehabilitation intervention. Center-of-pressure velocity in single-limb standing with eyes open and closed was not significantly different as a result of treatment. van Rijn et al[260] reported no significant improvement in subjective recovery, laxity, subjective instability, and recurrence of injury at 3 months and 1 year following injury in patients with acute ankle sprains receiving conventional medical treatment combined with supervised rehabilitation compared to patients receiving only conventional medical treatment.

I — van Rijn et al[258] later reanalyzed the data from this original trial and established significant improvement in functioning in individuals with severe ankle sprains (n = 102) who received physical therapy intervention and conventional medical treatment compared to control subjects who only received conventional medical treatment. In this analysis, subjects were further stratified based on severity of ankle injury according to the ankle function score.[49] Significant improvement was noted in the most functionally impaired subset of the intervention group, consisting of subjects with ankle function score outcomes of 40 or less on self-reported pain and stability. Intervention consisted of a standardized protocol of exercises, such as active range-of-motion exercises for the ankle and foot and progressive resistive exercises for the ankle and foot incorporating progressive weight bearing, based on guidelines established by the Royal Dutch Society for Physical Therapy.[252]

II — Holme et al[123] found a significant decrease in 1-year recurrence rate without corresponding significant changes in postural control and ankle muscle strength attributable to treatment initiated in the acute period following ankle sprain. Bassett and Prapavessis[16] documented significant improvement in self-reported ankle function with both home- and clinic-based physical therapy interventions. Self-reported ankle function was not significantly different between groups. Rate of attendance at clinic appointments was significantly higher in the group receiving primarily home-based intervention.

A — Clinicians should implement rehabilitation programs that include therapeutic exercises for patients with severe lateral ankle sprains.

PROGRESSIVE LOADING/SENSORIMOTOR TRAINING PHASE OF REHABILITATION

Manual Therapy

I — In a systematic review, van der Wees et al[252] identified a clinically significant initial effect of manual therapy to improve ankle dorsiflexion range of motion in individuals with postacute ankle sprains. Köhne et al[147] also reported significant improvement in ankle dorsiflexion range of motion and error measured during active maintenance of a learned position in individuals receiving repeated bouts of long-axis distraction manipulation directed at the talocrural joint.

II — Pellow and Brantingham[196] documented a significant effect of talocrural manipulation on pain, ankle range of motion, and self-reported function secondary to manual therapy in individuals with low-severity postacute ankle sprains (ie, grade I or II), which carried over to 1 month after discharge from the study. López-Rodríguez et al[159] identified significant changes in plantar foot weight bearing in response to talocrural long-axis distraction manipulation and posterior glide manipulation in individuals with subacute ankle sprains.

III — Collins et al[41] established significant improvement in ankle dorsiflexion without corresponding changes in pressure and thermal pain thresholds in a cohort with postacute ankle sprains receiving weight-bearing mobilization with movement directed at the talocrural joint. These techniques were previously described by others.[80,185] Vicenzino et al[263] documented a significant improvement in posterior talar glide and weight-bearing ankle dorsiflexion resulting from both non–weight-bearing and weight-bearing mobilization with movement directed to the talocrural joint.

III Whitman et al[271] found successful outcome of manual therapy and a range-of-motion exercise program within 3 clinic visits for 64 of 85 (75%) subjects with postacute lateral ankle sprains. A 4-factor clinical prediction rule was identified to predict likely rapid responders to manual therapy. Subjects meeting at least 3 of 4 criteria were up to 95% likely to respond favorably to intervention within 3 treatment sessions. Criteria included worse symptoms with standing, worse symptoms in the evening, navicular drop test of 5 mm or more, and hypomobility of the distal tibiofibular joint. Intervention included a pragmatic approach to thrust and nonthrust manipulation directed to the ankle, foot, and proximal and distal tibiofibular joints in addition to a general range-of-motion exercise program for a maximum of 3 visits.

A Clinicians should include manual therapy procedures, such as graded joint mobilizations, manipulations, and non–weight-bearing and weight-bearing mobilization with movement, to improve ankle dorsiflexion, proprioception, and weight-bearing tolerance in patients recovering from a lateral ankle sprain.

Therapeutic Exercise and Activities

I In a systematic review, van der Wees et al[252] identified no effects of exercise interventions on postural sway in individuals with functional ankle instability. In this review, 13 studies were included that used either balance retraining or strengthening interventions. Nonsignificant standardized mean differences were identified for all postural sway outcome measures under study. However, ankle passive range of motion demonstrated significant improvement. A systematic review by de Vries et al[61] noted inconclusive findings regarding the effectiveness of balance retraining activities; however, this form of neuromuscular training was thought to demonstrate short-term effectiveness. Low methodological quality was recognized as a deficiency in the identified studies. Webster and Gribble[267] conducted a systematic review of studies involving functional (weight bearing) rehabilitation strategies and outcomes measurements. These authors concluded that functional exercises and activities, especially utilizing unstable surfaces, promote improvement in dynamic postural control.

II Included in the systematic review by Webster and Gribble,[267] Rozzi et al[217] identified significant improvement in stability index measures of postural sway in individuals with functional ankle instability who underwent a progressive balance retraining program. Also included in the systematic review by Webster and Gribble,[267] McKeon et al[179] demonstrated significant improvement in single-limb postural control with eyes closed and squat reach measures in subjects with functional ankle instability who received a balance retraining program. McKeon et al[179] subsequently reported a significant decrease in rearfoot/lower-leg coupling variability during walking but not rearfoot inversion/eversion and lower-leg rotation in individuals with functional ankle instability following a balance retraining intervention. Kidgell et al[142] indicated significant improvement in center-of-pressure sway path in patients performing a single-leg balance retraining program utilizing both ankle disc and mini-trampoline activities, but not in patients receiving the control intervention. Han et al[105] recently described significant improvement in center-of-pressure excursion during stabilometric measurement in response to a balance retraining program in individuals with functional ankle instability.

II Tropp and colleagues[243] documented a reduced proportion of recurrent sprains in soccer players with a previous history of lateral ankle sprains who received ankle disc training (5%) or orthosis (3%) compared to orthosis use and no training (25%). Wester and colleagues[270] also documented a reduction in self-reported symptoms and decreased incidence of recurrent sprains in response to a 12-week wobble board training program in a cohort of individuals with postacute lateral ankle sprains. There were no significant differences between groups at any follow-up time point in volumetric edema measurements and time taken to become symptom free with walking or other activities.

III Coughlan and Caulfield[46] found no significant differences in ankle kinematics during treadmill walking and running as a result of balance retraining intervention within a cohort of individuals with postacute ankle sprains. Kaminski et al[134] found no significant change in isokinetic strength measurements of the ankle invertor and evertor muscle groups following a 6-week strengthening program.

III Moderate-quality evidence suggests adjunctive interventions can increase the rate of improvement observed as a result of therapeutic exercise and activity programs, such as taping[171] and external attentional focus.[154,216] Evidence supporting the use of stochastic resonance, a form of subsensory electrical stimulation, is conflicting.[19,213,214,267]

V Postural strategies to correct balance perturbations during sudden lower extremity movements involve musculature that crosses the hip joint,[191] and deficient hip strength has been identified as a risk factor for sustaining an inversion-mechanism ankle sprain.[176] In individuals with functional ankle instability, hip muscle recruitment patterns during perturbation are altered compared to nondisabled individuals.[18,29,30] Thus, therapeutic exercise and activities targeting potential hip and trunk muscle coordination, strength, and endurance deficits appear to have an important role in comprehensive rehabilitation programs for patients following ankle sprains.

C Clinicians may include therapeutic exercises and activities, such as weight-bearing functional exercises and single-limb balance activities using unstable surfaces, to improve mobility, strength, coordination, and postural control in the postacute period of rehabilitation for ankle sprains.

Sport-Related Activity Training

II Stasinopoulos[228] documented significant reduction in incidence of ankle sprains utilizing balance training and sport-related activity training, when compared to utilization of an ankle stirrup brace, in volleyball players (n = 52) who had a history of ankle sprain in the previous season that necessitated loss of playing time. There was no significant difference in ankle sprain incidence between groups receiving balance training[11,243] and sport-related activity training[11] and the number of ankle sprains in the subsequent season.

C Clinicians can implement balance and sport-related activity training to reduce the risk for recurring ankle sprains in athletes.

CLINICAL GUIDELINES

Summary of Recommendations

B **RISK FACTORS – ACUTE LATERAL ANKLE SPRAIN**

Clinicians should recognize the increased risk of acute lateral ankle sprain in individuals who (1) have a history of a previous ankle sprain, (2) do not use an external support, (3) do not properly warm up with static stretching and dynamic movement before activity, (4) do not have normal ankle dorsiflexion range of motion, and (5) do not participate in a balance/proprioceptive prevention program when there is a history of a previous injury.

C **RISK FACTORS – ANKLE INSTABILITY**

Clinicians should recognize the increased risk for developing ankle instability in patients who (1) have an increased talar curvature, (2) are not using an external support, or (3) did not perform balance or proprioception exercises following an acute lateral ankle sprain.

B **DIAGNOSIS/CLASSIFICATION – ACUTE LATERAL ANKLE SPRAIN**

Clinicians should use the clinical findings of level of function, ligamentous laxity, hemorrhaging, point tenderness, total ankle motion, swelling, and pain to classify a patient with acute ankle ligament sprain into the ICD category of sprain and strain of ankle (S93.4), and the associated ICF impairment-based category of ankle stability (b7150 stability of a single joint) and movement coordination impairments (b7601 control of complex voluntary movements).

B **DIAGNOSIS/CLASSIFICATION – ANKLE INSTABILITY**

Clinicians may incorporate a discriminative instrument, such as the Cumberland Ankle Instability Tool, to assist in identifying the presence and severity of ankle instability associated with the ICD category of instability secondary to old ligament injury, ankle and foot (M24.27), and the associated ICF impairment-based category of ankle stability (b7150 stability of a single joint) and movement coordination impairments (b7601 control of complex voluntary movements).

A **DIFFERENTIAL DIAGNOSIS – ACUTE LATERAL ANKLE SPRAIN**

Clinicians should use diagnostic classifications other than an acute lateral ankle sprain when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline. Particularly, the Ottawa and Bernese ankle rules should be used to determine whether a radiograph is required to rule out a fracture of the ankle and/or foot.

F **DIFFERENTIAL DIAGNOSIS – ANKLE INSTABILITY**

Clinicians should use diagnostic classifications other than ankle instability when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline.

A **EXAMINATION – OUTCOME MEASURES**

Clinicians should incorporate validated functional outcome measures, such as the FAAM and the LEFS, as part of a standard clinical examination. These should be utilized before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with ankle sprain and instability.

B **EXAMINATION – ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION MEASURES**

When evaluating a patient in the postacute period following a recent or recurring lateral ankle sprain, assessment of activity limitation, participation restriction, and symptom reproduction should include objective and reproducible measures, such as single-limb hop tests that assess performance with lateral movements, diagonal movements, and directional changes.

A **EXAMINATION – PHYSICAL IMPAIRMENT MEASURES**

When evaluating a patient with an acute or subacute lateral ankle sprain over an episode of care, assessment of impairment of body function should include objective and reproducible measures of ankle swelling, ankle range of motion, talar translation and inversion, and single-leg balance.

A **INTERVENTION – ACUTE/PROTECTED MOTION PHASE – EARLY WEIGHT BEARING WITH SUPPORT**

Clinicians should advise patients with acute lateral ankle sprains to use external supports and to progressively bear weight on the affected limb. The type of external support and gait assistive device recommended should be based on the severity of the injury, phase of tissue healing, level of protection indicated, extent of pain, and patient preference. In more severe injuries, immobilization ranging from semi-rigid bracing to below-knee casting may be indicated.

B **INTERVENTION – ACUTE/PROTECTED MOTION PHASE – MANUAL THERAPY**

Clinicians should use manual therapy procedures, such as lymphatic drainage, active and passive soft tissue and joint mobilization, and anterior-to-posterior talar mobilization procedures, within pain-free movement, to reduce swelling, improve pain-free ankle and foot mobility and normalize gait parameters in individuals with an acute lateral ankle sprain.

INTERVENTION – ACUTE/PROTECTED MOTION PHASE – PHYSICAL AGENTS

A Cryotherapy: clinicians should use repeated intermittent applications of ice to reduce pain, decrease the need for pain medication, and improve weight bearing following an acute ankle sprain.

C Diathermy: clinicians can utilize pulsating shortwave diathermy for reducing edema and gait deviations associated with acute ankle sprains.

D Electrotherapy: there is moderate evidence both for and against the use of electrotherapy for the management of acute ankle sprains.

D Low-level laser therapy: there is moderate evidence both for and against the use of low-level laser therapy for the management of acute ankle sprains.

A Ultrasound: clinicians should not use ultrasound for the management of acute ankle sprains.

A INTERVENTION – ACUTE/PROTECTED MOTION PHASE – THERAPEUTIC EXERCISES

Clinicians should implement rehabilitation programs that include therapeutic exercises for patients with severe lateral ankle sprains.

A INTERVENTION – PROGRESSIVE LOADING/ SENSORIMOTOR TRAINING PHASE – MANUAL THERAPY

Clinicians should include manual therapy procedures, such as graded joint mobilizations, manipulations, and non–weight-bearing and weight-bearing mobilization with movement, to improve ankle dorsiflexion, proprioception, and weight-bearing tolerance in patients recovering from a lateral ankle sprain.

C INTERVENTION – PROGRESSIVE LOADING/ SENSORIMOTOR TRAINING PHASE – THERAPEUTIC EXERCISE AND ACTIVITIES

Clinicians may include therapeutic exercises and activities, such as weight-bearing functional exercises and single-limb balance activities using unstable surfaces, to improve mobility, strength, coordination, and postural control in the postacute period of rehabilitation for ankle sprains.

C INTERVENTION – PROGRESSIVE LOADING/ SENSORIMOTOR TRAINING PHASE – SPORT-RELATED ACTIVITY TRAINING

Clinicians can implement balance and sport-related activity training to reduce the risk for recurring ankle sprains in athletes.

AFFILIATIONS AND CONTACTS

AUTHORS

RobRoy L. Martin, PT, PhD
Associate Professor
Department of Physical Therapy
Duquesne University
Pittsburgh, Pennsylvania
martinr280@duq.edu
Staff Physical Therapist
Centers for Rehab Services/Center for Sports Medicine
University of Pittsburgh Medical Center
Pittsburgh, Pennsylvania

Todd E. Davenport, DPT
Associate Professor
Department of Physical Therapy
University of the Pacific
Stockton, California
tdavenport@pacific.edu

Stephen Paulseth, DPT, MS
Paulseth and Associates Physical Therapy
Los Angeles, California
Clinical Faculty
Orthopedic Physical Therapy Residency Program
Division of Biokinesiology and Physical Therapy
University of Southern California
Los Angeles, California
paulsethpt@yahoo.com

Dane K. Wukich, MD
Chief, Division of Foot and Ankle Surgery
Assistant Professor of Orthopaedic Surgery
University of Pittsburgh Comprehensive Foot and Ankle Center
Pittsburgh, Pennsylvania
wukichdk@upmc.edu

Joseph J. Godges, DPT, MA
ICF Practice Guidelines Coordinator
Orthopaedic Section, APTA, Inc
La Crosse, Wisconsin
icf@orthopt.org
Associate Professor
Division of Biokinesiology and Physical Therapy
University of Southern California
Los Angeles, California
godges@usc.edu

REVIEWERS

Roy D. Altman, MD
Professor of Medicine
Division of Rheumatology and Immunology
David Geffen School of Medicine at UCLA
Los Angeles, California
journals@royaltman.com

Anthony Delitto, PT, PhD
Professor and Chair
School of Health and Rehabilitation Sciences
University of Pittsburgh
Pittsburgh, Pennsylvania
delitto@pitt.edu

John DeWitt, DPT
Director of Physical Therapy Sports and Orthopaedic Residencies
The Ohio State University
Columbus, Ohio
john.dewitt@osumc.edu

Amanda Ferland, DPT
Clinic Relationship Manager
OptimisPT
Murrieta, California
aferland@optimispt.com

Helene Fearon, PT
Principal and Consultant
Fearon/Levine Consulting
Phoenix, Arizona
helenefearon@fearonlevine.com

Joy MacDermid, PT, PhD
Associate Professor
School of Rehabilitation Science
McMaster University
Hamilton, Ontario, Canada
macderj@mcmaster.ca

James W. Matheson, DPT
President and Clinic Director
Catalyst Sports Medicine
Hudson, Wisconsin
jwmatheson@catalystsportsmedicine.com

Thomas G. McPoil, PT, PhD
Professor
School of Physical Therapy
Regis University
Denver, Colorado
tommcpoil@gmail.com

Stephen Reischl, DPT
Adjunct Associate Professor of Clinical Physical Therapy
Division of Biokinesiology and Physical Therapy
University of Southern California
Los Angeles, California
reischl@usc.edu

Leslie Torburn, DPT
Principal and Consultant
Silhouette Consulting, Inc
Redwood City, California
torburn@yahoo.com

James Zachazewski, DPT
Clinical Director
Department of Physical and Occupational Therapy
Massachusetts General Hospital
Boston, Massachusetts
jzachazewski@partners.org

REFERENCES

1. Aaltonen S, Karjalainen H, Heinonen A, Parkkari J, Kujala UM. Prevention of sports injuries: systematic review of randomized controlled trials. *Arch Intern Med*. 2007;167:1585-1592. http://dx.doi.org/10.1001/archinte.167.15.1585
2. Akbari M, Karimi H, Farahini H, Faghihzadeh S. Balance problems after unilateral lateral ankle sprains. *J Rehabil Res Dev*. 2006;43:819-824.
3. Alcock GK, Stratford PW. Validation of the Lower Extremity Functional Scale on athletic subjects with ankle sprains. *Physiother Can*. 2002;54:233-240.
4. Alonso A, Khoury L, Adams R. Clinical tests for ankle syndesmosis injury: reliability and prediction of return to function. *J Orthop Sports Phys Ther*. 1998;27:276-284.
5. Amaral De Noronha M, Borges NG, Jr. Lateral ankle sprain: isokinetic test reliability and comparison between invertors and evertors. *Clin Biomech (Bristol, Avon)*. 2004;19:868-871. http://dx.doi.org/10.1016/j.clinbiomech.2004.05.011
6. Arnason A, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. *Am J Sports Med*. 2004;32:5S-16S. http://dx.doi.org/10.1177/0363546503258912
7. Arnold BL, De La Motte S, Linens S, Ross SE. Ankle instability is associated with balance impairments: a meta-analysis. *Med Sci Sports Exerc*. 2009;41:1048-1062. http://dx.doi.org/10.1249/MSS.0b013e318192d044
8. Attarian DE, McCrackin HJ, DeVito DP, McElhaney JH, Garrett WE, Jr. Biomechanical characteristics of human ankle ligaments. *Foot Ankle*. 1985;6:54-58.
9. Aydogan U, Glisson RR, Nunley JA. Extensor retinaculum augmentation reinforces anterior talofibular ligament repair. *Clin Orthop Relat Res*. 2006;442:210-215. http://dx.doi.org/10.1097/01.blo.0000183737.43245.26
10. Bachmann LM, Kolb E, Koller MT, Steurer J, ter Riet G. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. *BMJ*. 2003;326:417. http://dx.doi.org/10.1136/bmj.326.7386.417
11. Bahr R, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. *Scand J Med Sci Sports*. 1997;7:166-171.
12. Bahr R, Karlsen R, Lian O, Ovrebø RV. Incidence and mechanisms of acute ankle inversion injuries in volleyball. A retrospective cohort study. *Am J Sports Med*. 1994;22:595-600.
13. 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;68:435-441.
14. Barg A, Tochigi Y, Amendola A, Phisitkul P, Hintermann B, Saltzman CL. Subtalar instability: diagnosis and treatment. *Foot Ankle Int*. 2012;33:151-160. http://dx.doi.org/10.3113/FAI.2012.0151
15. Barrett JR, Tanji JL, Drake C, Fuller D, Kawasaki RI, Fenton RM. High- versus low-top shoes for the prevention of ankle sprains in basketball players. A prospective randomized study. *Am J Sports Med*. 1993;21:582-585.
16. Bassett SF, Prapavessis H. Home-based physical therapy intervention with adherence-enhancing strategies versus clinic-based management for patients with ankle sprains. *Phys Ther*. 2007;87:1132-1143. http://dx.doi.org/10.2522/ptj.20060260
17. Baumhauer JF, Alosa DM, Renström AF, Trevino S, Beynnon B. A prospective study of ankle injury risk factors. *Am J Sports Med*. 1995;23:564-570.
18. Beckman SM, Buchanan TS. Ankle inversion injury and hypermobility: effect on hip and ankle muscle electromyography onset latency. *Arch Phys Med Rehabil*. 1995;76:1138-1143.
19. Bernier JN, Perrin DH. Effect of coordination training on proprioception of the functionally unstable ankle. *J Orthop Sports Phys Ther*. 1998;27:264-275.
20. Beynnon BD, Renström PA, Alosa DM, Baumhauer JF, Vacek PM. Ankle ligament injury risk factors: a prospective study of college athletes. *J Orthop Res*. 2001;19:213-220. http://dx.doi.org/10.1016/S0736-0266(00)90004-4
21. 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;79:371-383.
22. Bleakley C, McDonough S, MacAuley D. The use of ice in the treatment of acute soft-tissue injury: a systematic review of randomized controlled trials. *Am J Sports Med*. 2004;32:251-261. http://dx.doi.org/10.1177/0363546503260757
23. Bleakley CM, McDonough SM, MacAuley DC, Bjordal J. Cryotherapy for acute ankle sprains: a randomised controlled study of two different icing protocols. *Br J Sports Med*. 2006;40:700-705; discussion 705. http://dx.doi.org/10.1136/bjsm.2006.025932
24. Bleakley CM, O'Connor SR, Tully MA, et al. Effect of accelerated rehabilitation on function after ankle sprain: randomised controlled trial. *BMJ*. 2010;340:c1964. http://dx.doi.org/10.1136/bmj.c1964
25. Bohannon RW, Larkin PA, Cook AC, Gear J, Singer J. Decrease in timed balance test scores with aging. *Phys Ther*. 1984;64:1067-1070.
26. Broglio SP, Zhu W, Sopiarz K, Park Y. Generalizability theory analysis of Balance Error Scoring System reliability in healthy young adults. *J Athl Train*. 2009;44:497-502. http://dx.doi.org/10.4085/1062-6050-44.5.497
27. Buchanan AS, Docherty CL, Schrader J. Functional performance testing in participants with functional ankle instability and in a healthy control group. *J Athl Train*. 2008;43:342-346. http://dx.doi.org/10.4085/1062-6050-43.4.342
28. Budny A. Subtalar joint instability: current clinical concepts. *Clin Podiatr Med Surg*. 2004;21:449-460. http://dx.doi.org/10.1016/j.cpm.2004.03.003
29. Bullock-Saxton JE. Local sensation changes and altered hip muscle function following severe ankle sprain. *Phys Ther*. 1994;74:17-28; discussion 28-31.
30. Bullock-Saxton JE, Janda V, Bullock MI. The influence of ankle sprain injury on muscle activation during hip extension. *Int J Sports Med*. 1994;15:330-334. http://dx.doi.org/10.1055/s-2007-1021069
31. Burks RT, Morgan J. Anatomy of the lateral ankle ligaments. *Am J Sports Med*. 1994;22:72-77.
32. Butler AM, Walsh WR. Mechanical response of ankle ligaments at low loads. *Foot Ankle Int*. 2004;25:8-12.
33. Button G, Pinney S. A meta-analysis of outcome rating scales in foot and ankle surgery: is there a valid, reliable, and responsive system? *Foot Ankle Int*. 2004;25:521-525.
34. Caffrey E, Docherty CL, Schrader J, Klossner J. The ability of 4 single-limb hopping tests to detect functional performance deficits in individuals with functional ankle instability. *J Orthop Sports Phys Ther*. 2009;39:799-806. http://dx.doi.org/10.2519/jospt.2009.3042
35. Cameron KL, Owens BD, DeBerardino TM. Incidence of ankle sprains among active-duty members of the United States Armed Services from 1998 through 2006. *J Athl Train*. 2010;45:29-38. http://dx.doi.

org/10.4085/1062-6050-45.1.29

36. Campbell SE, Warner M. MR imaging of ankle inversion injuries. *Magn Reson Imaging Clin N Am*. 2008;16:1-18. http://dx.doi.org/10.1016/j.mric.2008.02.001

37. Carcia CR, Martin RL, Drouin JM. Validity of the Foot and Ankle Ability Measure in athletes with chronic ankle instability. *J Athl Train*. 2008;43:179-183. http://dx.doi.org/10.4085/1062-6050-43.2.179

38. Chambers RB, Cook TM, Cowell HR. Surgical reconstruction for calcaneonavicular coalition. Evaluation of function and gait. *J Bone Joint Surg Am*. 1982;64:829-836.

39. Choi WJ, Lee JW, Han SH, Kim BS, Lee SK. Chronic lateral ankle instability: the effect of intra-articular lesions on clinical outcome. *Am J Sports Med*. 2008;36:2167-2172. http://dx.doi.org/10.1177/0363546508319050

40. Chrintz H, Falster O, Roed J. Single-leg postural equilibrium test. *Scand J Med Sci Sports*. 1991;1:244-246. http://dx.doi.org/10.1111/j.1600-0838.1991.tb00305.x

41. Collins N, Teys P, Vicenzino B. The initial effects of a Mulligan's mobilization with movement technique on dorsiflexion and pain in subacute ankle sprains. *Man Ther*. 2004;9:77-82. http://dx.doi.org/10.1016/S1356-689X(03)00101-2

42. Colville MR, Marder RA, Boyle JJ, Zarins B. Strain measurement in lateral ankle ligaments. *Am J Sports Med*. 1990;18:196-200.

43. Cooke MW, Lamb SE, Marsh J, Dale J. A survey of current consultant practice of treatment of severe ankle sprains in emergency departments in the United Kingdom. *Emerg Med J*. 2003;20:505-507.

44. Cooke MW, Marsh JL, Clark M, et al. Treatment of severe ankle sprain: a pragmatic randomised controlled trial comparing the clinical effectiveness and cost-effectiveness of three types of mechanical ankle support with tubular bandage. The CAST trial. *Health Technol Assess*. 2009;13:1-121. http://dx.doi.org/10.3310/hta13130

45. Cordova ML, Sefton JM, Hubbard TJ. Mechanical joint laxity associated with chronic ankle instability: a systematic review. *Sports Health*. 2010;2:452-459. http://dx.doi.org/10.1177/1941738110382392

46. Coughlan G, Caulfield B. A 4-week neuromuscular training program and gait patterns at the ankle joint. *J Athl Train*. 2007;42:51-59.

47. Dahle LK, Mueller MJ, Delitto A, Diamond JE. Visual assessment of foot type and relationship of foot type to lower extremity injury. *J Orthop Sports Phys Ther*. 1991;14:70-74.

48. de Bie RA, de Vet HC, Lenssen TF, van den Wildenberg FA, Kootstra G, Knipschild PG. Low-level laser therapy in ankle sprains: a randomized clinical trial. *Arch Phys Med Rehabil*. 1998;79:1415-1420.

49. de Bie RA, de Vet HC, van den Wildenberg FA, Lenssen T, Knipschild PG. The prognosis of ankle sprains. *Int J Sports Med*. 1997;18:285-289. http://dx.doi.org/10.1055/s-2007-972635

50. Delahunt E, Coughlan GF, Caulfield B, Nightingale EJ, Lin CW, Hiller CE. Inclusion criteria when investigating insufficiencies in chronic ankle instability. *Med Sci Sports Exerc*. 2010;42:2106-2121. http://dx.doi.org/10.1249/MSS.0b013e3181de7a8a

51. Delahunt E, Monaghan K, Caulfield B. Altered neuromuscular control and ankle joint kinematics during walking in subjects with functional instability of the ankle joint. *Am J Sports Med*. 2006;34:1970-1976. http://dx.doi.org/10.1177/0363546506290989

52. Delahunt E, Monaghan K, Caulfield B. Ankle function during hopping in subjects with functional instability of the ankle joint. *Scand J Med Sci Sports*. 2007;17:641-648. http://dx.doi.org/10.1111/j.1600-0838.2006.00612.x

53. Delahunt E, Monaghan K, Caulfield B. Changes in lower limb kinematics, kinetics, and muscle activity in subjects with functional instability of the ankle joint during a single leg drop jump. *J Orthop Res*. 2006;24:1991-2000. http://dx.doi.org/10.1002/jor.20235

54. Demeritt KM, Shultz SJ, Docherty CL, Gansneder BM, Perrin DH. Chronic ankle instability does not affect lower extremity functional performance. *J Athl Train*. 2002;37:507-511.

55. Denegar CR, Hertel J, Fonseca J. The effect of lateral ankle sprain on dorsiflexion range of motion, posterior talar glide, and joint laxity. *J Orthop Sports Phys Ther*. 2002;32:166-173.

56. de Noronha M, França LC, Haupenthal A, Nunes GS. Intrinsic predictive factors for ankle sprain in active university students: a prospective study. *Scand J Med Sci Sports*. In press. http://dx.doi.org/10.1111/j.1600-0838.2011.01434.x

57. de Noronha M, Refshauge KM, Crosbie J, Kilbreath SL. Relationship between functional ankle instability and postural control. *J Orthop Sports Phys Ther*. 2008;38:782-789. http://dx.doi.org/10.2519/jospt.2008.2766

58. de Noronha M, Refshauge KM, Herbert RD, Kilbreath SL, Hertel J. Do voluntary strength, proprioception, range of motion, or postural sway predict occurrence of lateral ankle sprain? *Br J Sports Med*. 2006;40:824-828; discussion 828. http://dx.doi.org/10.1136/bjsm.2006.029645

59. Dettori JR, Basmania CJ. Early ankle mobilization, part II: a one-year follow-up of acute, lateral ankle sprains (a randomized clinical trial). *Mil Med*. 1994;159:20-24.

60. de Vries JS, Kingma I, Blankevoort L, van Dijk CN. Difference in balance measures between patients with chronic ankle instability and patients after an acute ankle inversion trauma. *Knee Surg Sports Traumatol Arthrosc*. 2010;18:601-606. http://dx.doi.org/10.1007/s00167-010-1097-1

61. de Vries JS, Krips R, Sierevelt IN, Blankevoort L. Interventions for treating chronic ankle instability. *Cochrane Database Syst Rev*. 2006:CD004124. http://dx.doi.org/10.1002/14651858.CD004124.pub2

62. DiGiovanni BF, Fraga CJ, Cohen BE, Shereff MJ. Associated injuries found in chronic lateral ankle instability. *Foot Ankle Int*. 2000;21:809-815. http://dx.doi.org/10.1177/107110070002101003

63. 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;13:309-317. http://dx.doi.org/10.1016/j.jsams.2009.05.002

64. Docherty CL, Arnold BL, Gansneder BM, Hurwitz S, Gieck J. Functional-performance deficits in volunteers with functional ankle instability. *J Athl Train*. 2005;40:30-34.

65. Docherty CL, Gansneder BM, Arnold BL, Hurwitz SR. Development and reliability of the ankle instability instrument. *J Athl Train*. 2006;41:154-158.

66. Docherty CL, Rybak-Webb K. Reliability of the anterior drawer and talar tilt tests using the LigMaster joint arthrometer. *J Sport Rehabil*. 2009;18:389-397.

67. Docherty CL, Valovich McLeod TC, Shultz SJ. Postural control deficits in participants with functional ankle instability as measured by the Balance Error Scoring System. *Clin J Sport Med*. 2006;16:203-208.

68. Dombek MF, Lamm BM, Saltrick K, Mendicino RW, Catanzariti AR. Peroneal tendon tears: a retrospective review. *J Foot Ankle Surg*. 2003;42:250-258.

69. Drewes LK, McKeon PO, Kerrigan DC, Hertel J. Dorsiflexion deficit during jogging with chronic ankle instability. *J Sci Med Sport*. 2009;12:685-687. http://dx.doi.org/10.1016/j.jsams.2008.07.003

70. Eechaute C, Vaes P, Duquet W. The chronic ankle instability scale:

clinimetric properties of a multidimensional, patient-assessed instrument. *Phys Ther Sport*. 2008;9:57-66. http://dx.doi.org/10.1016/j.ptsp.2008.02.001

71. Eechaute C, Vaes P, Duquet W. The dynamic postural control is impaired in patients with chronic ankle instability: reliability and validity of the multiple hop test. *Clin J Sport Med*. 2009;19:107-114. http://dx.doi.org/10.1097/JSM.0b013e3181948ae8

72. Eechaute C, Vaes P, Duquet W. Functional performance deficits in patients with CAI: validity of the multiple hop test. *Clin J Sport Med*. 2008;18:124-129. http://dx.doi.org/10.1097/JSM.0b013e31816148d2

73. Eechaute C, Vaes P, Van Aerschot L, Asman S, Duquet W. The clinimetric qualities of patient-assessed instruments for measuring chronic ankle instability: a systematic review. *BMC Musculoskelet Disord*. 2007;8:6. http://dx.doi.org/10.1186/1471-2474-8-6

74. Eggli S, Sclabas GM, Eggli S, Zimmermann H, Exadaktylos AK. The Bernese ankle rules: a fast, reliable test after low-energy, supination-type malleolar and midfoot trauma. *J Trauma*. 2005;59:1268-1271.

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

76. Elveru RA, Rothstein JM, Lamb RL. Goniometric reliability in a clinical setting. Subtalar and ankle joint measurements. *Phys Ther*. 1988;68:672-677.

77. Emery CA, Meeuwisse WH. The effectiveness of a neuromuscular prevention strategy to reduce injuries in youth soccer: a cluster-randomised controlled trial. *Br J Sports Med*. 2010;44:555-562. http://dx.doi.org/10.1136/bjsm.2010.074377

78. Emery CA, Rose MS, McAllister JR, Meeuwisse WH. 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. http://dx.doi.org/10.1097/JSM.0b013e31802e9c05

79. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Intrinsic risk factors for acute ankle injuries among male soccer players: a prospective cohort study. *Scand J Med Sci Sports*. 2010;20:403-410. http://dx.doi.org/10.1111/j.1600-0838.2009.00971.x

80. Exelby L. Peripheral mobilisations with movement. *Man Ther*. 1996;1:118-126. http://dx.doi.org/10.1054/math.1996.0259

81. Faude O, Junge A, Kindermann W, Dvorak J. Risk factors for injuries in elite female soccer players. *Br J Sports Med*. 2006;40:785-790. http://dx.doi.org/10.1136/bjsm.2006.027540

82. Ferkel RD, Chams RN. Chronic lateral instability: arthroscopic findings and long-term results. *Foot Ankle Int*. 2007;28:24-31. http://dx.doi.org/10.3113/FAI.2007.0005

83. Ferran NA, Oliva F, Maffulli N. Ankle instability. *Sports Med Arthrosc*. 2009;17:139-145. http://dx.doi.org/10.1097/JSA.0b013e3181a3d790

84. Finnoff JT, Peterson VJ, Hollman JH, Smith J. Intrarater and interrater reliability of the Balance Error Scoring System (BESS). *PM R*. 2009;1:50-54. http://dx.doi.org/10.1016/j.pmrj.2008.06.002

85. Fong DT, Chan YY, Mok KM, Yung P, Chan KM. Understanding acute ankle ligamentous sprain injury in sports. *Sports Med Arthrosc Rehabil Ther Technol*. 2009;1:14. http://dx.doi.org/10.1186/1758-2555-1-14

86. Fong DT, Hong Y, Chan LK, Yung PS, Chan KM. A systematic review on ankle injury and ankle sprain in sports. *Sports Med*. 2007;37:73-94.

87. Forkin DM, Koczur C, Battle R, Newton RA. Evaluation of kinesthetic deficits indicative of balance control in gymnasts with unilateral chronic ankle sprains. *J Orthop Sports Phys Ther*. 1996;23:245-250.

88. Freeman MA. Instability of the foot after injuries to the lateral ligament of the ankle. *J Bone Joint Surg Br*. 1965;47:669-677.

89. Freeman MA. Treatment of ruptures of the lateral ligament of the ankle. *J Bone Joint Surg Br*. 1965;47:661-668.

90. Freeman MA, Dean MR, Hanham IW. The etiology and prevention of functional instability of the foot. *J Bone Joint Surg Br*. 1965;47:678-685.

91. Friel K, McLean N, Myers C, Caceres M. Ipsilateral hip abductor weakness after inversion ankle sprain. *J Athl Train*. 2006;41:74-78.

92. Fujii T, Kitaoka HB, Luo ZP, Kura H, An KN. Analysis of ankle-hindfoot stability in multiple planes: an in vitro study. *Foot Ankle Int*. 2005;26:633-637.

93. Fujii T, Luo ZP, Kitaoka HB, An KN. The manual stress test may not be sufficient to differentiate ankle ligament injuries. *Clin Biomech (Bristol, Avon)*. 2000;15:619-623.

94. Geppert MJ, Sobel M, Bohne WH. Lateral ankle instability as a cause of superior peroneal retinacular laxity: an anatomic and biomechanical study of cadaveric feet. *Foot Ankle*. 1993;14:330-334.

95. Gerber JP, Williams GN, Scoville CR, Arciero RA, Taylor DC. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. *Foot Ankle Int*. 1998;19:653-660.

96. Gomez JE, Ross SK, Calmbach WL, Kimmel RB, Schmidt DR, Dhanda R. Body fatness and increased injury rates in high school football linemen. *Clin J Sport Med*. 1998;8:115-120.

97. Green T, Refshauge K, Crosbie J, Adams R. A randomized controlled trial of a passive accessory joint mobilization on acute ankle inversion sprains. *Phys Ther*. 2001;81:984-994.

98. Gribble PA, Hertel J. Considerations for normalization of measures of the Star Excursion Balance Test. *Meas Phys Educ Sci*. 2003;7:89-100.

99. Gribble PA, Hertel J, Denegar CR, Buckley WE. The effects of fatigue and chronic ankle instability on dynamic postural control. *J Athl Train*. 2004;39:321-329.

100. Gross P, Marti B. Risk of degenerative ankle joint disease in volleyball players: study of former elite athletes. *Int J Sports Med*. 1999;20:58-63. http://dx.doi.org/10.1055/s-2007-971094

101. Guyatt GH, Sackett DL, Sinclair JC, Hayward R, Cook DJ, Cook RJ. Users' guides to the medical literature. IX. A method for grading health care recommendations. Evidence-Based Medicine Working Group. *JAMA*. 1995;274:1800-1804.

102. Hägglund M, Waldén M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med*. 2006;40:767-772. http://dx.doi.org/10.1136/bjsm.2006.026609

103. Hale SA, Hertel J. Reliability and sensitivity of the Foot and Ankle Disability Index in subjects with chronic ankle instability. *J Athl Train*. 2005;40:35-40.

104. Hale SA, Hertel J, Olmsted-Kramer LC. The effect of a 4-week comprehensive rehabilitation program on postural control and lower extremity function in individuals with chronic ankle instability. *J Orthop Sports Phys Ther*. 2007;37:303-311. http://dx.doi.org/10.2519/jospt.2007.2322

105. Han K, Ricard MD, Fellingham GW. Effects of a 4-week exercise program on balance using elastic tubing as a perturbation force for individuals with a history of ankle sprains. *J Orthop Sports Phys Ther*. 2009;39:246-255. http://dx.doi.org/10.2519/jospt.2009.2958

106. Haraguchi N, Tokumo A, Okamura R, et al. Influence of activity level on the outcome of treatment of lateral ankle ligament rupture. *J Orthop Sci*. 2009;14:391-396. http://dx.doi.org/10.1007/s00776-009-1346-7

107. Hartsell HD, Spaulding SJ. Eccentric/concentric ratios at selected velocities for the invertor and evertor muscles of the chronically unstable ankle. *Br J Sports Med*. 1999;33:255-258.

108. Haywood KL, Hargreaves J, Lamb SE. Multi-item outcome measures for lateral ligament injury of the ankle: a structured review. *J Eval Clin Pract*. 2004;10:339-352. http://dx.doi.org/10.1111/j.1365-2753.2003.00435.x

109. Hertel J. Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. *J Athl Train*. 2002;37:364-375.

110. Hertel J. Sensorimotor deficits with ankle sprains and chronic ankle instability. *Clin Sports Med*. 2008;27:353-370. http://dx.doi.org/10.1016/j.csm.2008.03.006

111. Hertel J, Braham RA, Hale SA, Olmsted-Kramer LC. Simplifying the star excursion balance test: analyses of subjects with and without chronic ankle instability. *J Orthop Sports Phys Ther*. 2006;36:131-137. http://dx.doi.org/10.2519/jospt.2006.2103

112. Hertel J, Denegar CR, Monroe MM, Stokes WL. Talocrural and subtalar joint instability after lateral ankle sprain. *Med Sci Sports Exerc*. 1999;31:1501-1508.

113. Hertel J, Miller SJ, Denegar CR. Intratester and intertester reliability during the Star Excursion Balance Tests. *J Sport Rehabil*. 2000;9:104-116.

114. Hiller CE, Kilbreath SL, Refshauge KM. Chronic ankle instability: evolution of the model. *J Athl Train*. 2011;46:133-141. http://dx.doi.org/10.4085/1062-6050-46.2.133

115. Hiller CE, Nightingale EJ, Lin CW, Coughlan GF, Caulfield B, Delahunt E. Characteristics of people with recurrent ankle sprains: a systematic review with meta-analysis. *Br J Sports Med*. 2011;45:660-672. http://dx.doi.org/10.1136/bjsm.2010.077404

116. Hiller CE, Refshauge KM, Bundy AC, Herbert RD, Kilbreath SL. The Cumberland Ankle Instability Tool: a report of validity and reliability testing. *Arch Phys Med Rehabil*. 2006;87:1235-1241. http://dx.doi.org/10.1016/j.apmr.2006.05.022

117. Hiller CE, Refshauge KM, Herbert RD, Kilbreath SL. Balance and recovery from a perturbation are impaired in people with functional ankle instability. *Clin J Sport Med*. 2007;17:269-275. http://dx.doi.org/10.1097/JSM.0b013e3180f60b12

118. Hiller CE, Refshauge KM, Herbert RD, Kilbreath SL. Intrinsic predictors of lateral ankle sprain in adolescent dancers: a prospective cohort study. *Clin J Sport Med*. 2008;18:44-48. http://dx.doi.org/10.1097/JSM.0b013e31815f2b35

119. Hintermann B. Biomechanics of the unstable ankle joint and clinical implications. *Med Sci Sports Exerc*. 1999;31:S459-S469.

120. Hintermann B, Boss A, Schafer D. Arthroscopic findings in patients with chronic ankle instability. *Am J Sports Med*. 2002;30:402-409.

121. Hla KM, Ishii T, Sakane M, Hayashi K. Effect of anesthesia of the sinus tarsi on peroneal reaction time in patients with functional instability of the ankle. *Foot Ankle Int*. 1999;20:554-559.

122. Hollis JM, Blasier RD, Flahiff CM. Simulated lateral ankle ligamentous injury. Change in ankle stability. *Am J Sports Med*. 1995;23:672-677.

123. Holme E, Magnusson SP, Becher K, Bieler T, Aagaard P, Kjaer M. The effect of supervised rehabilitation on strength, postural sway, position sense and re-injury risk after acute ankle ligament sprain. *Scand J Med Sci Sports*. 1999;9:104-109. http://dx.doi.org/10.1111/j.1600-0838.1999.tb00217.x

124. Hosea TM, Carey CC, Harrer MF. The gender issue: epidemiology of ankle injuries in athletes who participate in basketball. *Clin Orthop Relat Res*. 2000:45-49.

125. Hubbard TJ, Kaminski TW. Kinesthesia is not affected by functional ankle instability status. *J Athl Train*. 2002;37:481-486.

126. Hubbard TJ, Kramer LC, Denegar CR, Hertel J. Contributing factors to chronic ankle instability. *Foot Ankle Int*. 2007;28:343-354. http://dx.doi.org/10.3113/FAI.2007.0343

127. Hunt TN, Ferrara MS, Bornstein RA, Baumgartner TA. The reliability of the modified Balance Error Scoring System. *Clin J Sport Med*. 2009;19:471-475. http://dx.doi.org/10.1097/JSM.0b013e3181c12c7b

128. Hupperets MD, Verhagen EA, van Mechelen W. Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomised controlled trial. *BMJ*. 2009;339:b2684.

129. Iverson GL, Kaarto ML, Koehle MS. Normative data for the Balance Error Scoring System: implications for brain injury evaluations. *Brain Inj*. 2008;22:147-152. http://dx.doi.org/10.1080/02699050701867407

130. Jennings J, Davies GJ. Treatment of cuboid syndrome secondary to lateral ankle sprains: a case series. *J Orthop Sports Phys Ther*. 2005;35:409-415. http://dx.doi.org/10.2519/jospt.2005.1596

131. Jerosch J, Bischof M. Proprioceptive capabilities of the ankle in stable and unstable joints. *Sports Exerc Inj*. 1996;2:167-171.

132. Johnson MR, Stoneman PD. Comparison of a lateral hop test versus a forward hop test for functional evaluation of lateral ankle sprains. *J Foot Ankle Surg*. 2007;46:162-174. http://dx.doi.org/10.1053/j.jfas.2006.12.007

133. Kaikkonen A, Kannus P, Järvinen M. A performance test protocol and scoring scale for the evaluation of ankle injuries. *Am J Sports Med*. 1994;22:462-469. http://dx.doi.org/10.1177/036354659402200405

134. Kaminski TW, Buckley BD, Powers ME, Hubbard TJ, Ortiz C. Effect of strength and proprioception training on eversion to inversion strength ratios in subjects with unilateral functional ankle instability. *Br J Sports Med*. 2003;37:410-415; discussion 415.

135. Kaminski TW, Dover GC. Reliability of inversion and eversion peak- and average-torque measurements from the Biodex System 3 dynamometer. *J Sport Rehabil*. 2001;10:205-220.

136. Karlsson J, Eriksson BI, Renström P. Subtalar instability of the foot. A review and results after surgical treatment. *Scand J Med Sci Sports*. 1998;8:191-197.

137. Karlsson J, Peterson L. Evaluation of ankle joint function: the use of a scoring scale. *Foot*. 1991;1:15-19. http://dx.doi.org/10.1016/0958-2592(91)90006-W

138. Kemler E, van de Port I, Backx F, van Dijk CN. A systematic review on the treatment of acute ankle sprain: brace versus other functional treatment types. *Sports Med*. 2011;41:185-197. http://dx.doi.org/10.2165/11584370-000000000-00000

139. Kerkhoffs GM, Blankevoort L, Sierevelt IN, Corvelein R, Janssen GH, van Dijk CN. Two ankle joint laxity testers: reliability and validity. *Knee Surg Sports Traumatol Arthrosc*. 2005;13:699-705. http://dx.doi.org/10.1007/s00167-005-0644-7

140. Kerkhoffs GM, Handoll HH, de Bie R, Rowe BH, Struijs PA. Surgical versus conservative treatment for acute injuries of the lateral ligament complex of the ankle in adults. *Cochrane Database Syst Rev*. 2007:CD000380. http://dx.doi.org/10.1002/14651858.CD000380.pub2

141. Kerkhoffs GM, Rowe BH, Assendelft WJ, Kelly KD, Struijs PA, van Dijk CN. Immobilisation for acute ankle sprain. A systematic review. *Arch Orthop Trauma Surg*. 2001;121:462-471.

142. Kidgell DJ, Horvath DM, Jackson BM, Seymour PJ. Effect of six weeks of dura disc and mini-trampoline balance training on postural sway in athletes with functional ankle instability. *J Strength Cond Res*. 2007;21:466-469. http://dx.doi.org/10.1519/R-18945.1

143. Kinzey SJ, Armstrong CW. The reliability of the star-excursion test in assessing dynamic balance. *J Orthop Sports Phys Ther*.

1998;27:356-360.

144. Kjaersgaard-Andersen P, Frich LH, Madsen F, Helmig P, Søgård P, Søjbjerg JO. Instability of the hindfoot after lesion of the lateral ankle ligaments: investigations of the anterior drawer and adduction maneuvers in autopsy specimens. *Clin Orthop Relat Res*. 1991:170-179.

145. Kofotolis N, Kellis E. Ankle sprain injuries: a 2-year prospective cohort study in female Greek professional basketball players. *J Athl Train*. 2007;42:388-394.

146. Kofotolis ND, Kellis E, Vlachopoulos SP. Ankle sprain injuries and risk factors in amateur soccer players during a 2-year period. *Am J Sports Med*. 2007;35:458-466. http://dx.doi.org/10.1177/0363546506294857

147. Köhne E, Jones A, Korporaal C, Price JL, Brantingham JW, Globe G. A prospective, single-blinded, randomized, controlled clinical trial of the effects of manipulation on proprioception and ankle dorsiflexion in chronic recurrent ankle sprain. *J Am Chiropr Assoc*. 2007;44:7-17.

148. Konradsen L, Olesen S, Hansen HM. Ankle sensorimotor control and eversion strength after acute ankle inversion injuries. *Am J Sports Med*. 1998;26:72-77.

149. Konradsen L, Voigt M, Hojsgaard C. Ankle inversion injuries. The role of the dynamic defense mechanism. *Am J Sports Med*. 1997;25:54-58.

150. LaBella CR, Huxford MR, Grissom J, Kim KY, Peng J, Christoffel KK. Effect of neuromuscular warm-up on injuries in female soccer and basketball athletes in urban public high schools: cluster randomized controlled trial. *Arch Pediatr Adolesc Med*. 2011;165:1033-1040. http://dx.doi.org/10.1001/archpediatrics.2011.168

151. Lamb SE, Marsh JL, Hutton JL, Nakash R, Cooke MW. Mechanical supports for acute, severe ankle sprain: a pragmatic, multicentre, randomised controlled trial. *Lancet*. 2009;373:575-581. http://dx.doi.org/10.1016/S0140-6736(09)60206-3

152. Lamb SE, Nakash RA, Withers EJ, et al. Clinical and cost effectiveness of mechanical support for severe ankle sprains: design of a randomised controlled trial in the emergency department [ISRCTN 37807450]. *BMC Musculoskelet Disord*. 2005;6:1. http://dx.doi.org/10.1186/1471-2474-6-1

153. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33:159-174.

154. Laufer Y, Rotem-Lehrer N, Ronen Z, Khayutin G, Rozenberg I. Effect of attention focus on acquisition and retention of postural control following ankle sprain. *Arch Phys Med Rehabil*. 2007;88:105-108. http://dx.doi.org/10.1016/j.apmr.2006.10.028

155. Lee KT, Park YU, Kim JS, Kim JB, Kim KC, Kang SK. Long-term results after modified Brostrom procedure without calcaneofibular ligament reconstruction. *Foot Ankle Int*. 2011;32:153-157. http://dx.doi.org/10.3113/FAI.2011.0153

156. Lentell G, Katzman LL, Walters MR. The relationship between muscle function and ankle stability. *J Orthop Sports Phys Ther*. 1990;11:605-611.

157. Leslie M, Zachazewski JE, Browne P. Reliability of isokinetic torque values for ankle-invertors and evertors. *J Orthop Sports Phys Ther*. 1990;11:612-616.

158. Lindenfeld TN, Schmitt DJ, Hendy MP, Mangine RE, Noyes FR. Incidence of injury in indoor soccer. *Am J Sports Med*. 1994;22:364-371.

159. López-Rodríguez S, Fernández de-las-Peñas C, Alburquerque-Sendín F, Rodríguez-Blanco C, Palomeque-del-Cerro L. Immediate effects of manipulation of the talocrural joint on stabilometry and baropodometry in patients with ankle sprain. *J Manipulative Physiol Ther*. 2007;30:186-192. http://dx.doi.org/10.1016/j.jmpt.2007.01.011

160. MacDermid JC, Walton DM, Law M. Critical appraisal of research evidence for its validity and usefulness. *Hand Clin*. 2009;25:29-42. http://dx.doi.org/10.1016/j.hcl.2008.11.003

161. Magerkurth O, Frigg A, Hintermann B, Dick W, Valderrabano V. Frontal and lateral characteristics of the osseous configuration in chronic ankle instability. *Br J Sports Med*. 2010;44:568-572. http://dx.doi.org/10.1136/bjsm.2008.048462

162. Malliaropoulos N, Ntessalen M, Papacostas E, Longo UG, Maffulli N. Reinjury after acute lateral ankle sprains in elite track and field athletes. *Am J Sports Med*. 2009;37:1755-1761. http://dx.doi.org/10.1177/0363546509338107

163. Malliaropoulos N, Papacostas E, Papalada A, Maffulli N. Acute lateral ankle sprains in track and field athletes: an expanded classification. *Foot Ankle Clin*. 2006;11:497-507. http://dx.doi.org/10.1016/j.fcl.2006.05.004

164. Man IO, Morrissey MC, Cywinski JK. Effect of neuromuscular electrical stimulation on ankle swelling in the early period after ankle sprain. *Phys Ther*. 2007;87:53-65. http://dx.doi.org/10.2522/ptj.20050244

165. Martin DE, Kaplan PA, Kahler DM, Dussault R, Randolph BJ. Retrospective evaluation of graded stress examination of the ankle. *Clin Orthop Relat Res*. 1996:165-170.

166. Martin R, Burdett R, Irrgang J. Development of the Foot and Ankle Disability Index (FADI) [abstract]. *J Orthop Sports Phys Ther*. 1999;29:A32-A33.

167. Martin RL, Irrgang JJ. A survey of self-reported outcome instruments for the foot and ankle. *J Orthop Sports Phys Ther*. 2007;37:72-84. http://dx.doi.org/10.2519/jospt.2007.2403

168. Martin RL, Irrgang JJ, Burdett RG, Conti SF, Van Swearingen JM. Evidence of validity for the Foot and Ankle Ability Measure (FAAM). *Foot Ankle Int*. 2005;26:968-983.

169. Martin RL, Irrgang JJ, Lalonde KA, Conti S. Current concepts review: foot and ankle outcome instruments. *Foot Ankle Int*. 2006;27:383-390.

170. Martin RL, McPoil TG. Reliability of ankle goniometric measurements: a literature review. *J Am Podiatr Med Assoc*. 2005;95:564-572.

171. Matsusaka N, Yokoyama S, Tsurusaki T, Inokuchi S, Okita M. Effect of ankle disk training combined with tactile stimulation to the leg and foot on functional instability of the ankle. *Am J Sports Med*. 2001;29:25-30.

172. Mawdsley RH, Hoy DK, Erwin PM. Criterion-related validity of the figure-of-eight method of measuring ankle edema. *J Orthop Sports Phys Ther*. 2000;30:149-153.

173. 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. http://dx.doi.org/10.1177/0363546511406242

174. McGuine TA, Hetzel S, Wilson J, Brooks A. The effect of lace-up ankle braces on injury rates in high school football players. *Am J Sports Med*. 2012;40:49-57. http://dx.doi.org/10.1177/0363546511422332

175. McGuine TA, Keene JS. The effect of a balance training program on the risk of ankle sprains in high school athletes. *Am J Sports Med*. 2006;34:1103-1111. http://dx.doi.org/10.1177/0363546505284191

176. McHugh MP, Tyler TF, Tetro DT, Mullaney MJ, Nicholas SJ. Risk factors for noncontact ankle sprains in high school athletes: the role of hip strength and balance ability. *Am J Sports Med*. 2006;34:464-470. http://dx.doi.org/10.1177/0363546505280427

177. McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. *Br J Sports Med*. 2001;35:103-108.

178. McKeon PO, Hertel J. Systematic review of postural control and lateral ankle instability, part I: can deficits be detected with instrumented testing. *J Athl Train*. 2008;43:293-304. http://dx.doi.org/10.4085/1062-6050-43.3.293

179. McKeon PO, Ingersoll CD, Kerrigan DC, Saliba E, Bennett BC, Hertel J. Balance training improves function and postural control in those with chronic ankle instability. *Med Sci Sports Exerc*. 2008;40:1810-1819. http://dx.doi.org/10.1249/MSS.0b013e31817e0f92

180. McKnight CM, Armstrong CW. The role of ankle strength in functional ankle instability. *J Sport Rehabil*. 1997;6:21-29.

181. Menadue C, Raymond J, Kilbreath SL, Refshauge KM, Adams R. Reliability of two goniometric methods of measuring active inversion and eversion range of motion at the ankle. *BMC Musculoskelet Disord*. 2006;7:60. http://dx.doi.org/10.1186/1471-2474-7-60

182. Milgrom C, Shlamkovitch N, Finestone A, et al. Risk factors for lateral ankle sprain: a prospective study among military recruits. *Foot Ankle*. 1991;12:26-30.

183. Milner CE, Soames RW. Anatomy of the collateral ligaments of the human ankle joint. *Foot Ankle Int*. 1998;19:757-760.

184. Mohammadi F. Comparison of 3 preventive methods to reduce the recurrence of ankle inversion sprains in male soccer players. *Am J Sports Med*. 2007;35:922-926. http://dx.doi.org/10.1177/0363546507299259

185. Mulligan BR. Mobilisations with movement (MWM's). *J Man Manip Ther*. 1993;1:154-156.

186. Munn J, Beard D, Refshauge K, Lee RJ. Do functional-performance tests detect impairment in subjects with ankle instability? *J Sport Rehabil*. 2002;11:40-50.

187. Munn J, Beard DJ, Refshauge KM, Lee RY. Eccentric muscle strength in functional ankle instability. *Med Sci Sports Exerc*. 2003;35:245-250. http://dx.doi.org/10.1249/01.MSS.0000048724.74659.9F

188. Munn J, Sullivan SJ, Schneiders AG. Evidence of sensorimotor deficits in functional ankle instability: a systematic review with meta-analysis. *J Sci Med Sport*. 2010;13:2-12. http://dx.doi.org/10.1016/j.jsams.2009.03.004

189. Munteanu SE, Strawhorn AB, Landorf KB, Bird AR, Murley GS. A weightbearing technique for the measurement of ankle joint dorsiflexion with the knee extended is reliable. *J Sci Med Sport*. 2009;12:54-59. http://dx.doi.org/10.1016/j.jsams.2007.06.009

190. Nakagawa L, Hoffman M. Performance in static, dynamic, and clinical tests of postural control in individuals with recurrent ankle sprains. *J Sport Rehabil*. 2004;13:255-268.

191. Neptune RR, Wright IC, van den Bogert AJ. Muscle coordination and function during cutting movements. *Med Sci Sports Exerc*. 1999;31:294-302.

192. Olmsted LC, Carcia CR, Hertel J, Shultz SJ. Efficacy of the Star Excursion Balance Tests in detecting reach deficits in subjects with chronic ankle instability. *J Athl Train*. 2002;37:501-506.

193. Pasila M, Visuri T, Sundholm A. Pulsating shortwave diathermy: value in treatment of recent ankle and foot sprains. *Arch Phys Med Rehabil*. 1978;59:383-386.

194. Pefanis N, Karagounis P, Tsiganos G, Armenis E, Baltopoulos P. Tibiofemoral angle and its relation to ankle sprain occurrence. *Foot Ankle Spec*. 2009;2:271-276. http://dx.doi.org/10.1177/1938640009349502

195. Pefanis N, Papaharalampous X, Tsiganos G, Papadakou E, Baltopoulos P. The effect of Q angle on ankle sprain occurrence. *Foot Ankle Spec*. 2009;2:22-26. http://dx.doi.org/10.1177/1938640008330769

196. Pellow JE, Brantingham JW. The efficacy of adjusting the ankle in the treatment of subacute and chronic grade I and grade II ankle inversion sprains. *J Manipulative Physiol Ther*. 2001;24:17-24. http://dx.doi.org/10.1067/mmt.2001.112015

197. Petersen EJ, Irish SM, Lyons CL, et al. Reliability of water volumetry and the figure of eight method on subjects with ankle joint swelling. *J Orthop Sports Phys Ther*. 1999;29:609-615.

198. Phillips B, Ball C, Sackett D, et al. Oxford Centre for Evidence-Based Medicine - Levels of Evidence (March 2009). Available at: http://www.cebm.net/index.aspx?o=4590. Accessed August 4, 2009.

199. Phisitkul P, Chaichankul C, Sripongsai R, Prasitdamrong I, Tengtrakulcharoen P, Suarchawaratana S. Accuracy of anterolateral drawer test in lateral ankle instability: a cadaveric study. *Foot Ankle Int*. 2009;30:690-695. http://dx.doi.org/10.3113/FAI.2009.0690

200. Pihlajamäki H, Hietaniemi K, Paavola M, Visuri T, Mattila VM. Surgical versus functional treatment for acute ruptures of the lateral ligament complex of the ankle in young men: a randomized controlled trial. *J Bone Joint Surg Am*. 2010;92:2367-2374. http://dx.doi.org/10.2106/JBJS.I.01176

201. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. *J Orthop Sports Phys Ther*. 2006;36:911-919. http://dx.doi.org/10.2519/jospt.2006.2244

202. Pontaga I. Ankle joint evertor-invertor muscle torque ratio decrease due to recurrent lateral ligament sprains. *Clin Biomech (Bristol, Avon)*. 2004;19:760-762. http://dx.doi.org/10.1016/j.clinbiomech.2004.05.003

203. Pope R, Herbert R, Kirwan J. Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in Army recruits. *Aust J Physiother*. 1998;44:165-172.

204. Pugia ML, Middel CJ, Seward SW, et al. Comparison of acute swelling and function in subjects with lateral ankle injury. *J Orthop Sports Phys Ther*. 2001;31:384-388.

205. Raatikainen T, Putkonen M, Puranen J. Arthrography, clinical examination, and stress radiograph in the diagnosis of acute injury to the lateral ligaments of the ankle. *Am J Sports Med*. 1992;20:2-6. http://dx.doi.org/10.1177/036354659202000102

206. Rahnama L, Salavati M, Akhbari B, Mazaheri M. Attentional demands and postural control in athletes with and without functional ankle instability. *J Orthop Sports Phys Ther*. 2010;40:180-187. http://dx.doi.org/10.2519/jospt.2010.3188

207. Rasmussen O, Tovborg-Jensen I. Anterolateral rotational instability in the ankle joint. An experimental study of anterolateral rotational instability, talar tilt, and anterior drawer sign in relation to injuries to the lateral ligaments. *Acta Orthop Scand*. 1981;52:99-102.

208. Renström P, Wertz M, Incavo S, et al. Strain in the lateral ligaments of the ankle. *Foot Ankle*. 1988;9:59-63. http://dx.doi.org/10.1177/107110078800900201

209. Riemann BL, Guskiewicz KM, Shields EW. Relationship between clinical and forceplate measures of postural stability. *J Sport Rehabil*. 1999;8:71-82.

210. Ringleb SI, Dhakal A, Anderson CD, Bawab S, Paranjape R. Effects of lateral ligament sectioning on the stability of the ankle and subtalar joint. *J Orthop Res*. 2011;29:1459-1464. http://dx.doi.org/10.1002/jor.21407

211. Rohner-Spengler M, Mannion AF, Babst R. Reliability and minimal detectable change for the figure-of-eight-20 method of measurement of ankle edema. *J Orthop Sports Phys Ther*. 2007;37:199-205. http://dx.doi.org/10.2519/jospt.2007.2371

212. Roos EM, Brandsson S, Karlsson J. Validation of the Foot and Ankle Outcome Score for ankle ligament reconstruction. *Foot Ankle Int*. 2001;22:788-794. http://dx.doi.org/10.1177/107110070102201004

213. Ross SE, Arnold BL, Blackburn JT, Brown CN, Guskiewicz KM. Enhanced balance associated with coordination training with stochastic resonance stimulation in subjects with functional ankle instability: an experimental trial. *J Neuroeng Rehabil*. 2007;4:47. http://dx.doi.org/10.1186/1743-0003-4-47

214. Ross SE, Guskiewicz KM. Effect of coordination training with and without stochastic resonance stimulation on dynamic postural stability of subjects with functional ankle instability and subjects with stable ankles. *Clin J Sport Med*. 2006;16:323-328.

215. Ross SE, Guskiewicz KM, Gross MT, Yu B. Assessment tools for identifying functional limitations associated with functional ankle instability. *J Athl Train*. 2008;43:44-50. http://dx.doi.org/10.4085/1062-6050-43.1.44

216. Rotem-Lehrer N, Laufer Y. Effect of focus of attention on transfer of a postural control task following an ankle sprain. *J Orthop Sports Phys Ther*. 2007;37:564-569. http://dx.doi.org/10.2519/jospt.2007.2519

217. Rozzi SL, Lephart SM, Sterner R, Kuligowski L. Balance training for persons with functionally unstable ankles. *J Orthop Sports Phys Ther*. 1999;29:478-486.

218. Ryan L. Mechanical stability, muscle strength and proprioception in the functionally unstable ankle. *Aust J Physiother*. 1994;40:41-47.

219. Safran MR, Benedetti RS, Bartolozzi AR, 3rd, Mandelbaum BR. Lateral ankle sprains: a comprehensive review: part 1: etiology, pathoanatomy, histopathogenesis, and diagnosis. *Med Sci Sports Exerc*. 1999;31:S429-S437.

220. Sefton JM, Hicks-Little CA, Hubbard TJ, et al. Sensorimotor function as a predictor of chronic ankle instability. *Clin Biomech (Bristol, Avon)*. 2009;24:451-458. http://dx.doi.org/10.1016/j.clinbiomech.2009.03.003

221. Sekir U, Yildiz Y, Hazneci B, Ors F, Saka T, Aydin T. Reliability of a functional test battery evaluating functionality, proprioception, and strength in recreational athletes with functional ankle instability. *Eur J Phys Rehabil Med*. 2008;44:407-415.

222. Siegler S, Block J, Schneck CD. The mechanical characteristics of the collateral ligaments of the human ankle joint. *Foot Ankle*. 1988;8:234-242.

223. Smith RW, Reischl S. The influence of dorsiflexion in the treatment of severe ankle sprains: an anatomical study. *Foot Ankle*. 1988;9:28-33.

224. Smith RW, Reischl SF. Treatment of ankle sprains in young athletes. *Am J Sports Med*. 1986;14:465-471.

225. Smith-Oricchio K, Harris BA. Interrater reliability of subtalar neutral, calcaneal inversion and eversion. *J Orthop Sports Phys Ther*. 1990;12:10-15.

226. Spahn G. The ankle meter: an instrument for evaluation of anterior talar drawer in ankle sprain. *Knee Surg Sports Traumatol Arthrosc*. 2004;12:338-342. http://dx.doi.org/10.1007/s00167-003-0477-1

227. Standring S, Gray H. *Gray's Anatomy: The Anatomical Basis of Clinical Practice*. 40th ed. St Louis, MO: Churchill Livingstone; 2008.

228. Stasinopoulos D. Comparison of three preventive methods in order to reduce the incidence of ankle inversion sprains among female volleyball players. *Br J Sports Med*. 2004;38:182-185.

229. Steffen K, Myklebust G, Andersen TE, Holme I, Bahr R. Self-reported injury history and lower limb function as risk factors for injuries in female youth soccer. *Am J Sports Med*. 2008;36:700-708. http://dx.doi.org/10.1177/0363546507311598

230. Stergioulas A. Low-level laser treatment can reduce edema in second degree ankle sprains. *J Clin Laser Med Surg*. 2004;22:125-128. http://dx.doi.org/10.1089/104454704774076181

231. Stiell IG, Greenberg GH, McKnight RD, Wells GA. Ottawa ankle rules for radiography of acute injuries. *N Z Med J*. 1995;108:111.

232. Stormont DM, Morrey BF, An KN, Cass JR. Stability of the loaded ankle. Relation between articular restraint and primary and secondary static restraints. *Am J Sports Med*. 1985;13:295-300.

233. Strauss JE, Forsberg JA, Lippert FG, 3rd. Chronic lateral ankle instability and associated conditions: a rationale for treatment. *Foot Ankle Int*. 2007;28:1041-1044. http://dx.doi.org/10.3113/FAI.2007.1041

234. Sugimoto K, Takakura Y, Okahashi K, Samoto N, Kawate K, Iwai M. Chondral injuries of the ankle with recurrent lateral instability: an arthroscopic study. *J Bone Joint Surg Am*. 2009;91:99-106. http://dx.doi.org/10.2106/JBJS.G.00087

235. Surve I, Schwellnus MP, Noakes T, Lombard C. A fivefold reduction in the incidence of recurrent ankle sprains in soccer players using the Sport-Stirrup orthosis. *Am J Sports Med*. 1994;22:601-606.

236. Takao M, Uchio Y, Naito K, Fukazawa I, Ochi M. Arthroscopic assessment for intra-articular disorders in residual ankle disability after sprain. *Am J Sports Med*. 2005;33:686-692. http://dx.doi.org/10.1177/0363546504270566

237. Takebayashi T, Yamashita T, Minaki Y, Ishii S. Mechanosensitive afferent units in the lateral ligament of the ankle. *J Bone Joint Surg Br*. 1997;79:490-493.

238. Tatro-Adams D, McGann SF, Carbone W. Reliability of the figure-of-eight method of ankle measurement. *J Orthop Sports Phys Ther*. 1995;22:161-163.

239. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res*. 1985:43-49.

240. Tohyama H, Yasuda K, Ohkoshi Y, Beynnon BD, Renström PA. 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;31:226-232.

241. Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. *Br J Sports Med*. 2006;40:610-613; discussion 613. http://dx.doi.org/10.1136/bjsm.2005.024356

242. Tropp H. Pronator muscle weakness in functional instability of the ankle joint. *Int J Sports Med*. 1986;7:291-294. http://dx.doi.org/10.1055/s-2008-1025777

243. Tropp H, Askling C, Gillquist J. Prevention of ankle sprains. *Am J Sports Med*. 1985;13:259-262.

244. Tropp H, Ekstrand J, Gillquist J. Stabilometry in functional instability of the ankle and its value in predicting injury. *Med Sci Sports Exerc*. 1984;16:64-66.

245. Tyler TF, McHugh MP, Mirabella MR, Mullaney MJ, Nicholas SJ. 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;34:471-475. http://dx.doi.org/10.1177/0363546505280429

246. Valderrabano V, Hintermann B, Horisberger M, Fung TS. Ligamentous posttraumatic ankle osteoarthritis. *Am J Sports Med*. 2006;34:612-620. http://dx.doi.org/10.1177/0363546505281813

247. Valovich McLeod TC, Perrin DH, Guskiewicz KM, Shultz SJ, Diamond R, Gansneder BM. Serial administration of clinical concussion assessments and learning effects in healthy young athletes. *Clin J Sport Med*. 2004;14:287-295.

248. Van Bergeyk AB, Younger A, Carson B. CT analysis of hindfoot alignment in chronic lateral ankle instability. *Foot Ankle Int*. 2002;23:37-42.

249. van Cingel R, van Melick N, van Doren L, Aufdemkampe G. Intra-examiner reproducibility of ankle inversion-eversion isokinetic strength in healthy subjects. *Isokinet Exerc Sci*. 2009;17:181-188. http://dx.doi.org/10.3233/IES-2009-0351

250. van den Bekerom MP, Oostra RJ, Alvarez PG, van Dijk CN. The anatomy in relation to injury of the lateral collateral ligaments of the ankle: a current concepts review. *Clin Anat*. 2008;21:619-626. http://dx.doi.org/10.1002/ca.20703

251. van den Bekerom MP, van der Windt DA, ter Riet G, van der Heijden GJ, Bouter LM. Therapeutic ultrasound for acute ankle sprains. *Cochrane Database Syst Rev*. 2011:CD001250. http://dx.doi.org/10.1002/14651858.CD001250.pub2

252. van der Wees PJ, Lenssen AF, Hendriks EJ, Stomp DJ, Dekker J, de Bie RA. Effectiveness of exercise therapy and manual mobilisation in ankle sprain and functional instability: a systematic review. *Aust J Physiother*. 2006;52:27-37.

253. van der Windt DA, van der Heijden GJ, van den Berg SG, ter Riet G, de Winter AF, Bouter LM. Ultrasound therapy for musculoskeletal disorders: a systematic review. *Pain*. 1999;81:257-271.

254. Van Deun S, Staes FF, Stappaerts KH, Janssens L, Levin O, Peers KK. Relationship of chronic ankle instability to muscle activation patterns during the transition from double-leg to single-leg stance. *Am J Sports Med*. 2007;35:274-281. http://dx.doi.org/10.1177/0363546506294470

255. van Dijk CN, Bossuyt PM, Marti RK. Medial ankle pain after lateral ligament rupture. *J Bone Joint Surg Br*. 1996;78:562-567.

256. van Dijk CN, Lim LS, Bossuyt PM, Marti RK. Physical examination is sufficient for the diagnosis of sprained ankles. *J Bone Joint Surg Br*. 1996;78:958-962.

257. Van Gheluwe B, Kirby KA, Roosen P, Phillips RD. Reliability and accuracy of biomechanical measurements of the lower extremities. *J Am Podiatr Med Assoc*. 2002;92:317-326.

258. van Rijn RM, van Heest JA, van der Wees P, Koes BW, Bierma-Zeinstra SM. Some benefit from physiotherapy intervention in the subgroup of patients with severe ankle sprain as determined by the ankle function score: a randomised trial. *Aust J Physiother*. 2009;55:107-113.

259. van Rijn RM, van Os AG, Bernsen RM, Luijsterburg PA, Koes BW, Bierma-Zeinstra SM. What is the clinical course of acute ankle sprains? A systematic literature review. *Am J Med*. 2008;121:324-331.e7. http://dx.doi.org/10.1016/j.amjmed.2007.11.018

260. van Rijn RM, van Os AG, Kleinrensink GJ, et al. Supervised exercises for adults with acute lateral ankle sprain: a randomised controlled trial. *Br J Gen Pract*. 2007;57:793-800.

261. Verhagen E, van der Beek A, Twisk J, Bouter L, Bahr R, van Mechelen W. The effect of a proprioceptive balance board training program for the prevention of ankle sprains: a prospective controlled trial. *Am J Sports Med*. 2004;32:1385-1393. http://dx.doi.org/10.1177/0363546503262177

262. Verhagen EA, Van der Beek AJ, Bouter LM, Bahr RM, Van Mechelen W. A one season prospective cohort study of volleyball injuries. *Br J Sports Med*. 2004;38:477-481. http://dx.doi.org/10.1136/bjsm.2003.005785

263. Vicenzino B, Branjerdporn M, Teys P, Jordan K. Initial changes in posterior talar glide and dorsiflexion of the ankle after mobilization with movement in individuals with recurrent ankle sprain. *J Orthop Sports Phys Ther*. 2006;36:464-471. http://dx.doi.org/10.2519/jospt.2006.2265

264. Wang YC, Hart DL, Stratford PW, Mioduski JE. Clinical interpretation of computerized adaptive test outcome measures in patients with foot/ankle impairments. *J Orthop Sports Phys Ther*. 2009;39:753-764. http://dx.doi.org/10.2519/jospt.2009.3122

265. Waterman BR, Belmont PJ, Jr., Cameron KL, Deberardino TM, Owens BD. Epidemiology of ankle sprain at the United States Military Academy. *Am J Sports Med*. 2010;38:797-803. http://dx.doi.org/10.1177/0363546509350757

266. Waterman BR, Owens BD, Davey S, Zacchilli MA, Belmont PJ, Jr. The epidemiology of ankle sprains in the United States. *J Bone Joint Surg Am*. 2010;92:2279-2284. http://dx.doi.org/10.2106/JBJS.I.01537

267. Webster KA, Gribble PA. Functional rehabilitation interventions for chronic ankle instability: a systematic review. *J Sport Rehabil*. 2010;19:98-114.

268. Wedderkopp N, Kaltoft M, Lundgaard B, Rosendahl M, Froberg K. Prevention of injuries in young female players in European team handball. A prospective intervention study. *Scand J Med Sci Sports*. 1999;9:41-47.

269. Weindel S, Schmidt R, Rammelt S, Claes L, Campe A, Rein S. Subtalar instability: a biomechanical cadaver study. *Arch Orthop Trauma Surg*. 2010;130:313-319. http://dx.doi.org/10.1007/s00402-008-0743-2

270. Wester JU, Jespersen SM, Nielsen KD, Neumann L. Wobble board training after partial sprains of the lateral ligaments of the ankle: a prospective randomized study. *J Orthop Sports Phys Ther*. 1996;23:332-336.

271. Whitman JM, Cleland JA, Mintken PE, et al. Predicting short-term response to thrust and nonthrust manipulation and exercise in patients post inversion ankle sprain. *J Orthop Sports Phys Ther*. 2009;39:188-200. http://dx.doi.org/10.2519/jospt.2009.2940

272. Wikstrom EA, Fournier KA, McKeon PO. Postural control differs between those with and without chronic ankle instability. *Gait Posture*. 2010;32:82-86. http://dx.doi.org/10.1016/j.gaitpost.2010.03.015

273. Wikstrom EA, Hubbard TJ. Talar positional fault in persons with chronic ankle instability. *Arch Phys Med Rehabil*. 2010;91:1267-1271. http://dx.doi.org/10.1016/j.apmr.2010.04.022

274. Wikstrom EA, Naik S, Lodha N, Cauraugh JH. Balance capabilities after lateral ankle trauma and intervention: a meta-analysis. *Med Sci Sports Exerc*. 2009;41:1287-1295. http://dx.doi.org/10.1249/MSS.0b013e318196cbc6

275. Wikstrom EA, Naik S, Lodha N, Cauraugh JH. Bilateral balance impairments after lateral ankle trauma: a systematic review and meta-analysis. *Gait Posture*. 2010;31:407-414. http://dx.doi.org/10.1016/j.gaitpost.2010.02.004

276. Wikstrom EA, Tillman MD, Chmielewski TL, Cauraugh JH, Naugle KE, Borsa PA. Dynamic postural control but not mechanical stability differs among those with and without chronic ankle instability. *Scand J Med Sci Sports*. 2010;20:e137-e144. http://dx.doi.org/10.1111/j.1600-0838.2009.00929.x

277. Wikstrom EA, Tillman MD, Chmielewski TL, Cauraugh JH, Naugle KE, Borsa PA. Self-assessed disability and functional performance in individuals with and without ankle instability: a case control study. *J Orthop Sports Phys Ther*. 2009;39:458-467. http://dx.doi.org/10.2519/jospt.2009.2989

278. Wilkerson GB, Pinerola JJ, Caturano RW. Invertor vs. evertor peak torque and power deficiencies associated with lateral ankle ligament injury. *J Orthop Sports Phys Ther*. 1997;26:78-86.

279. Willems T, Witvrouw E, Delbaere K, De Cock A, De Clercq D. Relationship between gait biomechanics and inversion sprains: a prospective study of risk factors. *Gait Posture*. 2005;21:379-387. http://dx.doi.org/10.1016/j.gaitpost.2004.04.002

280. Willems TM, Witvrouw E, Delbaere K, Mahieu N, De Bourdeaudhuij I, De Clercq D. Intrinsic risk factors for inversion ankle sprains in male subjects: a prospective study. *Am J Sports Med*. 2005;33:415-423.

281. Willems TM, Witvrouw E, Delbaere K, Philippaerts R, De Bourdeaudhuij I, De Clercq D. Intrinsic risk factors for inversion ankle sprains in females – a prospective study. *Scand J Med Sci Sports*. 2005;15:336-345. http://dx.doi.org/10.1111/j.1600-0838.2004.00428.x

282. Williams GN, Molloy JM, DeBerardino TM, Arciero RA, Taylor DC. Evaluation of the Sports Ankle Rating System in young, athletic individuals with acute lateral ankle sprains. *Foot Ankle Int*. 2003;24:274-282.

283. Williams S, Hume PA, Kara S. A review of football injuries on third and fourth generation artificial turfs compared with natural turf. *Sports Med*. 2011;41:903-923. http://dx.doi.org/10.2165/11593190-000000000-00000

284. Wilson DH. Treatment of soft-tissue injuries by pulsed electrical energy. *Br Med J*. 1972;2:269-270.

285. Wilson RW, Gansneder BM. Measures of functional limitation as predictors of disablement in athletes with acute ankle sprains. *J Orthop Sports Phys Ther*. 2000;30:528-535.

286. World Health Organization. *International Classification of Functioning, Disability and Health: ICF*. Geneva, Switzerland: World Health Organization; 2001.

287. Worrell TW, Booher LD, Hench KM. Closed kinetic chain assessment following inversion ankle sprain. *J Sport Rehabil*. 1994;3:197-203.

288. Yeung MS, Chan KM, So CH, Yuan WY. An epidemiological survey on ankle sprain. *Br J Sports Med*. 1994;28:112-116.

289. Youdas JW, McLean TJ, Krause DA, Hollman JH. Changes in active ankle dorsiflexion range of motion after acute inversion ankle sprain. *J Sport Rehabil*. 2009;18:358-374.