Rehabilitation for Functional Ankle Instability

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Objective: The article presents a focused review of the literature surrounding training methods for addressing the proprioceptive loss and subsequent balance problems that result from inversion ankle sprains. Data Sources: The authors searched the MEDLINE and CINAHL databases for the period 1985 through December 2001 using the key words ankle, ankle sprain, and rehabilitation. Study Selection: Any study investigating a rehabilitation or prevention program for the proprioceptive or balance aspects of ankle instability was included. Data Synthesis: Key components of the training regimen used in each study are described, and major findings are summarized. Conclusions: Based on the literature reviewed, there is evidence to suggest that training programs for individuals with ankle instability that include ankle-disk or wobble-board activities help improve single-leg-stance balance and might decrease the likelihood of future sprains. Key Words: sprain, balance, physical therapy, rehabilitation

Ankle sprains are common occurrences that often result in lingering problems if not adequately treated. In addition to range-of-motion loss and pain, an ankle sprain might result in impaired proprioception from nerve damage,1-3 therefore negatively affecting balance in the long term, especially during single-limb stance on the affected side.4,5 Most ankle sprains are caused by uncontrolled ankle inversion6 resulting in acute inflammation, pain, and decreased muscle strength about the joint complex. Ankle sprains can be graded mild, moderate, or severe based on the degree of ligamentous disruption.

Ankle sprains not only damage the supporting ligamentous structures of the ankle, potentially involving loss of the joint’s passive constraints and resulting in mechanical instability, but can also ultimately result in an impaired sense of control and coordination. These senses of control and coordination are collectively termed proprioception, which is made up of joint-position sense, kinesthesia, and strength of the surrounding musculature.7 Control of ankle motion occurs through a coordinated synchronization


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of muscle activation coupled with passive restraints in the form of ligaments, bones, and other structural components of the ankle. The coordination of the ankle stabilizers is an unconscious (or reflex) process, and many patients are unaware of the complexity of ankle control until damage has impaired this control.

The sensory components of ankle control are understood in relation to the work of Sherrington, who described the integration of the sensory influence on the motor response. Higher order activities requiring excellent balance and motor control rely on the integration of the sensory input from various sources and transmission to the brain and cerebellum, which directs the appropriate motor response.8 Proprioception is defined as “sensation pertaining to stimuli originating from within the body regarding spatial position and muscular activity or to the sensory receptors that they activate, joint position and kinesthesia.”9,p172 It depends on the integrity of the nerves, ligaments, tendons, and joint capsules.10 Proprioception is a term that is used to include joint-position sense, kinesthesia, and muscle strength, each of which can be impaired by an ankle sprain.7

Impaired proprioception can negatively affect balance, as well as an individual’s perceived ability to control the joint. Balance, also termed postural stability or control, consists of somatosensory, vestibular, and visual input11 and results in the ability to maintain one’s center of gravity over the base of support. A typical ankle sprain does not affect vestibular or visual input, although visual input might be manipulated during rehabilitation to challenge the patient. Damage to the proprioceptive apparatus might cause an individual to rely more heavily on the intact visual or vestibular components of balance, thereby decreasing the efficiency of the system.

**Functional Ankle Instability**

Functional ankle instability is a subjective complaint of instability in the absence of mechanical disruption. Potential causes include disrupted sensation caused by impaired sensory nerves, dysfunctional mechanoreceptors in the intact ankle capsule or ligaments, or the presence of edema blunting neural responsiveness.7 Functional instability,12,13 often described subjectively by clients as a perception of “giving way” during weight-bearing activities, is problematic to quantify. Functional ankle instability results from many sources, including delayed or increased reaction times of the muscles supporting the ankle joint,14-24 muscle weakness,25,26 mechanical instability, decreased kinesthetic awareness of the ankle,13,27,28 or combinations of these,13 resulting in functional limitations.

Delayed reaction time of the lower extremity muscles in response to a sudden inversion stress can contribute to a subjective report of ankle instability.14 When testing reaction time in different muscles, many researchers have noted delayed reaction time ipsilateral to the ankle sprain15-22 or in the stabilizing trunk musculature,23,24 suggesting that delayed reaction time
contributes to the functional ankle instability after ankle sprain. Traumatic ankle sprains have been simulated using a kinesthiometer, and reaction times assessed, with the general result of slower reaction time in the fibularis (peroneus) muscle group in individuals after ankle sprain when compared with those who have not incurred an ankle sprain. These studies demonstrate that minor (grade I) ankle sprains often include neural damage to the ankle’s control apparatus.

Delayed reaction time can also be compounded by muscle weakness. Most opposition to ankle inversion-sprain movements arises from the muscles of the fibularis group or the anterior tibial musculature. These muscles include the tibialis anterior, extensor hallucis longus, extensor digitorum longus, and the fibularis longus, brevis, and tertius. Weakness cannot be the sole cause of ankle-sprain-associated instability, however, because functional instability can exist in the absence of mechanical instability and muscle weakness. Augmented muscle support can be achieved by increasing muscle strength of the tibialis anterior and fibularis group, as well as the posterior compartment muscles, thus providing additional dynamic stability to the ankle joint.

The loss of passive constraints alters the neural input from sensory receptors located in the capsule and ligaments, limiting the function of the reflex arcs that provide ankle stability. The result is decreased kinesthesia, decreased tactile input, and/or decreased joint-position sense. The speed with which the joint moves influences the ability of the muscles near the joint to control its motion.

Treatment for an ankle sprain should involve a comprehensive program to restore strength to the muscles that support the ankle, a neuromuscular component to regain control, and a task-specific component to return the individual to activities of choice. Unfortunately, after an ankle sprain individuals are more likely to experience recurrent sprains and demonstrate difficulty with functional activities such as running or jumping as a result of the sensation of joint instability that can result from proprioceptive loss.

The purpose of this review is to present methods of subacute rehabilitation after inversion ankle sprain that might help clients compensate for impaired neuromuscular control and prevent future sprains.

**Rehabilitation After Ankle Sprain**

Delayed reaction time of the fibularis muscle group to sudden inversion stress, coupled with proprioceptive sensory loss, predispose an individual to a vicious cycle of recurrent ankle sprains. Formation of edema, loss of ankle range of motion, and decreased weight bearing are the primary concerns during the acute phase of injury. Once these problems have resolved, the clinician must address the long-term functional implications of impaired proprioception in the lower extremity. The core issue is whether the injured ankle can recover adequate proprioceptive ability or compensate for
loss of proprioceptive sense in order to prevent or correct functional instability and impaired balance. Recurrent sprains and continued subjective complaints of instability arise in both athletic and nonathletic populations.

Unilateral, or single-limb, stance is commonly used to test balance after ankle sprain and can provide insight into a patient’s functional stability. Most of the research regarding proprioceptive training after ankle sprain addresses the incorporation of balance training into a rehabilitation program. As early as 1965, Freeman et al reported on the efficacy of “physiotherapy” with or without coordination exercises after ankle sprain in comparison with immobilization. The physiotherapy consisted of ice, compression bandaging, resisted movements, stabilization exercises, and walking reeducation. The coordination exercises included single-limb stance, balancing on a wobble board, and ankle-disk training. Immobilization was achieved with plaster of Paris or suture of the lateral ligaments, followed by casting. Freeman et al reported that in the physiotherapy and coordination exercise group, 1 of 14 subjects reported subjective instability in the long term compared with 5 of 11 subjects in the physiotherapy-only group and 3 of 5 subjects in the immobilization group. In contemporary practice, commonly used interventions that can improve proprioception include strengthening all muscles crossing the ankle joint, usually with emphasis on dorsiflexors, invertors, and evertors; specific training of joint-position sense; and balance training such as single-limb standing, wobble-board training, or ankle-disk training.

Single-Limb Stance

The simplest technique for balance training is practicing balance on 1 lower extremity without any other support. Generally, when rehabilitating an individual with single-limb stance, activities progress from simple to more difficult. For example, removal of a sensory modality such as vision might prove challenging early in training. As recovery continues, altering the surface on which stance occurs (hard, carpet, pillow, trampoline) provides an additional challenge to balance. Finally, to facilitate return to functional activities, the addition of challenges to single-limb stance such as ball tossing or resistance training in a single-limb-stance position might be necessary. There are no studies isolating single-limb stance as the sole modality of balance training after ankle sprain, and this might be a topic of future research.

Wobble-Board Training

An option for improving balance on the affected limb is to use a wobble, or tilt, board. The apparatus consists of a rectangular or square platform with a single plane-rounded fulcrum underneath that extends the width of the board. The foot is placed on the board, and the patient practices balancing
either in single- or double-limb stance without allowing the edges of the board to touch the ground. Alternatively, the patient might be asked to actively move the ankle to alternately touch the floor with either side of the board. A wobble board allows for uniplanar movement at the ankle.

Bernier and Perrin recruited 45 people with functional ankle instability, which they defined as “at least one significant ankle inversion sprain in which the subject was on crutches or unable to bear weight, followed by repeated injury and/or feeling of instability and giving way." Subjects were randomly assigned to 1 of 3 groups: 17 subjects trained for 6 weeks using an ankle disk, a wobble board, and hopping exercises; 14 received sham electrical stimulation to the fibularis muscles; and 14 served as controls and received no treatment. Single-limb-stance balance was assessed using a moving platform system with both eyes-open and eyes-closed conditions. Both anteroposterior and mediolateral stability were assessed and reported using a modified equilibrium score. The authors reported improvements in the score for the trained group compared with the control and sham groups with eyes open. Active and passive joint-position sense (inversion/eversion) were also measured using a KinCom II. Bernier and Perrin found no difference among groups with respect to non-weight-bearing joint-position sense at the ankle. Their study showed that after ankle sprain, subjects could learn to control postural sway as long as they were able to keep their eyes open, suggesting that vision and learning play a large role in ankle control after sprain.

Ankle Disk

Many studies have reported on the use of a device called an ankle disk for training single-limb stance. Ankle disk generally consists of a circular platform with a hemispherical ball underneath, on which an individual can stand with one foot or both feet in the center of the board. Exercises might involve balancing on the disk without allowing edges of the platform to touch the floor or performing controlled circumferential movements of the ankle. The individual might be asked to move the ankle in such a way that the edge of the platform touches the floor first medially, then laterally or anteriorly, then posteriorly, or in a clockwise then counterclockwise direction. The ankle disk allows for multiplanar movement, in contrast with the wobble board’s uniplanar movement.

Training with ankle disks has been reported in the literature to improve balance in single-limb stance. Hoffman and Payne reported improvements in balance in healthy subjects who had trained on an ankle disk 3 times per week for 10 weeks. Two similar studies with injured subjects examined single-limb-stance balance after training with an ankle disk. One study used soccer players with reported functional instability who trained for a total of 400 minutes over 8 weeks. Balance improved after training, indicating better postural control in the soccer players. Visual input was not investigated in this study. Subjects in the studies who trained with an
ankle disk showed improved balance in single-limb stance compared with untrained subjects and with previous performance. Balance was investigated by Leanderson et al. in a noncomparative study of ballet dancers after ankle injuries resulting in instability. Measures of single-limb-stance balance over time after the sprains were taken using a computer-assisted force plate. The authors reported an acute decrease in balance initially, followed by gradual improvements to preinjury levels during a 12-week rehabilitation program. Rehabilitation consisted of early range-of-motion activities, ankle-disk training, and lower extremity strengthening exercises. Subjects in both studies who trained with an ankle disk showed improved balance during the study, indicating greater postural stability.

Rozzi et al. reported significant improvement in single-limb balance as assessed on a computerized platform system both in individuals with functionally unstable ankles (experimental group) and in unimpaired individuals (comparison group) after training. Balance was assessed on a Biodex Stability System, on which the stability of the stance platform can be varied. The system grades balance by the number of degrees from horizontal the subject displaces the platform. The training program was performed on the testing device and incorporated multiplanar single-limb balancing and active mediolateral, anteroposterior, and circular movements with visual feedback. The pressure shifts on the Biodex are similar to those performed on an ankle disk. Training was performed 3 times per week for 4 weeks. Both the experimental and comparison groups improved in stability with training; the posttraining stability index (with larger numbers indicating poorer stability) was the same for both groups. Stability indices on the less-stable platform changed from $5.93 \pm 3.65$ to $2.63 \pm 1.92$ for the trained limb in the experimental group and in the trained comparison group changed from $4.67 \pm 3.43$ to $2.69 \pm 2.32$, indicating an increase in balancing ability for both groups but with greater improvement in the experimental group. On the more stable platform, both the experimental and comparison groups improved in standing stability. In addition, a questionnaire administered before and after training revealed improvement in subjective sense of ankle stability. These results should be considered carefully because of flaws of the study, such as the training procedures and the potential role of learning.

Sheth et al. investigated the effect of ankle-disk training on muscle-recruitment patterns. Using 20 healthy individuals, their study analyzed leg-muscle contraction patterns before and after a training program. Training consisted of 15 minutes of daily exercise on the ankle disk for 8 weeks. Using needle electromyography, the authors determined that subjects learned to delay the onset of ankle-invertor activation compared with ankle-evertor activation when exposed to a simulated ankle-sprain mechanism, thereby providing some dynamic protection against ligamentous injury. Although this study included uninjured subjects, it does address one of the deficits seen in individuals after ankle sprain: altered patterns of muscle recruitment. If ankle-disk training were to promote similar changes in
muscle-activation patterns in subjects after ankle sprain, perhaps instability could be mitigated.

Based on the studies discussed, there is good evidence that rehabilitation with an ankle disk or wobble board after an ankle sprain can improve certain measures reflecting balance. Further questions remain: Do these improvements translate into prevention of future sprains in individuals with ankle instability, and does training in uninjured individuals decrease the incidence of ankle sprains from occurring initially?

**Prevention of Ankle-Sprain Recurrence**

A number of studies have investigated the effectiveness of preventive interventions on the incidence or recurrence of ankle sprains in athletes. The prevention programs used a multitude of modalities with some success. Bahr et al\(^{39}\) followed Norwegian volleyball players over 3 seasons and recorded the frequency of ankle sprains. After the implementation of a 3-part prevention program consisting of training with a wobble board, education on hitting and blocking techniques, and injury awareness, the incidence of ankle injuries decreased twofold from baseline.

Another study examined 25 Swedish soccer teams including players with reported functional instability and others with healthy ankles.\(^3\) During a 6-month season, the investigators recorded frequency of ankle sprains for 3 groups: subjects training with an ankle disk, subjects using an ankle-support orthosis, and control subjects. The players in the training group used an ankle disk for 10 minutes daily, 5 times per week for 10 weeks, and for 5 minutes 3 times per week for the remainder of the season. Among players with and without previous ankle sprains, 5% of the training group sustained a sprain during the season, compared with 3% of the players in the orthosis group and 17% of the players in the control group. Among players with previous ankle sprains, 5% of the training group sustained a sprain during the season, compared with 2% in the orthosis group and 25% of the players in the control group. Therefore, training is effective to a similar degree as bracing in reducing the incidence of ankle sprain in men with a history of ankle injury, but most likely through a different mechanism.

A third study\(^{40}\) divided 48 individuals with acute ankle sprains into 2 groups. One group used a wobble board for balance training after the injury, whereas the control group did not. All participants were active in sports at least 2 hours per day. The trained group used a wobble board for 12 weeks, practicing for 15 minutes each day. At a 230-day follow-up, the authors reported a 25% recurrence rate for ankle sprain in the training group, compared with a 54% recurrence rate in the control group. Although much better than the control, the 25% recurrence rate in the training group is relatively high. It is interesting that none of the subjects in the training group reported subjective instability of the ankle, compared with 25% in the control group.\(^{40}\)
Conclusion

After an inversion ankle sprain, functional instability can lead to recurrent sprains and to long-term functional limitations such as difficulty in walking on uneven surfaces, running, jumping, and cutting. Clinically, functional ankle instability can be associated with poor performance on tests of balance on the affected limb, such as single-limb stance. The literature suggests that training on an apparatus such as an ankle disk or wobble board improves performance on single-limb balancing but does not support improved performance in tests of non-weight-bearing position sense. The improvements with training occur in individuals who have sustained an ankle sprain, as well as in uninjured individuals, decreasing the incidence of primary and recurrent sprains. The most common methods of training balance in single-limb stance include ankle-disk and wobble-board activities and simple single-limb-standing exercises. Training individuals through these methods enhances functional stability, which implies that the proprioceptive deficits resulting from an inversion ankle sprain can be reduced or compensated for by improving other components of balance.

References


