

## Interventions for the Prevention of First Time and Recurrent Ankle Sprains

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Ankle sprains are among the most common injuries in the physically active population [1–3]. It is estimated that 23,000 ankle sprains occur daily in the United States, which translates to about 1 sprain per 10,000 people every day [4]. The primary predisposing factor to suffering an ankle sprain is a history of previous sprains [5]. Although ankle sprains often are viewed as mild injuries, they represent a significant public health problem [6,7]. It has been estimated that sprains to the ankle/foot account for 1.6 million physician office visits and over 8000 hospitalizations per year [8]. Approximately 30% of those who suffer a first-time ankle sprain develop chronic ankle instability (CAI); however this rate has been reported as high as 70% [9,10]. Residual symptoms of ankle sprains can alter the health of individuals who suffer from recurrent instability significantly, causing them to become less active over the life span [11].

At the high school level, ankle sprains are the most common injury suffered out of all lower extremity injuries [12]. The highest prevalences of ankle sprains were in boys' and girls' basketball and soccer, boys' football, and girls' volleyball [13]. According to Injury Surveillance System data from the National Collegiate Athletic Association, ankle sprain was the most common injury in men's and women's basketball [14,15], men's and women's soccer [16,17], women's volleyball [18], and the second most common injury in men's football [19]. In addition, ankle injuries have been reported to be a major cause of early development of osteoarthritis [20,21]. Based on this information, ankle instability represents a major obstacle to the health and well-being of the physically active within the United States.

Although there has been considerable research on risk factors associated with ankle sprains [5], there is not a clear consensus on the most appropriate intervention strategies to prevent them. The epidemiological evaluation of risk and the identification of risk factors establish the contributing causes of this major

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problem. The development and implementation of prevention programs that alter identified risk factors and the systematic evaluation of the efficacy of those interventions are essential in the direction towards problem resolution [22,23].

## **PREVENTION OF ANKLE SPRAINS**

Over the past 40 years, intervention strategies have been introduced for the prevention of first-time ankle sprains and the recurrence of ankle instability after suffering a first-time sprain. These interventions have included balance/coordination training, sport/activity-specific technical training, external support (bracing/taping), foot orthotics, footwear, and strengthening/stretching. In the past 10 years, there have been several systematic reviews that have focused on the efficacy of these strategies for treating acute [24–26] and chronic ankle instability [26,27] and their prophylactic effects in the prevention of ankle sprains [26,28]. Of all of these intervention strategies, the most consistent evidence supports the prophylactic effects of the use of external support [28,29] or balance/coordination training [26,28] in the prevention of first-time and recurrent sprains. The purpose of this article is to provide the reader with an overview of these prevention strategies, what is known in the literature, what is not known, and what is needed to be known. Throughout the manuscript, evidence will be classified according to the International Classification of Function, Disability, and Health (ICF) as activity-specific or participation-specific. In addition, guidelines will be provided based on the most current evidence to support these interventions and the goals of future research.

## **EXTERNAL SUPPORT AND ANKLE SPRAINS**

### **External Support and the Prevention of Ankle Sprains**

Of all the prevention strategies that have been introduced over the past 40 years, the use of external support has been shown to have the most consistent effect on the reduction in ankle sprain risk associated with physical activity [30]. These effects have been investigated in fairly diverse populations ranging from the general public, to high school athletes, collegiate athletes, professional athletes, and military recruits [25,28,29]. In a 2001 systematic review of the literature of prevention strategies for ankle sprains, Handoll and colleagues [29] found that there is clear evidence to support the use of external support such as semirigid or lace-up braces and taping for the prevention of ankle sprains. These interventions have been shown to decrease the risk of ankle sprain by 50% to 70% in those who have a history of ankle sprain. This is critical in what has been established about the prevention of ankle sprains. These interventions appear to be most effective in those who have sustained a previous ankle sprain. In those who have not sustained a previous ankle sprain, the prophylactic effects are not as clear. Therefore, providing individuals with a history of ankle sprain who participate in activities associated with a high risk of ankle sprain such as basketball, volleyball, soccer, and football appears to be a valid prophylactic measure for the prevention of recurrent sprains.

The external support of choice should be based on comfort, perceived instability, and cost [31,32]. Olmsted and colleagues [33] found that taping and bracing were equally effective at preventing ankle sprains in those who had a history of sprain among community-based soccer players and collegiate intramural basketball players. According to the numbers-needed-to-treat (NNT) analysis, taping and bracing have much greater prophylactic effects for those who have a history of sprain [33]. The prophylactic effects for those without a history of sprain are negligible compared with those who have a history. This suggests that screening for those individuals who have a history of ankle sprain and providing external support would be an effective strategy for preventing future sprains. There is evidence to suggest that taping and bracing offer similar prophylactic effects in those who have a history of sprain [25,33]. The cost of taping, however, may be 3 to 25 times higher than the cost of bracing those who are at risk based on the type of activity, the number of tape applications, and number of people participating [33]. It also should be noted that semirigid stirrup braces may be applied more easily than lace-up braces because of a less complicated design [32]. This may be an important issue with regards to compliance of brace application.

Although the prophylactic effects of external support appear to be clear, there also has been concern regarding the detrimental effects of bracing on functional performance [34]. The application of ankle braces has been shown to have no significant detrimental effects on functional performance measures such as rapidly changing direction [35], sprinting [36], and vertical jump [34]. Improvements on these tasks have been found for those who have postacute or recurrent sprains [35]. Recently, the placebo effect of taping has been demonstrated in functional activities in those who have chronic ankle instability [37]. Subjects reported feeling more stable, confident, and reassured with the application of the standard taping technique (stir-ups, figure of 8, heel-lock) or a single strip of tape applied to the calf compared with the untaped condition while performing functional tasks such as hopping and balancing [33]. Although taping and bracing have been touted with providing mechanical support, it is apparent that the mechanisms for functional improvements in perceived stability remain unknown. Currently, there is no evidence to suggest that long-term brace application has detrimental effects on the functional performance in those who are already at a high level of physical activity. The long-term reliance on external support may be most appropriate for those conditions where the patient may be at a high risk for injury such as participation in cutting and jumping sports (ie, soccer, volleyball, basketball, football) or changing environmental conditions such as hiking or cross country running.

### External Support and Lateral Ankle Sprain Outcomes

There have been several methods introduced for the conservative treatment of acute ankle sprains. Of these, the most effective appears to be those interventions that focus on functional treatment of the ankle rather than immobilization [24,30,38]. Immobilization as a conservative treatment strategy for acute lateral

ankle sprains has been shown to have significant short- and long-term negative consequences on the function of the ankle [24,30,38]. Functional treatment includes such interventions as early mobilization and providing external support through the utilization of taping, lace-up, or semi-rigid braces. In addition, the standard rehabilitation protocol, which emphasizes the reduction of pain and swelling and the restoration of strength; range of motion, including proper arthrokinematics [39]; and balance/coordination, is part of the functional treatment progression.

Based on a review of evidence, Struijs and Kerkhoffs [30] found that functional treatment was the superior approach for reducing the sequelae of ankle sprain such as recurrent instability, pain, and significant time loss from work or sport. The role of external support played a critical role in these outcomes. The use of external support is an effective strategy for reducing the perception of joint instability and shortening the time to return to work/sport [25]. External support included the use of tape and semirigid and lace-up braces. Kerkhoffs and colleagues [25] reported no differences in the reported symptoms of pain, subjective instability, objective instability, or range of motion among these types of external supports in those who suffered lateral ankle sprain. Based on this information, it is apparent that providing external support in conjunction with functional treatments addressing pain, strength, range of motion, and balance/coordination appear to be effective in shortening the time to return to work/sport [25,31,40]. The selection of these external supports should be based on comfort, convenience of application, and cost-effectiveness [25,33,34].

### Future Directions

There is a paucity of evidence to support the assumption that external support after ankle injury returns the patient to normal functional participation in the long term. The evidence is clear that the risk of ankle sprain is reduced with the application of external support over a relatively short follow-up period (up to 1 year). There is very limited to no evidence to support a change in the quality of life in these individuals. Do these individuals return to a normal level of involvement in life situations related to the application of external support? If so, it then becomes important to determine the quality of participation, the perception of disability associated with participation in work/sport, and the ability to participate at the desired skill level. In addition, it would be clinically important to know whether there are discrepancies in the amount of exposure to work/sport individuals have after ankle sprain with the use of external support compared with preinjury status. It may be that those who receive external support participate less than, more cautiously, and/or at a lower skill level than preinjury level. Those confounding factors therefore lead to a decreased incidence of recurrent sprain.

Based on what has been established in the literature, it is apparent that more well-designed, high-quality, large-scale clinical trials of bracing and taping to prevent ankle sprains are warranted [25]. These clinical trials should not only evaluate the effects of external support on variables such as time-to-return

to work/sport, but also on participation-specific outcomes such as quality of life with the application of external support, level of disability associated with involvement in sport and/or work, change in status of exposure to sport or work environments, and perception of participation compared with before injury. Do these interventions significantly alter the perception of disability and allow for more normal interactions than existed prior to onset of injury. Thacker and colleagues [28] recommended that external support be used for up to 6 months after ankle sprain. What remains unknown is whether the early return to sport/work with the use of external support leads to detrimental sequelae beyond the period of 6 to 12 months after injury. These components are crucial to determine whether bracing is truly a viable option for the long term or whether there are other strategies that would offer more robust prophylactic effects with less incidence of such negative consequences as the development of post-traumatic osteoarthritis [20,21].

## **BALANCE/COORDINATION TRAINING**

### **Balance/Coordination Training and the Prevention of Ankle Sprains**

Balance/coordination training typically involves activities in single-limb stance that challenge the person's ability to maintain balance. A major confounding factor in the interpretation of the effects of balance training is the variety of activities and programs that have been implemented. Balance training programs have utilized balance boards [41,42], foam pads [11], dynamic hopping activities [43], and technical training [43,44]. During these activities, athletes typically maintain single limb stance and perform sport-related activities such as dribbling, passing, or shooting [41,42]. Technical training associated with volleyball also has been reported [43,44]. In these activities, players are coached about proper take-off and landing techniques during various volleyball-specific drills. All of these activities have been demonstrated to be effective in reducing the risk of ankle sprain associated with sports such as soccer, volleyball, and basketball [26,41-43] and improving the functional outcomes of those who have acute and chronic ankle instability [26,40,45-51].

McKeon and Hertel [26] conducted a systematic review of the efficacy of balance training in reducing the risk of ankle sprain. There is strong evidence from several prospective studies [41-43] that balance/coordination training is effective in reducing the risk of ankle sprains, especially in those who have a previous history of sprain [41,42]. Bahr and colleagues [43] demonstrated that the longer a prevention program with components of balance training is employed, the greater the prophylactic benefit. The balance training prevention program implemented for 2 consecutive years provided greater ankle sprain risk reduction (49%) compared with 1 year (21%) [42]. In addition, the NNT analysis revealed a shift from 27 players in the first year to 12 players in the second year in order to prevent one ankle sprain [26]. These results should be interpreted with caution considering the homogenous sample used of elite male volleyball players. McGuine and Keene [42] and Verhagen and colleagues [41] demonstrated that season-long programs performed three to five times per

week that involve single limb stance balance training activities that incorporated stable and unstable surfaces as well as sport specific components such as throwing and catching a ball, dribbling, and passing were effective in reducing the incidence of ankle sprain during participation in an athletic season. Based on an NNT analysis of these studies, McKeon and Hertel [26] determined that in order to prevent one ankle sprain, an average of 26 players would need to undergo balance training in order to prevent one subsequent sprain. In those who had a history of sprain, the NNT was reduced to an average of 21.5. For those without a history of ankle sprain, the reduction in risk is less clear. It is again apparent that those who have a history of ankle sprain benefit most from balance and coordination interventions.

### Balance/Coordination Training and Acute Lateral Ankle Sprain Outcomes

The performance of single-limb balance exercises on an unstable surface has shown promise as an effective intervention for reducing the recurrence of injury after acute ankle sprain [40,45]. In these studies, the use of a wobble board, balance exercises with eyes open and eyes closed, and functional activities such as figure of 8 running exercises provided significant prophylactic effects on the recurrence of ankle sprains after treatment for acute sprain [40,45]. Holme and colleagues [40] compared the outcomes after acute ankle sprain between those who received a supervised functional rehabilitation program twice a week and those who received information regarding a standard home rehabilitation protocol. Wester and colleagues [45] compared the outcomes after acute ankle sprain of those who received a 12-week home-based wobble board program with those who received only standard treatment. Both of these studies had a post-treatment follow-up period where patients were contacted to report whether a sprain had occurred after rehabilitation. Based on relative risk analysis of these studies, McKeon and Hertel [26] calculated a 54% to 76% relative risk reduction of suffering recurrent ankle sprain after undergoing these types of balance training programs following acute ankle sprain. In addition, those who underwent balance training reported fewer episodes of instability at follow up. The follow-up periods for these studies were an average of 230 days [45] to 12 months [40].

### Balance/Coordination Training and Chronic Ankle Instability Outcomes

Those who suffer from chronic ankle instability also have been shown to benefit from balance training. Various programs have been introduced that involve maintaining single-limb stance on stable and unstable surfaces, performance of functional activities such as hopping and figure of 8 running, and general strengthening [46–52]. These programs have been implemented from 4 to 8 weeks for one to five times per week. Rozzi and colleagues [51], Hale and colleagues [49], and McKeon and colleagues [50] demonstrated that performing supervised balance training for 4 weeks significantly improves self-reported measures of disability in those who have chronic ankle instability. Eils and Rosenbaum [46] established that after 12 months, those with CAI who

undergo balance training report a 60% decrease in episodes of the ankle giving way. Based on these studies, there appears some evidence that balance training is effective in improving the level of function in those who have CAI; yet there is no direct evidence to support a reduction in the risk of recurrent ankle sprain.

### Future Directions

Throughout the literature on the effects of balance/coordination training on the outcomes of those with ankle sprain, it is unknown what types of programs offer the most benefit to those who have ankle instability, or to those who may go on to suffer a first-time sprain. It is important to establish whether a progression of low-impact activities such as the maintenance of single-limb stance on stable and unstable surfaces to more dynamic activities such as running, cutting, and hopping offer greater prophylactic benefit than programs that only rely on single-limb stance activities. The length of follow-up after balance/coordination training and the information obtained in the follow-ups are also crucial outcomes to address. Do those who undergo balance/coordination training after ankle injury report improved quality of life, less osteoarthritis, and less ankle sprains than those who do not over a follow-up period longer than 1 year? In addition, the optimal time to introduce a balance training program (eg, preseason, off-season, within the first 2 weeks after injury), the optimal length of a balance training program (eg, 4 weeks, 6 weeks, season-long), the number of sessions per week (eg, one, three, five, daily), and the length of each session (10 minutes to 1 hour) still need to be established.

### CONTINUUM OF INSTABILITY: ARE WE ASSESSING DISABILITY?

There has been extensive research on the role of external support and other interventions on the perceived ankle instability a person experiences who has suffered a sprain. There is little evidence, however, that connects that local instability with global disability. In 1980, the World Health Organization developed a model in an attempt to provide standardized language for health and health-related states. This model is known as the ICF [53]. Human functioning is classified by the ICF as having three levels. These include functioning at the level of the body or body part, functioning at the level of the person as a whole, and functioning at the level of the whole person in a societal context. These functions are labeled broadly: Body functions and structure, activity, and participation, respectively [53]. Rather than viewing function and disability as separate, the ICF views these two as individual aspects as outcomes associated with the interaction between a health condition and contextual factors such as the environment. The ICF model provides a framework for the descriptions of function and disability as they relate to body structures and function, activity, and participation. Impairments refer to changes in body structure or function associated with a health condition (ie, ankle sprain). Activity is related to execution of a task (ie, running, cutting, hopping), whereas participation refers to involvement in a life situation (playing soccer). Limitations of activity refer

to difficulty performing a task, and restrictions in participation refer to problems that an individual experiences when involved in life situations. The purpose of this model is to develop the framework for a common language to be used as a tool to chart the detriments of health conditions and the benefits of interventions to treat and prevent them. The physiological, neuromuscular, and biomechanical impairments associated with ankle instability have been studied extensively; however, clear evidence as to the reduction in risk based on the structural or functional modifications from the interventions discussed previously have not been well established.

Despite the evidence to support conservative functional treatment of ankle sprains, the recurrence of ankle instability after initial sprain and the propensity for developing post-traumatic osteoarthritis [20,21] are noteworthy. From the structural framework of the ICF model and the evidence presented previously, it is apparent that the application of external support and the implementation of balance training programs have a positive influence at the activity limitations and participation restrictions in those with ankle instability. The structural and functional changes associated with these improvements that occur with these interventions remain unclear.

In both intervention strategies discussed previously, those who benefit from the prophylactic effects of external support and balance training are those who have a history of a previous sprain. This indicates that those with the health condition (ankle instability) have greater prophylactic benefit than those without the health condition. Both strategies reduce the risk of ankle sprains over a relatively short follow-up period and return those who have ankle sprain back to participation in work/sport sooner than those who do not receive these interventions. There is a paucity of evidence to suggest that those who return to work/sport with the use of external support or after undergoing balance training are at less risk of developing osteoarthritis, other functional impairments associated with ankle injury, and have improved quality of life in the long term [54]. These outcomes need to be established. Several clinimetric instruments have been established to quantify the amount of disability a person experiences because of foot/ankle injury. The Foot and Ankle Disability Index [49,50,55] (now the Foot and Ankle Ability Measure [56]) and the Ankle Joint Functional Assessment Tool [51] have been used to quantify improvements in self-reported function after balance training in those who have CAI. The utilization of instruments such as these is an essential component of determining the long-term efficacy of the interventions discussed previously.

Verhagen and colleagues [57] found that those who have a history of ankle sprain within the past year are at significantly greater risk of suffering another sprain throughout a competitive volleyball season. For those who had a history of sprain who had not suffered one in over a year, however, the risk of suffering a sprain during the season was equal to those who had never suffered a sprain. This becomes critical when making decisions with regard to the length of intervention studies, the strategies to reduce the recurrence of sprains, and the follow-up period after study. Specifically, it is important when advising

individuals who have suffered a sprain that proper rehabilitation and implementation of prevention strategies must be employed to reduce future occurrences of an ankle sprain.

The prescription of activity modifications over a lifetime and maintenance therapy is not understood clearly. Recommendations to perform balance training and the use of external support often are limited to the initial treatment period. It would be expected that someone with ligamentous or proprioceptive compromise from injury would need to devote attention to this limitation throughout life. Although modification of lifestyle and alterations in diet and exercise are common prescriptions by a physician to prevent heart attack or high blood pressure, this is not always the case with ankle sprains. It is known that there is a high recurrence rate, yet specific strategies for reducing injury over the long term is not common practice, and little is documented or known from clinical trials. Health care professionals may be limiting their ability to provide the best care by not providing specific rehabilitative exercise (balance training and strengthening) and suggestions for participation after patients are treated for an acute injury. For example, for patients who wish to participate in cutting activities, a maintenance program of exercises and recommendation to prophylactically brace in high-risk activities might prevent reoccurrence of ankle sprains. It is not known if a more comprehensive approach to managing acute and chronic injuries would result in a reduction of the prevalence of injuries or reduction in health care costs and days lost because of injury.

### **FURTHER DIRECTIONS**

Based on the evidence presented, there is a need to establish long-term outcomes associated with the use of external support and balance training in those who have ankle instability. It is apparent that the use of external support decreases the time to return to work/sport after ankle sprain. What needs to be established is whether this early return with the use of external support substantially improves the quality of life and significantly reduces the risk of osteoarthritis in these patients. Balance training also appears to offer clear prophylactic effects for those with ankle instability. What needs to be established are the optimal types of activities that produce the greatest risk reduction in those who have ankle instability. Well-designed clinical trials assessing the prophylactic effects of various balance training programs are warranted. These trials must include long-term follow-up periods that address outcomes related to disability, injury recurrence, and the development of osteoarthritis. Lastly, the combination of balance training and external support needs to be investigated. Are the prophylactic benefits of implementing both interventions greater than one or the other?

### **SUMMARY**

The use of external support and balance training individually reduces the risk of reinjury in those who have a history of ankle instability. Better assessment of outcomes associated with the ICF model through systematic study of these two

interventions may provide better answers to treatment paradigms. Most importantly, the application of external support and balance training are effective in assisting patients in returning to function, especially following an acute injury.

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