Ankle Injury Prevention Programs for Soccer Athletes Are Protective
A Level-I Meta-Analysis

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**Background:** Soccer has one of the highest rates of ankle injury in sports for both males and females. Several injury prevention programs have been developed to address this concern. The purposes of this study were to conduct a meta-analysis of ankle injury prevention programs for soccer players, assess the heterogeneity among the studies, and evaluate the reported effectiveness of the prevention programs.

**Methods:** A systematic search of the literature was conducted in PubMed (MEDLINE), Embase, CINAHL (Cumulative Index to Nursing and Allied Health), and the Cochrane Central Register of Controlled Trials (CENTRAL) database. Studies were limited to clinical investigations of injury prevention programs specific to the ankle in soccer players. Title, abstract, and full-text review were utilized to identify articles that met the inclusion criteria. The Cochrane Q test and I² index were independently used to assess heterogeneity among the studies. Sensitivity analyses were performed to assess heterogeneity. The pooled risk difference was calculated by random-effects models with use of the DerSimonian-Laird method. Publication bias was assessed with a funnel plot and Egger weighted regression technique.

**Results:** Ten studies met the inclusion criteria as randomized controlled trials. A total of 4,121 female and male soccer athletes were analyzed for ankle injuries. Significant heterogeneity was found among studies of ankle injury prevention (p = 0.002), with an I² index of 65.2%. For studies of ankle injury prevention programs, the risk ratio was 0.60 (95% confidence interval, 0.40 to 0.92) and a significant reduction in the risk of ankle injury was found in the prevention group (p = 0.002). No evidence of publication bias was found among the included studies.

**Conclusions:** This meta-analysis of studies regarding ankle injury prevention programs identified a significant reduction in the risk of ankle injury. Future high-quality research designs with a low risk of bias are necessary to further evaluate the effectiveness of specific exercises and the optimal timing and age at intervention for the prevention of ankle injuries in the athletic soccer player.

**Level of Evidence:** Therapeutic Level I. See Instructions for Authors for a complete description of levels of evidence.

With an estimated 265 million players worldwide as of 2006, soccer is the most popular sport in the world. The sport has grown immensely in the United States over the past 3 decades, due in large part to increased participation among youth and female competitors, and participation continues to grow annually. The ankle is one of the most frequent sites of injury in soccer players, with ankle sprain being the most common specific injury in athletes of both sexes at high school, college, and professional levels of play. In fact, soccer has one of the highest rates of ankle injury in sports for both males and females. According to the National Center for Injury Prevention and Control of the Centers for Disease Control and Prevention, the estimated total lifetime medical cost, in the U.S. in 2010, for the treatment of a sprain or strain of the lower leg or ankle was $672,972,000 for females between 10 and 39 years old and $623,549,000 for males between 10 and 39 years old. For these reasons, ankle injury prevention has become an increasingly important concern for athletic and medical communities alike. Many different injury prevention programs have been used in an effort to reduce injuries of the lower extremity.
Clinical trials have attempted to demonstrate the efficacy of these various intervention programs; however, studies of this nature are time-consuming, expensive, and difficult to conduct. These limitations can lead to study design and methodology flaws that subsequently increase the risk for bias and reduce the quality of evidence provided by the study.

The purposes of this systematic review and meta-analysis were to identify Level-I studies of ankle injury prevention programs for soccer players, assess the internal validity of these studies, and evaluate the quantitative pooled effectiveness of these prevention programs.

### Materials and Methods

#### Criteria for Selecting Studies

#### Types of Studies

Inclusion and exclusion criteria were established a priori. Only randomized controlled trials (RCTs) of injury prevention programs with Level-I evidence, as defined by the Cochrane Handbook, were included in this review. The criteria described by the Oxford Centre for Evidence-Based Medicine (http://www.cebm.net) were used for level-of-evidence assessments. Therefore, Level-II (prospective, nonrandomized studies), Level-III (retrospective studies), Level-IV (case series), and Level-V (expert opinion) publications were not included in the analysis. Articles not published in English were also excluded from the study.

#### Types of Participants

Of the studies included in the meta-analysis, only those involving soccer players were included in this analysis. Sex, athletic skill level, or age group did not influence the inclusion of a study in the analysis.

#### Types of Interventions and Comparison Groups

Only studies that utilized interventions to prevent ankle injuries were included. The interventions utilized included neuromuscular, proprioceptive, strengthening, and stretching exercises. If a study used an exogenous modality as a means of prevention (e.g., bracing or taping), it was excluded. One study compared multiple treatment groups including proprioceptive exercises, strengthening exercises, and orthosis use; however, only the data from the proprioception exercises group and the strengthening exercises group were included.

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**TABLE I Summary Table of Study Characteristics**

<table>
<thead>
<tr>
<th>Study</th>
<th>Journal</th>
<th>Level of Evidence</th>
<th>Sex</th>
<th>Mean Age (Range) (yr)</th>
<th>Program Exercises</th>
<th>Study Design</th>
<th>Follow-up (mo)</th>
<th>Dropouts</th>
<th>No. of Subjects at Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soligard et al.30 (2008)</td>
<td>British Medical Journal</td>
<td>I F</td>
<td>15.4 (13-17)</td>
<td>Multifaceted approach: warm-up, stretch, proprio, and balance training</td>
<td>Prospective cluster-RCT</td>
<td>8</td>
<td>47</td>
<td>1,892</td>
<td></td>
</tr>
<tr>
<td>Trapp et al.21† (1985)</td>
<td>American Journal of Sports Medicine</td>
<td>I M</td>
<td>NR</td>
<td>Proprioceptive (balance board)</td>
<td>Prospective RCT</td>
<td>6</td>
<td>0</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Mohammadi9† (2007)</td>
<td>American Journal of Sports Medicine</td>
<td>I M</td>
<td>24.6 (21.0-27.2)</td>
<td>Proprioceptive and strengthening exercises</td>
<td>Prospective RCT</td>
<td>1 season</td>
<td>0</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>van Beijsterveldt et al.28 (2012)</td>
<td>British Journal of Sports Medicine</td>
<td>I M</td>
<td>24.8 (20-29)</td>
<td>Core stability, proprioception, dynamic stabilization, proprio, and eccentric muscle training</td>
<td>Prospective cluster-RCT</td>
<td>1 season</td>
<td>29</td>
<td>456</td>
<td></td>
</tr>
</tbody>
</table>

*NR = not reported (data not reported and unable to contact primary or secondary author), and U = under. †Only data from the proprioceptive training group were extracted. ‡Two separate groups were included in this study: the proprioceptive exercise group and the strengthening exercise group (the orthosis group was excluded from analysis).
extracted for inclusion in the meta-analysis, while the orthosis group was excluded.

### Outcome Measures

Studies that had “ankle injury” as an outcome measure were eligible for inclusion. Ankle injury was defined as any acute or overuse injury or one that was due to either contact or noncontact trauma, including both ligamentous and nonligamentous injury, occurring to the ankle. Acute injuries were those with a sudden onset with obvious trauma, and overuse injuries were those occurring with an insidious onset.

### Search Method and Strategy

Four major medical databases were searched from inception through February 15, 2015: MEDLINE, Embase, CINAHL (Cumulative Index to Nursing and Allied Health), and Cochrane Central Register of Controlled Trials (CENTRAL) database. A medical library search strategist was consulted to develop a sensitive and comprehensive search strategy, as has been done in previous studies (see acknowledgment). Briefly, the following search criteria were used: (injuries OR injury OR injur*) AND (prevention OR prevented OR prevent OR prevents OR prevent*) AND (ankle AND (soccer OR football)).

Supplemental bibliographic reference searches of articles to identify potentially missed, relevant studies were also conducted (a detailed list of the search strategy is available in the Appendix).

### Data Collection and Analysis

#### Study Selection Procedure

The study selection process was conducted independently by 2 reviewers (N.L.G. and J.C.J. Jr.). If a study passed an initial screening on the basis of the title and abstract review, more information was needed to determine if the trial met inclusion criteria; therefore, the full text was retrieved and reviewed in detail. If a disagreement arose between the 2 reviewers, a third reviewer (K.G.S.) helped to establish a group consensus agreement.

#### Data Extraction

Data were extracted from studies that met the above-mentioned inclusion criteria independently by the 2 reviewers (N.L.G. and J.C.J. Jr.). From each study, the following data were extracted: journal of publication, title, author(s), publication year, subject sex, subject age, number of subjects in intervention and treatment arms, type of intervention(s), characteristics of intervention(s), study design, follow-up time, and outcome data. Additionally, the following outcome data elements were also extracted from each study: type of injury, frequency of injury occurrence, duration of follow-up, diagnostic methods for outcomes of interest, number of dropouts, and compliance rate. Authors of a study were contacted for clarification if any of the data elements of interest were missing or unclear.

### Risk-of-Bias Assessment

The internal validity of all RCTs and cluster-RCTs that met the inclusion criteria were assessed by 2 independent reviewers (N.L.G. and J.C.J. Jr.) using the assessment algorithm described by van Tulder et al. A risk-of-bias score was assigned to each study on the basis of its assessed internal validity. The Van Tulder scale is a critical appraisal tool for the assessment of RCTs developed by the Cochrane Collaboration Back Review Group and has been used in previous meta-analyses. Many methodological criteria that have empirically been shown to create an exaggeration of treatment effects are included in this critical appraisal tool.

As with the data extraction mentioned above, if any of the specific criteria of the Van Tulder scale were not explicitly stated in the text of a study, the study authors were contacted for clarification. A third reviewer (K.G.S.) was consulted if disagreements arose. This process of assessment is consistent with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement for conducting systematic reviews.

### Meta-Analysis and Statistical Procedures

The ankle injury rates concerning intervention and control groups from each study were evaluated and summarized in tabular form. Relative risk (RR) was used to estimate the intervention effect on the prevalence of ankle injuries, by comparing the ankle injury rate in the intervention group (numerator) with the rate in the comparison group (denominator).

The analysis of publication bias was performed with STATA statistical software (release 13; StataCorp) using the Harbord test, Peters test, and Begg test, which are general approaches to test publication bias in a meta-analysis. The Egger test has traditionally been widely used, but has been shown to be biased for binary outcomes. The Harbord test is more appropriate as a modification of the Begg test for small-study effects in a meta-analysis of RCTs. The Harbord and Peters tests are regression-based tests, which are parametric. However, the Begg test is based on a rank correlation method, which is nonparametric. The
analysis of publication bias was presented qualitatively using a funnel plot derivation. With the use of STATA, an inverse variance method was employed to calculate the weight for each study included, with random-effects meta-analyses with the DerSimonian-Laird method used to estimate the between-study variance. The Cochrane Q test, with a p value of 0.10 considered significant, and the Higgins and Thompson I² index were independently used to assess heterogeneity among the studies.

Results

Search Findings

Inclusion and exclusion criteria identified 9 RCTs of ankle injury prevention programs for soccer players within the medical literature databases that were searched. However, 1 study assessed 2 different prevention strategies and therefore is treated as 2 separate studies for this meta-analysis, which can be considered to have 10 RCTs. A total of 1,634 articles were screened on the basis of the title and/or abstract, and of those studies, 50 full-text articles were retrieved and reviewed. This review resulted in 10 RCTs that met the inclusion criteria (Fig. 1). The primary reasons for not including a study in this review were a nonrandomized study design, the lack of a comparison group, and study subjects who were not soccer-playing athletes.

Search Characteristics

A summary of all studies included in the systematic review and meta-analysis is provided in Table I. A total of 4,121 athletes in the 10 RCTs were analyzed. Six studies included only male subjects, 3 studies included only female subjects, and 1 study included both male and female subjects. The study design of each trial was either a prospective cluster-RCT or a prospective RCT. All studies had ankle injury as an outcome measure (Table II).

Risk of Bias

The average risk-of-bias score of the studies included was 6.4 (range, 5 to 10) of a maximum score of 11 (Table III). Authors of the 9 articles, or 10 studies with 1 article considered as 2 studies, were contacted for clarification on at least 1 of the internal validity elements collected in the van Tulder scale assessment that was not apparent or clearly stated in the manuscript. One study accurately and completely described within the text all elements of internal validity that were assessed. The dropout rate was found to be acceptable in 6 of the 9 studies, was not reported in 2 studies, and was found to be unacceptable in 1 study (Table III). The other elements that were not adequate included avoidance of cointerventions, compliance, group similarity at baseline, concealment of treatment allocation, adequate randomization method, conducting of an intention-to-treat analysis, and subject blinding. However, subject blinding in particular is difficult if not impossible in this type of study design.

Study-Specific and Quantitative Analysis

The overall estimated RR for ankle injuries was <1, indicative of a protective effect, with 8 studies individually having an estimated RR of <1 (4 studies had a significant difference). The pooled effect size of the injury prevention interventions, using a random-effects meta-analysis technique, showed a significant protective
effect against ankle injuries (RR of 0.60; 95% confidence interval [CI], 0.40 to 0.92; \( p = 0.002 \)) (Fig. 2). Sensitivity analyses were conducted, and the data were analyzed with fixed-effects meta-analyses using both the Mantel-Haenszel method and an inverse-variance method. These analyses found similar results with respect to the RR, indicating the intervention is effective at preventing ankle injuries.

**Publication Bias**

In assessing for publication bias as described above, the results of the Harbord test identified weak evidence for small-study effects \( (p = 0.06) \). However, both the Peters test and the Begg test were also performed and found no evidence of publication bias \( (p = 0.165 \text{ and } p = 0.07, \text{ respectively}) \). A contour-enhanced funnel plot was created to qualitatively represent this result (Fig. 3).

<table>
<thead>
<tr>
<th>A. Was the method of randomization adequate?</th>
<th>Yes†</th>
<th>Yes†</th>
<th>Yes†</th>
<th>Yes†</th>
<th>Yes†</th>
<th>Yes†</th>
<th>Yes†</th>
<th>Yes</th>
<th>No†</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Was the treatment allocation concealed?</td>
<td>Yes†</td>
<td>Yes†</td>
<td>Yes†</td>
<td>Yes†</td>
<td>Yes</td>
<td>NR</td>
<td>Yes†</td>
<td>Yes</td>
<td>No†</td>
</tr>
<tr>
<td>C. Were the groups similar at baseline regarding the most important prognostic indicators?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>D. Was the patient blinded to the intervention?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No†</td>
<td>Yes†</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>E. Was the care provider blinded to the intervention?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No†</td>
<td>Yes†</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>F. Was the outcome assessor blinded to the intervention?</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes†</td>
<td>Yes†</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>G. Were the cointerventions avoided or similar?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>H. Was the compliance acceptable in all groups?</td>
<td>Yes†</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes†</td>
<td>No†</td>
<td>Yes</td>
<td>Yes†</td>
</tr>
<tr>
<td>I. Was the dropout rate described and acceptable?</td>
<td>No†</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes†</td>
<td>Yes</td>
<td>Yes†</td>
</tr>
<tr>
<td>J. Was the timing of the outcome assessment in all groups similar?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>K. Did the analysis include an intention-to-treat analysis?</td>
<td>Yes†</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No†</td>
<td>Yes†</td>
<td>Yes†</td>
<td>Yes</td>
<td>No†</td>
</tr>
</tbody>
</table>

| Risk of bias score | 6   | 8   | 5   | 6   | 9   | 6   | 10  | 8   | 6   |

*NR = not reported. †Information obtained through direct communication with study author. ‡Analysis was not necessary to complete because there were no dropouts and no subjects switching between groups.
Discussion

In the sport of soccer, the ankle is one of the most frequently injured areas for both males and females. Many injury prevention programs have been developed in an attempt to reduce the rate of ankle sprains in the athletic population. This meta-analysis was initiated to identify the highest level of evidence for injury prevention programs developed for soccer players, to assess the quality of this body of literature, and to use empirical meta-analytical approaches to assess the true effectiveness of such programs. Overall, we found a significant protective effect in support of injury prevention programs for reducing ankle injuries in this athletic population.

Previous analysis of studies that assess the efficacy of ankle injury prevention programs is limited. Valovich McLeod reviewed the efficacy of reducing ankle sprains in adolescent athletes using balance training programs. In that investigation, only 4 studies (2 RCTs and 2 cohort studies) were identified, and the author concluded that these programs were moderately effective in reducing ankle sprains in this population. Thacker et al. conducted a comprehensive systematic review of the evidence on different interventions for preventing ankle sprains. They identified several major areas of prevention, including external ankle support, risk factors, and methods to prevent ankle sprains (including training). The authors concluded that some recommendations made in injury prevention studies could not be supported by the evidence; however, they stated that certain prevention exercises such as those targeting proprioception and strengthening are likely to...
reduce certain injuries. Recently, Schiftan et al. conducted a systematic review and meta-analysis that assessed the efficacy of proprioceptive training in preventing ankle sprains in athletes of multiple sports. An overall significant reduction in ankle injuries was found with use of proprioceptive training. The results of the study by Schiftan et al. are comparable with those of our current study, which found a significant protective effect of ankle injury prevention programs for soccer players. However, we are unable to comment on the role of individual elements of the injury prevention programs, the role of sex, or player skill level in our analysis. Our study was designed a priori to have an appropriate statistical power to detect differences in the rate of ankle injuries between athletes managed with injury prevention programs and those who were not. Subgroup analyses on these individual covariates would not have sufficient power for detection. Furthermore, several studies have advised against the use of subgroup analyses as the multiplicity of these analyses leads to spurious results and are a risk for a false-positive result that may mislead the reader. Additionally, many authors have raised concern for outcome reporting bias in publications when multiple subgroups are analyzed but are not the primary outcome of a study design. Therefore, these analyses were not performed in our study.

The current study had several limitations. In regard to the types of studies analyzed in this meta-analysis, there was minimal methodological heterogeneity; however, one can never control all elements of clinical heterogeneity. We attempted to control for this by limiting our cohort to a single sport—soccer. There was also a wide variation among age groups studied, ranging from children to adults. Furthermore, the competition level also varied from recreational to professional. One variable that we did try to control for was study design. Prospective cohort (Level-II) studies also are available in the literature, but they were excluded in this analysis because of the lower level of evidence. Although our statistical analysis suggested no evidence of publication bias, there did appear to be qualitative asymmetry of the funnel plot. There are various explanations for this asymmetry, including the degree of statistical heterogeneity, the number of studies included in the meta-analysis, and small-study effects. The data abstractors for the current study were not blinded to the studies they were reviewing. However, this is not a standard advised by the PRISMA protocol, and there is no evidence that this extra step affects outcomes.

In conclusion, this meta-analysis of ankle injury prevention programs in soccer players found an overall, significant protective effect for reducing ankle injuries in soccer athletes. To our knowledge, this is the first meta-analysis of Level-I RCTs of ankle injury prevention programs for soccer players. The findings of this meta-analysis support the use of these interventions to prevent ankle injuries in these athletes.

The clinical trials that assess the efficacy of injury prevention programs are difficult to conduct, and the researchers who do so are to be congratulated. We encourage further research in this area, and we urge future researchers to follow the guidelines established in the CONSORT (Consolidated Standards of Reporting Trials) statement.

### Appendix

A summary of the search strategy for studies on ankle injury prevention programs for soccer players is available with the online version of this article as a data supplement at jbs.org.

\[ \text{Note: The authors thank Mary McFarland of the Eccles Health Science Medical Library for assisting with the development of a sensitive search strategy for this study.} \]

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### References


