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Review

The effectiveness of proprioceptive training in preventing ankle sprains in sporting populations: A systematic review and meta-analysis

Gabriella Sophie Schiftan, Lauren Ashleigh Ross, Andrew John Hahne*

Department of Physiotherapy, La Trobe University, Australia

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ABSTRACT

Objectives: To systematically summarise the evidence on the effectiveness of proprioceptive training in reducing the incidence and recurrence rates of ankle sprains in the sporting population.
Design: A systematic review and meta-analysis of randomised controlled trials.
Methods: A computer-based literature search of MEDLINE, EMBASE, CINAHL, SPORTDiscus and PEDro (to October 2013) was conducted. Methodological quality of individual studies was assessed using the PEDro scale. Meta-analysis was performed on eligible studies to produce a pooled estimate of the effectiveness of the intervention.
Results: Seven moderate-to-high quality randomised controlled trials involving 3726 participants were included. Results of the meta-analysis combining all participants, irrespective of ankle injury history status, revealed a significant reduction of ankle sprain incidence when proprioceptive training was performed compared to a range of control interventions (relative risk = 0.65, 95% CI 0.55–0.77). Results favouring the intervention remained significant for participants with a history of ankle sprain (relative risk = 0.64, 95% CI 0.51–0.81). Results looking exclusively at primary prevention in those without a history were also statistically significant (relative risk = 0.57, 95% CI 0.34 to 0.97), although the pooled effect was obtained from two non-significant trials.
Conclusions: Proprioceptive training programmes are effective at reducing the rate of ankle sprains in sporting participants, particularly those with a history of ankle sprain. Current evidence remains inconclusive on the benefits for primary prevention of ankle sprains.

1. Introduction

Ankle sprains are the most common sports-related injury.[1] They are especially prevalent in sports requiring frequent jumping, directional changes and pivoting such as basketball, football, soccer, handball, netball, and volleyball.[1] Ankle sprains often result in pain, disability, dysfunction, time lost from activity, the requirement for treatment, and economic burden.[2–4] Furthermore, athletes who sprain their ankle are prone to reinjure the same ankle,[3,5,6] with recurrent ankle sprains commonly leading to ongoing impairment and chronic instability.[4,5,7]

Popular interventions for preventing ankle sprains include tape, ankle braces, evertor muscle strengthening and proprioceptive training.[5,8] Braces and tape have been shown to be effective preventive methods against ankle sprains,[5,8,9] however, they do have disadvantages. For example, there is some evidence that braces may hinder elements of athletic performance,[9,10] while taping needs to be skilfully applied, loosens with activity, and can irritate the skin.[9,11] Exercise programmes may avoid those disadvantages, although compliance is a potential barrier.[5,12] Athletes may also choose to utilise several preventative measures in conjunction, such as taping and an exercise programme.[5]

Proprioception is a complex neuromuscular process concerned with the internal kinaesthetic awareness of body position and movement.[13,14] It is reliant on appropriate afferent and efferent signalling and plays an important role in joint stability and injury prevention.[13,15] Proprioceptive training involves exercises that challenge the ability of the targeted joint to detect and react to afferent input regarding joint position.[13,15,16] Examples of proprioceptive exercises include balancing on a wobble board or ankle disc, throwing and catching or dribbling a ball whilst in single leg stance, or balancing with eyes closed.[11,17,18] There is evidence showing that one's risk of suffering an ankle sprain is doubled in

* Corresponding author.
E-mail addresses: a.hahne@latobe.edu.au, andrewhahne@gmail.com (A.J. Hahne).

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the year following initial injury.[6,19] It is theorised that impaired proprioception in the injured joint pre-disposes it to re-injury.[20,21] Proprioceptive training aims to improve the capabilities of this system in order to prevent primary and secondary ankle injuries.

Several systematic reviews have explored the effectiveness of exercise programmes for the prevention and management of ankle sprains.[5,12,15,22–26] Components of these exercise programmes have included proprioceptive training, strengthening, agility, plyometrics, sport-specific exercises or a combination of several components (with the later often called neuromuscular training).[5,26] While most existing reviews have concluded that exercise programmes reduce ankle sprain injuries,[5,12,23,24,26] no reviews have focussed exclusively on the effects of proprioceptive training alone without the addition of co-interventions such as strengthening, plyometrics or agility training. It has been hypothesised that proprioceptive exercises may be the most important component of ankle rehabilitation programmes,[5] but to date the isolated effect of proprioceptive training has not been evaluated in a systematic review.

The purpose of this systematic review was to determine whether proprioceptive training as a sole intervention is effective for reducing the incidence or recurrence rate of ankle sprains among sporting populations.

2. Methods

A systematic review was performed using the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[27] and the Cochrane handbook.[28] Ethical approval was not required for this review.

A computerised literature search was performed in October 2013 using MEDLINE, EMBASE, CINAHL, SPORTDiscus and the Physiotherapy Evidence Database (PEDro). Search terms were developed in order to identify proprioceptive training programmes for the ankle joint in sporting populations. Full search terms for MEDLINE are presented in Supplemental File 1. Filters were utilised to limit results to human participants and studies published in English. No limitations were imposed on the date of publication. Additionally, the reference lists of all the selected publications and relevant systematic reviews were screened to retrieve any additional studies. As terminology for balance, proprioceptive and neuromuscular training is often used interchangeably,[24,26] we searched for all terms but only included studies that focussed solely on proprioceptive training (exercises to challenge the detection and maintenance of ankle joint position) without the addition of adjunct interventions such as muscle strengthening exercises.

Studies were included if they met the following criteria: (1) the study design was a moderate-to-high quality randomised controlled trial with a PEDro score of at least 4/10,[29] (2) participants were involved in recreational or professional sport, with or without a history of ankle sprain, (3) the intervention group received exclusively a proprioceptive training programme with no other adjunct interventions and was compared to a control group who did not receive proprioceptive training and (4) incidence or recurrence rate of ankle sprain was reported as an outcome measure.

Search results were stored and organised using the EndNote X6 computer software (Thomson-Reuters). Duplicates were removed and two authors (GSS & AJH) independently reviewed the studies for eligibility based on title and abstract. Studies deemed potentially eligible by at least one reviewer were then assessed independently by both reviewers for eligibility based on the full text. Any disagreements were to be resolved by consensus with the third author (LAR), however, this was not required.

The methodological quality of the included studies was assessed using the Physiotherapy Evidence Database (PEDro) scale. The scale is used to rate studies from 0–10 according to 10 methodological criteria (Supplemental File 2). This appraisal tool was chosen because it has been shown to provide sufficient reliability and validity for use in systematic reviews of physiotherapy related RCTs.[30,31] The scale was applied independently by two reviewers (GSS & AJH), with any differences in an article's assigned score being resolved by consensus.[28] For this review, it was considered unlikely that participants, therapists or assessors would be blinded to the intervention; therefore, a maximum score of 7 was predicted. With this in mind, studies scoring 6 or 7 were considered to be of 'excellent' quality, those scoring 5 were deemed 'good' quality and a score of 4 was felt to be of 'moderate' quality. Studies scoring less than 4 were considered to be of 'poor' quality and were excluded from the review.[29]

Two reviewers (GSS & LAR) independently extracted data from each included study. The data extracted included the number of participants, the nature, frequency and duration of the intervention received, details of the control group, follow-up periods and incidence rates of ankle sprain injuries. Relative risks (RR) and numbers needed to treat (NNT) were calculated using the PEDro confidence interval calculator (www.pedro.org.au). Data were assessed for statistical heterogeneity, which was considered likely if p-values of <0.1 were obtained on the X^2 test, or if the I^2 statistic was >25%.[32,33] Trials that were deemed to be statistically homogenous were subjected to meta-analysis. Meta-analyses were undertaken with RevMan 5.2 using a random-effects model. It was planned to undertake a pre-specified subgroup analysis that divided effects into those relating to participants with a history of ankle sprain and those without a history. Additional data were sought from authors of eligible studies for this purpose if it was not available within the article.

3. Results

Electronic database searches yielded 345 studies after the removal of duplicates (Fig. 1). Eighteen articles underwent full-text review. Eleven of these studies were excluded for the following reasons: they were not completed randomised controlled trials,[34–38] the proprioceptive training administered consisted of adjunct interventions (e.g. evertor strengthening),[39,40] the control group also received proprioceptive exercises,[41] or the study scored less than 4/10 on the PEDro scale.[42–44] This left seven total studies (involving 3726 participants) for inclusion in the final analysis.[11,18,45–49] One author provided additional data for the purposes of the planned subgroup analysis.[11] Characteristics of the included studies are presented in Table 1.

The PEDro scores of the included studies ranged from 4 to 7, with an average score of 5.4/10 (see Supplemental File 2 for individual scores). Using our PEDro score grading system, three articles were considered to be of "excellent" quality (scoring 6 or 7),[18,46,47] two were considered good quality (scoring 5),[11,48] and two were rated as moderate quality (scoring 4).[45,49]

The seven trials were found to be statistically homogenous, allowing for meta-analysis to be undertaken. Results of the meta-analysis revealed a statistically significant reduction in ankle sprains favouring the proprioceptive training group (7 trials, RR = 0.65, 95% CI 0.55–0.77) (Fig. 2 – top). This represented a pooled number needed to treat (NNT) of 17 (95% CI 33–11), indicating that 17 athletes would need to undertake proprioceptive training in order for one ankle sprain to be prevented. Comparison interventions included usual care/warm-up routines, strength training and an orthosis. When results were sub-divided to look at the secondary preventative effects of proprioceptive training on those exclusively with a history of ankle sprain, results were similarly in favour of the intervention (4 trials, RR = 0.64, 95% CI 0.51–0.81; NNT = 13,