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Review

The effect of ankle taping or bracing on proprioception in functional ankle instability: A systematic review and meta-analysis

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Abstract

Objectives: To determine if wearing an ankle brace or taping the ankle, compared to no brace or tape, improves proprioceptive acuity in people with a history of ankle sprain or functional ankle instability.
Design: Systematic review and meta-analysis.
Methods: Studies using controlled, cross-over designs whereby participants who had sprained their ankle at least once or had functional ankle instability, underwent some form of proprioceptive sensation testing with and without ankle brace or tape, were included. Proprioceptive acuity was reported for the ankle tape/brace condition and the condition where no tape or brace was worn. Meta-analysis was employed to compare proprioceptive acuity with and without ankle tape/brace.
Results: Eight studies were included in the review. Studies measured either sense of movement or sense of joint position. The mean differences in 19 of 32 comparisons were not significant. Of the remaining mean differences, 10 were positive, indicating better proprioceptive acuity in the taped/braced condition and 3 were negative, indicating poorer proprioceptive acuity. Overall, there was no significant effect with ankle tape/brace compared to the no tape/brace condition (mean difference: 0.08°, 95% CI: −0.39 to 0.55). This finding was consistent when the two aspects of proprioception (sense of movement or joint position) were considered separately.
Conclusions: The pooled evidence suggests that using an ankle brace or ankle tape has no effect on proprioceptive acuity in participants with recurrent ankle sprain or who have functional ankle instability.

Keywords: Chronic ankle instability; Functional ankle instability; Prophylaxis

1. Introduction

Ankle injuries are among the most common sports-related injuries, accounting for up to 20% of injuries.[1] Ankle sprains account for 33–73% of ankle injuries.[1] The serious consequences of a sprain include ongoing instability and sprain recurrence,[2] although it is not known what physiological changes following the original sprain predispose an individual to these consequences. One hypothesis is that proprioception, which refers to a group of sensations including sense of movement, sense of joint position and sensations related to muscle force,[3] is impaired following the first ankle sprain.[4,5] Freeman and Dean[4] proposed that injury to the articular structures as a result of ankle sprain damage the articular receptors. They further proposed that the resultant disruption of afferent information arising from the damaged mechanoreceptors affects the ability to detect the range of sensations that contribute to proprioceptive acuity, in particular sense of movement and of joint position.[6] In support of this theory, several studies found a deficit in aspects of proprioception among participants with post-sprain ankle instability; using meta-analysis, Munn et al.[7] found a pooled mean difference of 0.7° (95% CI 0.2–1.2°) for passive joint position sense and 0.6° (95% CI 0.2–1.0°) for active joint position sense.

Ankle tape or an ankle brace is used by those who have experienced an ankle sprain as a means of preventing

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further injury.[8] Taping or bracing is thought to enhance proprioceptive acuity by increased stimulation of the cutaneous mechanoreceptors.[9] But in those studies which have measured proprioceptive sensations in participants with a history of ankle sprain, findings are varied, with some studies reporting improvements[10] and others reporting no change[6] or worse[11] proprioceptive acuity when taped or braced. By pooling these studies, however, it may be possible to make an overall assessment of the effectiveness of ankle taping or bracing and to determine if any specific factors, such as aspect of proprioception measured, explain the varied findings. Therefore, the aim of this study was to conduct a systematic review of controlled, cross-over studies to determine whether ankle taping or bracing compared to no taping or bracing improves proprioception in people with a history of ankle sprain or functional ankle instability.

2. Methods

Inclusion criteria were studies that (i) included participants who had sprained their ankle at least once or had functional ankle instability, defined as repeated episodes of the ankle 'giving way' following a history of ankle sprain; (ii) included a condition where tape or a brace was used on the sprained ankle and there was a control condition where no tape or brace was used on the same ankle; (iii) measured acuity of one or more of the proprioceptive sensations, e.g. threshold for detection of passive movement, position matching, active or passive joint position sense, movement discrimination, under both the tape/brace and control conditions; and (iv) used a controlled cross-over design. Intervention studies where taping or bracing was applied for a prolonged period, e.g. days or weeks, were included if a relevant outcome measure of proprioceptive acuity was obtained at either baseline or post intervention under controlled cross-over conditions. Studies were excluded if proprioceptive acuity was measured within three weeks of the most recent sprain. Furthermore, tests of balance, sway, peroneal reaction time or other non-specific tasks were not considered to be tests of proprioceptive sensations specifically.

The databases of MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, AMED (via OvidSP), CINAHL, SPORTDiscus (via EBSCO), PEDro and Web of Science were searched from the earliest record until March, 2012 with no language restriction imposed. Combinations of key words related to ankle sprain (e.g. ankle, instability, injury, and sprain), proprioception (e.g. kinaesthesia, movement detection, and position sense) and the tape/brace intervention (e.g. brace, tape, orthosis, and bandage) were used. The keywords from each of these three categories were combined with 'AND' (see Fig. 1 – supplementary material for MEDLINE search strategy). Bibliographies of all papers retrieved for evaluation following the electronic search were also examined. A citation search of all included papers was also performed using the Science Citation Index.

All studies identified by the search strategy were independently screened against the eligibility criteria by two researchers (combinations of JR, LN, CH) unblinded to authors' identity. Studies were first screened by title and abstract and those studies which could not be eliminated were retrieved for further evaluation. Any disputes were resolved by discussion or by a fourth researcher (KR) if a consensus could not be reached. Studies reported in abstract format were only included if all the required information could be determined. Where published papers provided insufficient information, we attempted to retrieve the necessary information via contact with authors.

Data extraction was performed independently by two researchers (JR, KR) with discrepancies resolved by consensus. Consensus data are presented in this systematic review. The data extracted related to sample size, participants' characteristics (age, height, weight, sprain history, and population), intervention characteristics (type of prophylaxis, how it was applied in the case of tape/bandage) and outcome measurements (aspect of proprioception measured, measurement procedure and the outcome measure reported).

Study quality was assessed using the Downs and Black scale.[12] We used 14 of the 27 criteria which logically applied to crossover study designs. Study quality was assessed independently by two researchers (JR, CH) with differences resolved by consensus. No study was excluded and no additional analysis was undertaken on the basis of the assessment of study quality.

2.1. Data analysis

The mean difference (with 95% CI) for all pairwise comparisons available in a study was calculated as the difference between the mean proprioceptive acuity scores (in degrees) from the tape/brace and the control conditions. A negative mean difference indicated poorer proprioceptive acuity in the tape/brace condition. Standardized mean differences, or effect sizes, and 95% CI were also calculated using the Hedges' g adjustment for small sample size bias. The mean difference was used as the primary measure of the benefit of tape/brace on proprioception. The I^2 measure of inconsistency was used to examine between-study variability.[13] No analysis was conducted for publication bias due to the small number of studies included in this review and the likelihood that this would lead to an inappropriate interpretation of the outcome.[14]

2.2. Meta-analysis

As all studies included multiple pairwise comparisons, decision rules were applied to prioritise the data to be used in the meta-analysis. If a study used multiple velocities,

reproduction angles or test conditions (i.e. tape compared with flexible and/or semi-rigid brace), the velocity, angle and test condition which permitted comparison between the greatest number of studies was selected. Inversion measurements were preferred over eversion measurements if the directions were not pooled. These decision rules were determined after data extraction, but before calculation and consideration of the mean differences and effect sizes to avoid any bias in study selection. The mean differences across studies were combined where possible using a random-effects model to derive pooled estimates of the effect of tape/brace. In addition to calculating the pooled estimate for all studies, several additional analyses were also undertaken. Proprioception was compared between (i) the different aspects of proprioception measured; (ii) the different directions of movement within each aspect of proprioception; and (iii) the different directions of movement regardless of aspect of proprioception measured. Only the first of these additional analyses was planned a priori. All analyses were conducted using Comprehensive Meta-analysis, version 2 (Biostat Inc., Englewood, NJ). The mean differences and effect sizes are presented for all pairwise comparisons in Table 4 (supplementary material), however, only those comparisons used to derive the pooled estimates are presented in the forest plots.

3. Results

The electronic search yielded 672 studies (Fig. 1). After removal of duplicates and elimination of studies on the basis of title and abstract, 52 studies were retrieved for evaluation. Of the 52 studies retrieved, 44 were excluded; 41 on the basis of the eligibility criteria, one because the data we required were unable to be retrieved following unsuccessful attempts to contact the author and two due to repeated data sets. The remaining eight studies measured an aspect of proprioception in participants with ankle sprain and/or functional ankle instability both with and without ankle tape/brace and were included in the analyses.

Details of each included study are presented in Tables 1, 2 and 4 (supplementary material). All data in Tables 1 and 4 are presented as mean ± standard deviation (SD), or as mean and range if a SD was not provided or could not be calculated. Calculated mean difference and effect sizes with 95% CI are also presented in Table 4.

All studies included relatively young adults who had a history of ankle sprain and/or ankle instability (see Participant characteristics; Table 1 – supplementary material). Information regarding ankle sprain history and ankle instability was in most cases clearly reported; however, there was little consistency across studies in terms of the ankle injury eligibility criteria. Three studies included participants based on sprain history only,[6,11,15] two studies based on functional instability only[10,16] and three studies based on both sprain and functional instability.[17–19] Five studies provided clear quantitative criteria on the number of sprains required for inclusion, for example, ≥2 sprains,[17] ≥1 sprain,[15,18] or ≥3 sprains with at least one in the previous 2 years.[6,11] Three studies required participants to have symptoms of functional ankle instability in addition to a history of ankle sprain[16–18] and one further study stated that participants presented with functional instability, but it was not reported how this was defined.[15]

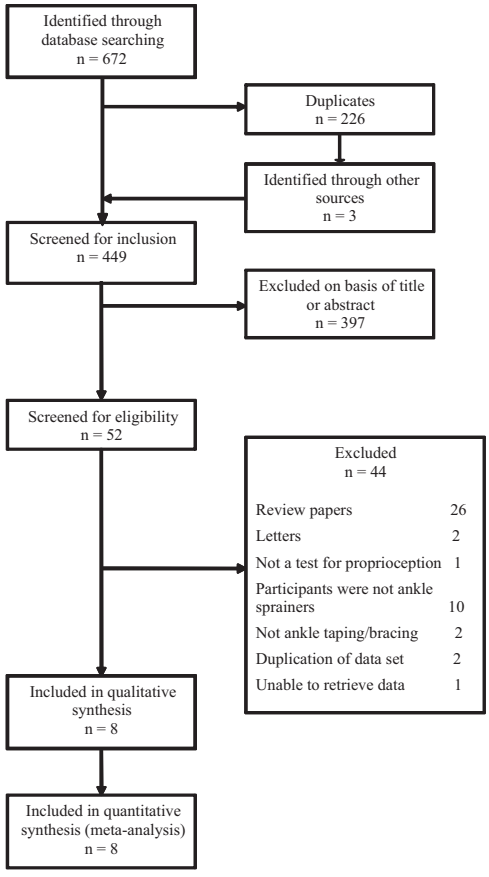

Fig. 1. Flow diagram illustrating selection of studies for inclusion in the systematic review.

Each study compared proprioceptive acuity under an ankle taping or bracing condition with a control (no tape/no brace) condition (see Test conditions; Table 2 – supplementary material). Five studies examined one or more types of bracing in addition to taping.[10,16–18,19] In one of these studies, this examination was made in independent groups; that is one group of participants underwent a tape condition and a control condition and a separate group of participants underwent a brace condition and a control condition.[18] In those studies which examined the effect of more than one type of bracing, both a flexible brace and semi-rigid brace were used.[10,16,17] In total, four studies included a flexible brace[10,16,17,19] and fours studies included a semi-rigid brace.[10,16–18] The method of tape application was inconsistent between studies; two studies used a basketweave application[10,16] whereas three studies used combinations of basketweave, heel-lock, stirrups and figure-6 applications.[6,11,15,18]

Three studies measured passive movement detection and five studies measured joint position sense. Of the three studies which measured passive movement detection, two examined inversion and eversion movements[11,16] and one examined plantarflexion and dorsiflexion movements.[6] Two studies reported proprioceptive acuity as the 70% threshold for detection of movement,[6,11] with the remaining study reporting the angular displacement required to detection of movement.[16] The precision of the measurement may have contributed to the relative differences in the magnitude of the standard deviations, with the equipment of Refshauge et al.[6,11] capable of measuring displacements in 0.1° increments, but that of Hubbard and Kaminski[16] only able to measure in 0.5° increments.

Of the five studies that measured joint position sense, two examined active reproduction of a passively positioned ankle (same foot used), with movements into inversion.[10,17] One study examined active reproduction of an actively positioned ankle (same foot used), with movements into inversion and plantarflexion.[15] One study examined estimation of the joint angle following a passive reproduction of a passively positioned ankle (same foot used), with movements into inversion.[18] The remaining study[19] matched movement of the passively positioned right ankle with the left ankle, although it was not stated whether the matching movement on the left was active or passive. The direction of movement was also not clearly stated, although it can be deduced from the discussion that the movements were into plantarflexion. Finally, this study did not report which ankle suffered repetitive sprain or functional instability, or if indeed both ankles were injured, meaning that it was not clear whether the injured ankle was the ankle responsible for matching the original movement.

With respect to study quality, the two assessors agreed on 90% of the items and reached consensus on the remainder. The scores for study quality ranged from 5 to 11 out of 14 items assessed, although 7 of the 8 studies scored from 9 to 11 (Table 3 – supplementary material). The study which scored 5 out of 14 items[19] did not sufficiently or clearly describe the participants, interventions, or outcomes. No study included a representative sample, or made an attempt to blind the assessors.

Mean differences, effects sizes and 95% CI were able to be calculated for all comparisons within all the included studies (Table 4 – supplementary material). The mean differences and effect sizes in 19 of 32 comparisons were not significant. Of the 13 comparisons that reported significant effect sizes and mean differences, 10 were positive, indicating better proprioceptive acuity in the taped/braced condition and 3 were negative, indicating poorer proprioceptive acuity. All significant negative effects occurred in the taped condition while the significant positive effects occurred with both taped and braced conditions. Furthermore, all significant negative effects occurred when proprioception was measured using threshold to movement detection whereas all significant positive effects occurred when proprioception was measured using joint position sense.

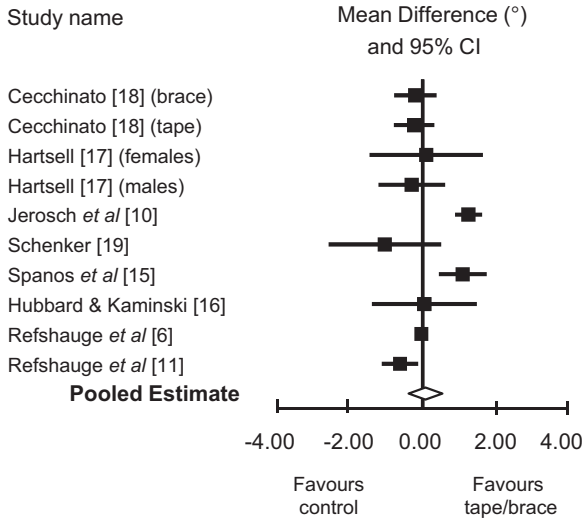

Fig. 2. Mean difference and 95% CI for all comparisons included in the meta-analysis and pooled estimate (random effects model). Positive values favour tape/brace. Negative values favour control.

3.1. Effect of tape/brace on proprioception (meta-analysis)

When considering both measured aspects of proprioception together, there was no significant effect of ankle tape/brace. The mean difference was 0.08°, 95% CI: −0.39 to 0.55 (Fig. 2). There was significant heterogeneity among the studies ($I^2 = 87\%$, $p < 0.001$).

3.2. Effect of tape/brace on different aspects of proprioception (meta analysis)

There was no significant effect with ankle tape/brace when proprioception was measured as either joint position sense or threshold to movement detection. For joint position sense studies, the mean difference was 0.20°, 95% CI: −0.49 to 0.88 (Fig. 3). There was significant heterogeneity among the studies ($I^2 = 86\%$, $p < 0.001$). For threshold to movement detection studies, the mean difference was −0.24°, 95% CI: −0.71 to 0.23 (Fig. 3). There was significant heterogeneity among the studies ($I^2 = 64\%$, $p < 0.001$).

3.3. Effect of tape/brace on different directions of movement within each aspect of proprioception (meta analysis)

For studies which measured joint position sense, there was no significant effect with ankle tape/brace when proprioception was measured in the inversion/eversion plane or the plantarflexion/dorsiflexion plane. For inversion/eversion, the mean difference was 0.33°, 95% CI: −0.37 to 1.03 (Fig. 2 – supplementary material). There was significant heterogeneity among the studies ($I^2 = 87\%$, $p < 0.001$). For plantarflexion/dorsiflexion, the mean difference was −1.04°,

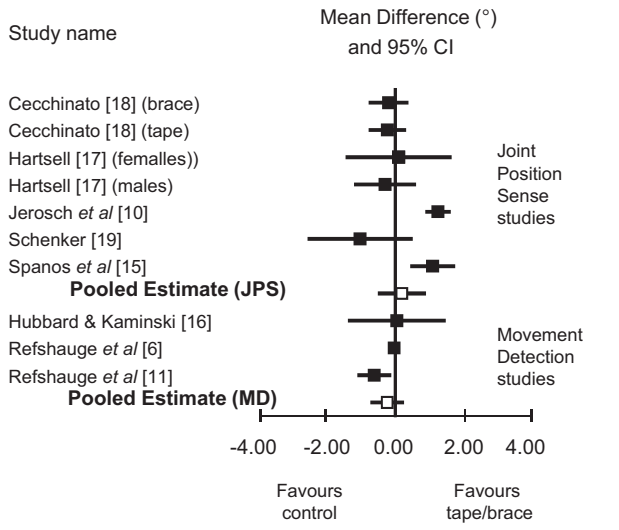

Fig. 3. Mean difference and 95% CI for all comparisons included in the meta-analysis and pooled estimates (random effects model) for joint position sense (JPS) studies and movement detection (MD) studies. Positive values favour tape/brace. Negative values favour control.

95% CI: −2.57 to 0.49 (Fig. 2 – supplementary material). The I^2 statistic was not calculated as only one study measured joint position sense in the plantarflexion/dorsiflexion plane.

For studies which measured threshold to movement detection, there was a negative effect with ankle tape/brace when proprioception was measured in the inversion/eversion plane, but not in the plantarflexion/dorsiflexion plane. For inversion/eversion, the mean difference was −0.55°, 95% CI: −1.00 to −0.10 (Fig. 3 – supplementary material). There was no evidence of heterogeneity among the studies ($I^2 = 0\%$, $p = 0.380$). For plantarflexion/dorsiflexion, the mean difference was −0.03°, 95% CI: −0.17 to 0.11 (Fig. 3 – supplementary material). The I^2 statistic was not calculated as only one study measured threshold to movement detection in the plantarflexion/dorsiflexion plane.

3.4. Effect of tape/brace on different directions of movement (meta analysis)

When considering both measured aspects of proprioception together, there was no significant effect with ankle tape/brace in either the inversion/eversion plane or the plantarflexion/dorsiflexion plane. For inversion/eversion, the mean difference was 0.17°, 95% CI: −0.48 to 0.82 (Fig. 4 – supplementary material). There was significant heterogeneity among the studies ($I^2 = 88\%$, $p < 0.001$). For plantarflexion/dorsiflexion, the mean difference was −0.24°, 95% CI: −1.04 to 0.56 (Fig. 4 – supplementary material). There was no significant heterogeneity among the studies ($I^2 = 40\%$, $p = 0.19$).

4. Discussion

This systematic review examined evidence for the effect of wearing ankle tape or an ankle brace on proprioception in people with a history of ankle sprain or functional ankle instability. Within each study, multiple comparisons were made between an ankle tape/brace and a control condition. Of 32 comparisons in total, 19 found no difference between conditions, 10 indicated proprioceptive acuity was improved with application of tape or a brace and 3 indicated proprioceptive acuity was worse. Using meta-analysis, we found no significant effect of ankle tape/brace on proprioception. We also found no significant effect with ankle tape/brace when considering different aspects of proprioception measured (joint position sense and threshold to movement detection) or different directions of test movements, except for a significant negative effect when threshold to movement detection was measured in the inversion/eversion plane (mean difference: −0.55°, 95% CI: −1.00 to −0.10). While ankle taping or bracing has been shown to reduce the risk of re-spraining the ankle,[8] this reduction in risk is not likely to be due to enhanced proprioception. Instead the mechanism for effect probably lies elsewhere and may involve the effect that ankle taping or bracing has on restricting joint range of motion,[20,21] reducing mechanical instability[22] or improving confidence during functional tasks.[23]

In a previous systematic review examining ankle taping only, Hughes and Rochester[24] were unable to reach a conclusion about the effect on proprioception due to the small number of studies of limited methodological quality. However, of the four studies which were included, only one specifically measured an aspect of proprioception,[6] while the others measured the output side of a reflex into which proprioceptive sensations comprise just one input, i.e. peroneal muscle reaction time in response to a simulated ankle sprain[25] or postural sway.[26,27] Our study, on the other hand, included only those studies that measured an aspect of proprioception, such as sense of movement, sense of joint position and sensations related to muscle force, according to the definition of Gandevia.[3] In our review we also included additional studies that were not included in the Hughes and Rochester review.[24] Jerosch et al.[10] and Hubbard and Kaminski[16] were not included by Hughes and Rochester,[24] however, in these studies a taping intervention was used, an aspect of proprioception was measured and participants had recurrent ankle sprain and functional ankle instability. Therefore our review has identified a larger number of papers relevant to the effect of taping (and bracing) on proprioception and was more specific, only including those studies which assessed proprioception.

It is of interest to note that when all 32 pairwise comparisons are examined (Table 4 – supplementary material), all significantly positive effects on proprioception were from studies that measured joint position sense, whereas all significantly negative effects were from studies that measured threshold to movement detection. This observation is

consistent with previous work which has found that different aspects of proprioception are not well correlated in participants with recurrent ankle sprain.[28] From a physiological viewpoint, this may not be surprising as it has previously been shown that signals for movement and for position at the elbow may follow different processing lines.[29] Alternatively, de Jong et al.[28] suggested that pathological differences following injury might also influence how well a person performs during a test of proprioception. It is impossible to assess whether there was any relationship between severity of injury or pathological consequences of injury and proprioceptive acuity for this systematic review because these variables were inconsistently reported across studies. However, it may be of interest in the future to examine whether the effect of ankle taping or bracing on proprioceptive acuity is influenced by the severity or pathological consequences of the injury as this would enable clinicians to understand whether there is a subset of people with a history of ankle sprain or functional ankle instability for whom taping or bracing the ankle might improve proprioception.

An alternative explanation for the differences in direction (positive versus negative) of the significant effects between joint position sense studies and movement detection studies may relate to the type and way in which the tape/brace was applied. The 10 significant positive effects, all from studies which measured joint position sense, came from trials of braces, both semi-rigid and rigid, and of tape (basketweave application). Conversely, the 3 significant negative effects sizes occurred in trials that only used taping and that used a different method of application to those in the joint position sense studies.[11] It is possible that the way in which the tape was applied may not have provided coherent signals via the cutaneous receptors, thereby adding "noise" to the system, consequently reducing proprioceptive acuity.[11] This noise may only affect the ability to detect movements, or alternatively, the type of taping and bracing used in the joint position sense studies may not have induced noise.

Most studies provided extensive and clear descriptions of the inclusion criteria related to participants' history of ankle injury, however there was little consistency in inclusion criteria between studies. Furthermore, beyond this minimum number and severity of sprains required for inclusion, no study reported the number and severity of ankle sprains sustained by participants. The potential heterogeneity in the pool of participants included in this systematic review may be one explanation for the inconsistent results across studies and the high level of heterogeneity found with the I^2 statistic. Recently, Delahunt et al.[30] reported on the broad range of inclusion criteria used in studies which recruited participants with chronic problems following ankle sprain. The range of criteria included varying numbers of ankle sprain episodes and the presence of 'giving way', pain, weakness, instability and decreased function. In our review, we found a similarly broad range of criteria; while all studies included participants with a history of ankle sprain, the number of repeat sprains varied; only some studies stipulated that their participants also had to exhibit symptoms of functional instability, although it is possible that the authors simply failed to report it. Based on the findings of Delahunt et al.,[30] there is no universal definition for chronic problems after ankle sprain, or for inclusion/exclusion criteria, and this makes comparisons and pooling of data in systematic reviews problematic. Furthermore it has recently been proposed that there are seven subgroups of participants with chronic problems following ankle sprain.[31] Such heterogeneity among participants might be reduced if they were to be classified according to these groups.

The main limitation associated with this review is that it combined studies despite differences in participants studied, the type of taping or brace used and the way in which proprioception was measured. There was significant heterogeneity in the pooling of studies, and in most instances, this was not eliminated in the additional analyses when the effects of some potential sources of heterogeneity were likely to have been isolated. However, the I^2 statistic, as with other tests of heterogeneity has low statistical power when only a small number of studies is combined.[32] Therefore, whether the presence of heterogeneity reflected that the variability among the study results was not due to chance or that the measure used to examine heterogeneity was not robust in the face of so few studies (never more than 10 datasets were combined) is unknown.

5. Conclusion

Wearing ankle tape or a brace has no effect on proprioception, and there is some evidence to suggest that proprioception may be worse in the inversion/eversion plane when proprioception is measured as threshold to movement detection. Although our findings do not support the common belief that proprioception is enhanced with ankle taping or bracing, taping and bracing the ankle should not be discouraged because the available evidence supports their use for preventing injury. It is likely, however, that this protective effect is not due to enhanced proprioception.

Practical implications

- Only a small number of studies exist which examine the effect of ankle tape or ankle brace on proprioceptive acuity of people who suffer repeated ankle sprain.
- Collectively, the evidence suggests that proprioceptive acuity at the ankle is not increased with the use of ankle tape or ankle braces in people who suffer repeated ankle sprain.
- The findings of this review do not discourage the use of ankle tape or ankle braces for preventing further injury by people who suffer ankle sprain.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jsams.2012.03.008.

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