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A Systematic Review on the Effectiveness of Different Functional Treatments for Acute Ankle Sprains

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Abstract

Background: An ankle sprain is a very common sport-related injury and can reduce participation in sports and employment. It can also create further complications in the function of the joint.

Purpose: To evaluate the effectiveness of different functional treatments and to ascertain which functional treatment is the most effective method for acute ankle sprains.

Study Design: Systematic review.

Methods: The design of this systematic review was developed in accordance with PRISMA-P 2015 statement and performed according to its guidelines. A computerized literature search was performed from PubMed Central, MEDLINE via OVID and Cochrane library. Randomized controlled trials or quasi-experimental studies, published within a ten-year period (2007 to 2017), in peer-reviewed journals, with full-text articles and written in English were included in this study. Any type of functional treatments being applied to treat acute ankle sprains were considered as an intervention and only adult participants were included in this review. Surgical methods, unpublished trials, not written in the English language or not experimental research were excluded.

Results: From the pooled data of this review, the stocking was more effective at improving pain, swelling, functional outcomes, range of motion, and return to sport/work, and had higher patient satisfaction than the bandage. There was no evidence that the taping and lace-up brace were more effective than other functional interventions in the treatment of acute ankle sprains. Furthermore, the prevalence of complications was greatest for the taping and lace-up brace interventions. The semi-rigid or posterior rigid support group had a better functional recovery and higher patient satisfaction, but some complications were present.

Conclusion: The semi-rigid or posterior rigid support group and stocking were the most effective functional interventions for acute ankle sprain treatment.

What is known about this subject: The functional treatments are becoming popular due to being effective, inexpensive and simplistic to apply. Different types of functional interventions have been used according to the choice of clinicians and patients in the treatment of ankle sprains. According to the previous researches, semi-rigid support, ankle braces, bandage and lace-up supports have greater advantages than other functional treatments from different perspectives (Example. the elastic bandage had a slower recovery rate than semi-rigid brace but less complications than taping, the lace-up support was better in swelling management than other functional treatments).

What this study adds to existing knowledge: This study found that the stocking is an effective treatment for managing acute ankle sprains. It is valuable for the patient because the cost of the stocking is considerably cheaper than other functional treatments and it is very easy to wear. Some popular functional treatments like lace-up support; taping and semi-rigid braces were shown to have some complications.

Keywords: Ankle sprains; Elastic bandage; Stocking; Tape; Lace-Up support; Semi-Rigid brace; External ankle support

Introduction

Ankle ligament sprains are a common sport-related injury, with 85% of ankle injuries being sprains [1]. Sustaining such an injury reduces participation in sports, could negatively impact employment and creates further complications in the function of the joint like instability [2]. A study in the United States reported an ankle sprain incidence rate of 2.15 per 1000 persons in a year [3]. In the UK, 3% to 5 % of accidence and emergency department patients were treated for an ankle sprain each day [4]. Appropriate management is crucial because the long-term residual symptoms are common and that could lead to prolonged absenteeism from regular activities [5].

The typical symptoms of acute ankle sprains are pain, inflammation or functional disability [6]. The process of ligaments healing is divided into three states: the inflammatory stage lasts for 10 days after the injury, the proliferation phase lasts for 4 to 8 weeks and the remodeling phase lasts for 1 year after trauma. However, the process might vary for each individual [7].

The mechanism of injury for ankle ligament sprains is typically a combination of abduction and inversion of the foot in planter-flexion position [8]. The severity of the injury can be categorised as grade I,

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II and III. A grade I sprain is a slight stretching of the ankle ligaments without any instability, a grade II sprain is a slight tear of the ligament and slight instability can be found, and a grade III sprain is the complete rupture of the ligaments and instability [9]. Generally, grade I and II ankle sprains are treated conservatively. Conversely, a grade III ankle sprain is a severe injury and there are several different treatment options such as immobilisation, surgery, physiotherapy and functional supports [10].

Even though many treatment options are suggested for an acute ankle sprain, the following three main treatment options are commonly used for the management of it: immobilisation, functional treatment and surgery [11]. However, most clinicians prefer non-surgical treatments [8] because surgical treatments have a larger cost implication, can lead to post-surgical complications and have prolonged sick-leave from work [12]. Functional treatment is described as an early mobilisation program combined with the usage of an external ankle support [13]. It protects the injured ankle by protecting the stress of scar tissue in the inflammatory period. After that period, it promotes alignment and strength of the new collagen tissues [14]. Currently, functional treatments are becoming popular due to being effective, inexpensive and simplistic to apply [15], with a survey reporting that 70% of medical practitioners have been using functional interventions for treatment of ankle sprains [16].

A study by Kerkhoffs et al. [17] evaluated the effectiveness of functional treatments, stating that patient satisfaction and other outcomes were better than immobilisation as a treatment for ankle sprains. Moreover, the data from a randomised controlled trial showed that surgical treatment had greater long-term complications than functional treatments [18].

From a clinical point of view, there is much evidence to support the belief that functional treatment is an effective therapy for acute ankle sprains. However, evidence is still needed to evaluate which kind of functional treatment is best. Peterson et al. [8] pointed out that the semi-rigid brace effectively protects a sprained ankle and is an effective treatment for acute ankle sprains. Nonetheless, the limited number of trials and insufficient data prevents definitive conclusions regarding the effectiveness of functional treatments for acute ankle sprains. A systematic review evaluated that ankle brace was more effective in reducing swelling than other functional treatments, but interpreting the conclusions must be done with caution due to the heterogeneity of included studies [2]. The different functional treatments for acute ankle sprains were assessed in a systematic review. The elastic bandage had a slower recovery rate than semi-rigid brace but fewer complications than taping. The lace-up support was better in dealing with swelling than other functional treatments [12]. Nevertheless, the findings of the review could not clearly indicate the most effective method, as there were no study selection criteria relating to injury severity or follow-up periods.

Since functional treatments are frequently applied in treatment of ankle sprains, it is necessary to evaluate which functional treatment is most effective for managing ankle sprain symptoms and outcomes. Therefore, the aim of this study was to systematically review the effectiveness of different functional treatments and to ascertain which functional treatment is the most effective method for acute ankle sprains.

Methods

The design of this systematic review was developed in accordance with PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 statement and performed according to its guideline [19].

Search strategy

Two reviewers independently performed a computerized literature search from PubMed Central, MEDLINE via OVID and Cochrane library. Firstly, the literature search was simply started with 'ankle sprains' [MeSH term] 'AND' 'treatment'. Then, 'elastic bandage', 'stocking', 'taping', 'elastic taping', 'lace-up support', 'semi-rigid brace', 'ankle support' and 'effective', keywords were searched individually or combined with the initial search strategy by using Boolean search terms 'AND' and 'OR'.

Study selection

Experimental studies like Randomized Controlled Trials (RCT) and quasi-experimental studies (allocation performed with the date of birth, alteration or record numbers) were considered for this study. Moreover, the studies published within ten-year period (September 2007 to September 2017), peer-review journals, full-text articles and written in English were only included in this study. The study time period of each study had at least 28 days to final outcome measure. The time lost from play in severe ankle sprain is >28 days, whereas in a moderate case is <28 days [20]. Therefore, only studies that had at least 28 days from injury until the final outcome measure were used to ensure an appropriate time period had been used to evaluate the treatment effect of the intervention. Studies were independently chosen by the two reviewers if there was any disagreement; it was solved with consensus or took opinion from a third collaborator.

Type of participants

Adult skeletally mature participants with acute ankle sprain are participated in this review. An acute ankle sprain means the cause of the injury had to be due to a 'one-off, identifiable event. The ankle sprain is defined as partially or completely torn of one or more ligaments of the ankle [2].

Type of interventions

Any type of the following functional treatments being applied to treat acute ankle sprains were considered as an intervention and grouped accordingly:

α) Elastic bandage, stocking or all external assistance with elastic sock-like material to support ankle joint

β) All types of adhesive and elastic tapes to support ankle joint

χ) Lace-up ankle support or others external assistances made up of soft canvas-like or nylon materials

δ) Semi-rigid ankle support, posterior rigid support or other external assistances made up of firm thermo plastic elements [11].

Type of outcome measures

The following information was sought and extracted from each article: pain; swelling; functions; range of motion (ROM); complications and side effects; return to sports/ return to work (a person is able to go back to playing sports or participate in an activity at a pre-injury level) and; patient satisfaction.

Exclusion criteria

This systematic review excluded the following types of studies; case reports or technical reports without statistical comparison,

research duration shorter than 28 days, surgical procedures, ankle and foot fractures, research with non-adult participants (<18 years old), unpublished, not peer reviewed, studies conducted before 2007, not a full-length publication of original data, studies not published in English language or not an experimental research design.

Quality assessment

The two reviewers also independently assessed the methodological quality of the eligible studies using the PEDro scale [21], any disagreements were solved by consensus discussion. The PEDro scale consists of 11 criteria and if each criterion was clearly satisfied, one point was awarded. However, criterion 1 assessed the external validity of the study and it was not counted in the final PEDro score. Therefore, the final score ranged between 0-10 and studies scoring ≥6 were considered to be high quality [22]. Moreover, the level of evidence of the study was assessed with the Australian National Health and Medical Research Council level of evidence scale (NHMRC). Classifications of levels of evidence of the clinical studies are expressed in Table 1 [23].

Table 1: The Australian National Health and Medical Research Council level of evidence scale [1].

Grade 1	Systematic Review of all appropriate RCT
Grade II	At least properly designed RCT
Grade III -1	Well-designed Pseudo RCT
Grade III -2	Cohort or case controlled studies
Grade III- 3	Multiple time series /dramatic effects from un-controlled studies
Grade IV	Case series

Data extraction

After eligible studies were selected and full texts acquired, the principle investigator extracted the relevant outcomes information from the articles. The following information were extracted from the articles; sample size, intervention type, duration, and outcome measures. The two authors identified the type of study and assessed with PEDro scale and NHMRC scale for the methodological quality and level of evidence. Due to the heterogeneity of outcomes, interventions and study types, statistical comparison could not be undertaken and a narrative synthesis by different interventions was undertaken.

Results

A computerized literature search (Figure 1) was started on September 1, 2017 and the irrelevant articles were excluded after screening of the titles and 100 potentially relevant articles were retrieved for abstract screening. Finally, ten studies were eligible for the systematic review,

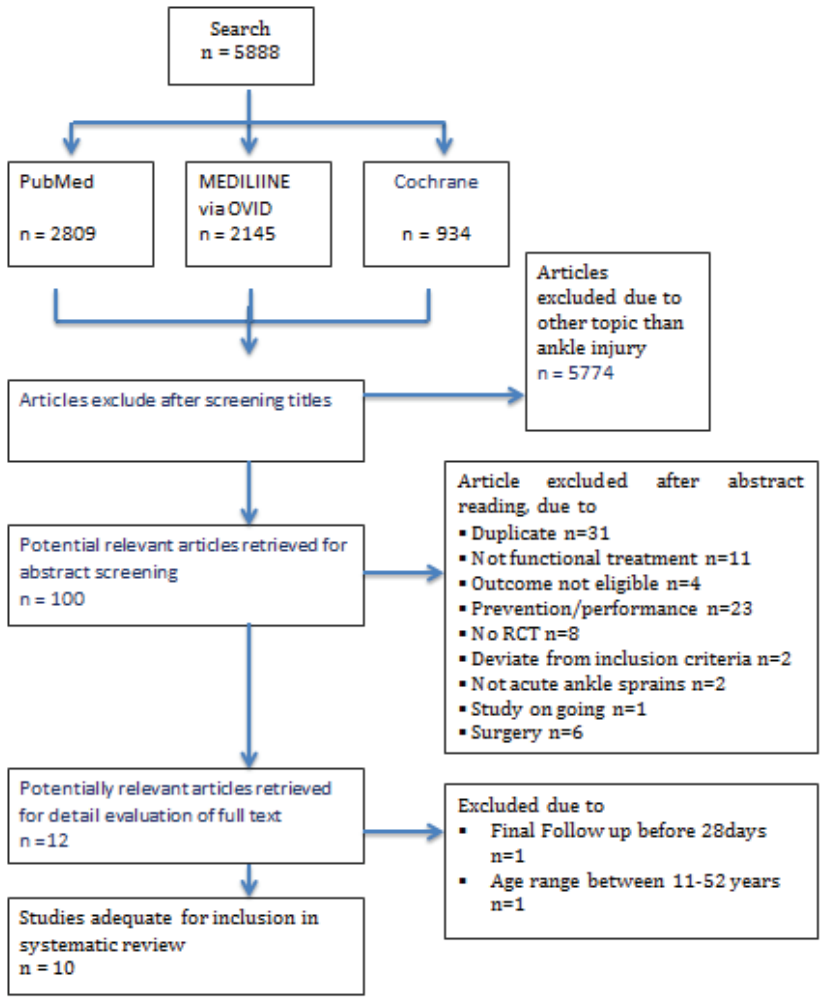

Figure 1: Flow chart of selected trials.

comprising a total of 1704 adult participants with acute ankle sprains. Detailed characteristics of selected trials are expressed in Table 2.

Seven trials [10,24-28,32]were considered as high quality studies because of their PEDro score of ≥ 6/10, whereas three studies had a PEDro score of < 6 and considered as low quality studies Table 3 [29-31].

Study	Participants and Intervention	Outcome Measures and Follow up	Results
Best et al. (2015) [3]	47 patients with acute ankle sprains Grade II or more, adult age Both male and female Group 1 Phase-adapted semi-rigid orthosis "Malleo TriStep"(MTS) n=27 Group 2 Non phase-adapted semi-rigid orthosis "Aircast Air-stirrup"(AC) n=20 (6 weeks treatment)	(1) Foot and ankle outcome score (FAOS) compromising Pain, Symptoms, Activity of daily livings, Sport activities and quality of life (2) American Orthopedic foot and ankle society's (AOFAS) Ankle hind foot scale (3) Balance test, Shuttle run, Vertical drop jump and Zig zag run Follow-up - Base line, 1 and 3 months	• FAOS score significantly improved in both groups, no significant differences between 2 groups • AOFAS score improved significantly MTS group at 1and 3 month p<0.01 compared to baseline, AOFAS improved in AC group at 1 and 3 month p<0.01 compared to baseline/ • Balance tests no differences between two groups. • Shuttle run result showed MTS (p<0.01) shorter split time than AC (p<0.05) • For Vertical drop jump, AC group have longer time than MTS, but lower vertical height • Zig Zag run expressed MTS group run faster than AC
Bendahou et al. (2014)[2]	126 patients with acute mild/ moderate/severe ankle sprains Adult Age, male and female Group 1 Placebo stocking n=65 Group 2 Compression stocking n=61 Not clearly express how many days to wear the stockings	(1) Pain assessed at rest and during walking (2) Bimalleolar and mid-foot circumference for swelling (3) Return to work or daily activities Follow-up – 1st day, 6 to 9 days, 15 to 30 days and 90 days	• Recover normal painless walking day was 13(10-18) in compression stroking and 21(16-24) in placebo, No significant between two groups p=0.20 • Pain at rest and during walking were not decreased in 2 groups (p=0.08 and p=0.11) • The time to return to sport activities was significantly short in the compression stocking p=0.02 38(30-60) days in stocking and 60(35-81) days in placebo • Bimalleolar and mid-foot circumference were not markedly difference in follow-ups
Cooke et al. (2009) [5]	149 patients with Grade II and III ankle sprain, Adult, Both male and female Group 1 Below knee cast n=119 10 days treatment Group 2 Bledsoe Boot N=149 Group 3 Tubular Bandage n=144 Group 4 Aircast n=149 Treatment periods of Group 2,3,and 4 have not expressed	(1) Function of foot was assessed with FAOS (2) SF-12 questionnaires for mobility, recovery of normal occupation and impact of treatment (3) Pain with Visual analogue scale (VAS) (4) Benefit Scale (5) Recorded date was used to evaluate the return to work or leisure activities Follow-up 1st day, 4weeks, 12 weeks and 9 months	• At 4 week ▪ The below knee cast reduced VAS than tubular bandage (Pain at rest), SF12 Physical function and following FAOS subscales; pain and quality of life (QOL) ▪ No significant differences between bandage, Aircast and Bledsoe boot • At 12 week ▪ The below Knee cast was improved and statically significant than tubular bandage in following FAOS subscales; pain, activity of daily living (ADL), QOL and sport activities ▪ Pain at weight bearing was (VAS) marginally better in cast than tubular bandage ▪ Aircast brace was significantly better than tubular bandage in FAOS subscale QOL and SF 12 mental function ▪ No significant differences between tubular bandage and Bledsoe boot • At 9 month -No significant differences between all groups • Benefit scale -Tubular bandage had reported as a less benefit intervention • Complications -Cellulitis – one in Aircast and one in Bledsoe. Suspected DVT or pulmonary embolism in bandage (2 patients), Aircast (1 patient) and Cast (1 patient)
Kemler et al. (2015) [12]	157, adults with acute lateral ankle sprain, Both male and female Group 1 Soft brace (Push med ankle brace) n=77, 4 weeks Group 2 Taping n=80, 4 weeks	(1) Residual symptoms (2) Functional outcome (Assessed with questioners for ankle dorsiflexion comparing with sound leg) (3) Recurrence 1 year follow up	• No significant differences between tape and Push med ankle brace on swelling (p=0.820), functional outcome (p=0.850) and pain (p=0.707) at one year follow up (p=0.820) • 39% in Push med ankle brace treatment and 52% in tape treatment group did not complete the 4 weeks treatment due to skin irritation • Recurrence rate 17% in Push med ankle brace and 14% in Tape group, whereas 3% in brace group got re-injury during treatment period
Lardenoye et al. (2012) [18]	100 patients with Grade II and III ankle sprains Age skeletally mature adult age Both male and female Group 1- Tape (Coumans-bandage) n=50, for 4 weeks Group 1- Semi-rigid brace n=50, for 4 weeks	(1) Patient satisfaction with verbal rating scale (2) Karlsson scoring scale for function (Determining pain, giving way, instability, stiffness, stair climbing and activities) (3) ROM (4) Complications with questionnaire Follow up -3,5,9 and 13 weeks	• Patient satisfaction was markedly higher in Semi-rigid brace at 3 and 5 week p<0.05 • Patient satisfaction was decreased markedly in tape from week 1 till week 5 p<0.05 • Semi-rigid brace had higher patient satisfaction than Tape p<0.0001 • Karlasson score increased significantly in both groups during 4 weeks treatment and further increased until 8 weeks (p=0.4), but no difference between two groups • Active and passive ROM improved similarly, but not difference between 2 groups (week 5 p=0.9, p=0.7 / week 13 p=0.2, p=1.0) • 59.1%of Tape had complications (dermatitis, bullae formation or skin abnormalities) • The Semi-rigid brace group had significant lower complication rate 14.6% p<0.0001

Lamb et al. (2009) [17]	584 patients with severe ankle sprains Adult, Both male and female Group 1 - Tubigrip bandage n=144 Group 2- Below-knee cast n=142, 10days Group 3- Air-cast brace n =149 Group 4-Bledsoe boot n=149	(1) Function of foot was assessed with FAOS (2) SF 12 (Physical and mental quality of life) (3) Complications with self-rated report Follow up1, 3 and 9 month	• At 3 months, below knee cast had better effectiveness than Tubigrip in FAOS ankle function, especially in sub-scales pain, symptoms and activity P<0.007 and SF12 physical scale as well • The Aircast brace improved in FAOS ankle function than Tubigrip at 3 months • Bledsoe boot did not show advantage over Tubigrip in FAOS • Aircast and Bledsoe had better SF12 mental score than Tubigrip and cast at 3 months • At 9 month, No significant differences between all groups • Complications such as deep-vein thrombosis (Air-cast, Tubgrip, cast), pulmonary embolus (Air-cast, Tubgrip), cellulitis (Aircast and Bledsoe) were reported • Tubigrip bandage was the least effective intervention
Naeem et al (2014) [22]	126 patients with Grade I and II acute lateral ankle sprain Adult, male and female Group 1- Tubigrip (TG) n=40 Group 2- Plaster of Paris (POP) n=40 (Treatment period was not expressed)	(1) Visual analogue scale for pain (VAS) (2) Functional assessment with Karlsson score 1st day, 2 week and 6 week follow-up	• The VAS of TG -First day 8.40 ± 0.92, week two 6.15 ± 0.94, week six 3.88 ± 0.85 • The VAS of POP -First day 8.27 ± 0.94, week two 6.28 ± 0.11, week six 4.97 ± 0.82 ▪ Results of pain in two groups were not statically significant in week 2 (p=0.434) ▪ Tubigrip reduced pain than POP at week 6 (p<0.001) • No difference in Karlsson score at week 2 (p=0.759) ▪ Tubigrip was more effective in term of functional outcome than POP in week 6 (p<0.001)
Pardo et al., (2014) [28]	186 patients with severe lateral ankle ligament injury Adult, male and female Group 1 Walking boot for 3 weeks Immobilized with Brace for 3 weeks Group 2 AIRCAST Functional brace 1, 3, 6 and 12 week	(1) Visual analogue pain scale (2) Functional outcomes by the American Orthopedic foot and ankle score (AOFAS) questioners	• VAS of Walking boot -First day 3.3 ± 1.5, week three 1.7 ± 1.2 and week six 0.8±0.9 • VAS of functional brace -First day 3 ± 1.4, week three 1.4 ± 1.2 and week six 0.5 ± 0.8 • Pain was improved in both group, but no difference was found (p=0.0348) • AOFAS outcome of Walking boot-First day 61 ±11.2, week three 79.5 ± 9.2 and week six 90.5 ± 10.6 • AOFAS outcome of Functional brace-First day 67 ± 10.8, week three 84.8 ± 8.8 and week six 94.3 ± 6.6 • Functional score significant improved in functional brace than immobilised boot on week three (p=0.0348) and week six (p=0.027) • Week twelve AOFAS of walking boot was 97.4 ± 5.5 and functional brace was 98.4 ± 4.4 where no differences was found
Sultan et al., (2012) [29]	36 patients with ankle sprains Adult, male and female Group 1 Tubigrip bandage n=18 7weeks Group 2 Elastic stocking (ES) n=18 7weeks 1st day, 4 weeks and 8 weeks	(1) Swelling (ankle and calf circumference) (2) ROM (3) VAS (4) AOFAS (5) SF12 v2 (6) Patient Satisfaction (7) Follow up – 4 and 8 week	• Swelling significantly reduced in stocking than bandage at 4 weeks p<0.001, no difference in 8 weeks • ROM significant rose in stocking than bandage at 8 weeks (79 and 56) p<0.001 • VAS of ES was significantly reduced than Tubigrip (p<0.001) • AOFAS score of ES was significantly improved than Tubigrip (p=0.002) • SF12v2 functional outcome (physical and mental component) showed ES more improved than Tubigrip (p<0.001) • Patient satisfaction assessed with the time of following; ▪ ES needed crutches 1.6(1-3) days and Tubigrip needed 5.6(2-10) days, P=0.003 ▪ Return to work ES 5.2(1-8), Tubigrip 10.1(3-17) days, p=0.11 ▪ Used of analgesic ES 7.1(5-10), Tubigrip 10.4(6-18), p=0.297 ▪ Stair climb without aid ES9.5(5-15), Tubigrip 12.7(8-18), p=0.242
van den Bekerom et al., (2016) [31]	193 patients with Grade II and III Acute ankle sprain, adult Both male and female Group 1 – Tape n=66 Group 2 – Semi-rigid brace n=58, 6 weeks Group 3 - Lace-up brace n=62, 6 weeks	(1) Karlsson scoring scale for function (2) Tegner activity scale for function (3) FAOS (4) Return to work/sports (5) Pain at rest VAS score (6) Complications 2,4week and 6 month after treatment	• Karlsson score was not significantly different in all groups • Tegner activity scale for function was not significantly different in all groups • Lace-up had significant higher score in FAOS subscale sports than semi-rigid brace(p=0.02), but others FAOS subscales were not different in three groups • Return to work/sports, VAS score were not significantly different between three groups • Two patients from tape group got skin blister and changed to semi-rigid therapy

Table 2: Detail Characteristics of included articles.

Nine studies considered as Grade II level of evidence [10,24-28,30-33] and one study [12] considered as Grade III-2 level of evidence based on the classification of levels of evidence (Table 1).

Elastic bandage, stocking and all external assistance with elastic sock-like materials

Five high methodological quality trials [10,24-27] reported a focus on elastic bandages, stockings and all external assistance with elastic sock-like materials. All five studies were level of evidence grade II according to the NHMRC scale.

Pain: The study by Bendahou et al. [24] appraised that pain at rest and walking were not different between stocking and placebo groups. Neem et al. [25] expressed that Tubigrip bandage markedly reduced pain (VAS) compared to Plaster of Paris (POP) in six weeks follow-up (p<0.001), but there was no difference at week 4 (p=0.434). Cook et al. [10] evaluated that the below knee cast was more effective in pain

Criterion	Best et al., (2015)[3]	Bendahou et al., (2014)[2]	Cooke et al., (2009)[5]	Kemler et al., (2015)[12]	Lardenoye et al. (2012)[18]	Lamb et al., (2009)[17]	Naeem et al., (2014)[22]	Pardo et al., (2014)[28]	Sultan et al., (2012)[29]	*van den Bekerom et al., (2016)*[31]
1.	1	1	1	0	1	1	1	1	1	1
2.	0	0	1	0	1	1	1	0	1	0
3.	1	1	1	1	1	1	0	0	1	1
4.	0	0	1	0	1	0	0	0	0	0
5.	0	0	0	0	1	0	0	0	0	0
6.	1	0	1	0	1	1	0	0	1	0
7.	1	1	0	1	0	0	1	1	1	1
8.	1	1	1	1	1	1	1	1	1	1
9.	1	1	1	1	1	1	1	1	1	1
10.	1	1	1	1	1	1	1	1	1	0
Total	7	6	8	5	9	7	6	5	8	5

Where:
1. Subjects were randomly allocated to groups
2. Allocation was concealed
3. The groups were similar at baseline regarding the most important prognostic indicators
4. There was blinding of all subjects
5. There was blinding of all therapists who administered the therapy
6. There was blinding of all assessors who measured at least one key outcome
7. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups
8. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case; data for at least one key outcome was analyzed by "intention to treat"
9. The results of between-group statistical comparisons are reported for at least one key outcome
10. The study provides both point measures and measures of variability for at least one key outcome

Table 3: Methodology quality of studies.

management than tubular bandage, however tubular bandage was not different with Aircast brace and Bledsoe boot at 4 and 12 weeks. At 9 months there were no significant differences in all groups. Sultan et al. [26] noted that pain score (VAS) was significantly reduced in stocking than Tubigrip in follow-ups ($p<0.001$).

Swelling: The study by Bendahou et al. [24] indicated that stocking had similar effects to a placebo in swelling management in follow-ups. The study by Sultan et al. [26] found that elastic stocking significantly reduced swelling compared to Tubigrip ($p<0.001$).

Functions: The study by Cook et al. [10] found that below knee casts was more effective than tubular bandage in FAOS subscales pain and QOL and SF12 physical function at week 4, though no significant difference was found between the tubular bandage and the Aircast and Bledsoe. At week 12 assessment, the below knee cast significantly improved the following FAOS subscales compared to tubular bandage; pain, ADL, QOL and sports activities. Similarly, the Aircast brace created a more significant improvement than tubular bandage in the FAOS subscale QOL and SF12 mental function, although no significant difference between tubular bandage and Bledsoe boot was found. At 9 months there were no significant differences in all groups.

The study by Lamb et al. [27] found that below knee cast had better effectiveness than Tubigrip in overall ankle function (FAOS) specifically in sub-scales like pain, symptoms and ADL at 3 months, but there was no difference at 9 months. The Aircast brace was also more effective than the Tubigrip in FAOS at 3 months. There was no difference at 9 months in those two groups. No difference was found between Bledsoe boots and Tubigrip at each follow-up.

The study by Naeem et al. [25] evaluated the function with Karlsson score. Although no difference was found in week 2 ($p=0.759$), in week 6 Tubigrip's score markedly increased compared to Plaster of Paris (POP) ($p<0.001$). The study by Sultan et al. [26] reported that the functional outcomes of AOFAS and SF12v2 score were significantly improved in elastic stocking at week 4 and week 8 compared to Tubigrip ($p=0.002$ and $p<0.001$ respectively).

Ankle mobility or range of motion: Only one study described the ROM as an outcome. The elastic stocking had a greater improvement in ROM than Tubigrip by 8 weeks (79° and 56°, $p<0.001$, respectively) [26].

Complications and side effects: Cooke et al. [10] found two participants with suspected deep vein thrombosis or pulmonary embolism in the group of treatment of tubular bandage. Similarly, deep-vein thrombosis (DVT) and suspected pulmonary embolus were reported in Tubigrip treating group [27].

Return to sports / work: There was only one study that considered return to sport, which compared the stocking and placebo stocking. The period of return to sports activities was shorter ($p=0.02$) in the stocking than placebo [24].

Patient satisfaction: Data from Cooke et al. [10] conveyed that tubular bandage had lower benefit score than the below knee cast, Aircast and Bledsoe boot. The study by Sultan et al. [26] assessed patient satisfaction with the period of following. The duration crutches were used was considerably shorter in stocking than Tubigrip ($p=0.003$) whereas, stair climbing ($p=0.242$), using analgesic ($p=0.297$) and return to work ($p=0.11$) were not much different.

All types of adhesive and elastic tapes to support the ankle joint

One high methodological quality trial [28] and two low methodological quality trials [29,30] reported a focus on all types of adhesive and elastic tapes to support the ankle joint. Two studies considered level of evidence II [28,30] and one study considered level of evidence III-2 [29].

Pain: A low quality study by Kemler et al. [29] noted that no difference was seen between tape and Push med brace on pain (questionnaires) at 1 year follow up ($p=0.707$). A low quality study by van den Beckerom et al. [30] compared the effect of tape with semi-

rigid brace and lace-up braces and showed that VAS score was not significantly different between these groups.

Swelling: Only one study examined the effectiveness of tape and Push med brace on swelling. The data from that study showed no significant difference between the two groups [29].

Function: Kelmer et al. [29] appraised the functional outcomes of tape and Push med ankle brace at one-year follow-up and no difference was found. A high quality study by Lardenoye et al. [28] revealed that the Karlasson score of tape and semi-rigid brace was not different. The trial by van den Bekerom et al. [30] showed that the Tegner activity scale and FAOS were not different between tapes; semi-rigid brace and lace-up brace.

Ankle mobility or range of motion: There was only one study that considered ROM, which compared tape and semi-rigid brace. According to the data from that study, active and passive ROM was similar between two groups at week 4 and week 12 follow-ups [28].

Complications and side effects: Kemler et al. [29] showed that 52% of those in the tape group did not complete the 4 weeks treatment due to skin irritation and the recurrence rate was 14% in that group at 1-year follow-up. Another study revealed that 59% of patients from the tape group experienced complications such as dermatitis, bullae formation and skin problems. The tape group had significantly higher complication rates compared to the semi-rigid brace group 14.5% ($p<0.0001$) [28]. Two patients from the tape group suffered from skin blisters and changed to semi-rigid therapy in the study by van den Bekerom et al [30].

Patient satisfaction: The study by Lardenye et al. [28] appraised the patient satisfaction with a verbal rating scale. Satisfaction of patients in the tape was markedly decreased in from week 1 until week 5, which compared with semi-rigid brace ($p<0.05$).

Return to sports / work: No study was found for this outcome.

Lace-up ankle support or other external assistances made up of soft canvas-like or nylon materials

Two low methodological quality trials [29,30] reported an emphasis on the lace-up ankle support or others external assistance made up of soft canvas-like or nylon materials. One study considered level of evidence II [30] and one study considered level of evidence III-2 [29].

Pain: Data from Kemeler et al. [29] showed that no significant difference was seen between the tape and Push med brace regarding pain ($p=0.707$). The study by van den Bekerom et al. [30] also showed a similar result when comparing the lace-up support with tape and semi-rigid brace.

Swelling: In terms of swelling outcome, only one study compared the Push med ankle brace and tape at one-year follow-up. No significant difference was found ($p=0.820$) [29].

Functions: The functional outcome (assessed with questionnaires) of tape and Push med ankle brace at one-year follow-up was not different [29]. The Karlsson score and Tegner activity score were similar in Tape, Lace-up brace and semi-rigid brace. However, the FAOS sub-scale 'Function in sports' at 6 months was significant higher in lace-up support than semi-rigid brace ($p=0.02$) [30].

Complications and side effects: Kemler et al. [29] stated that 39% of those in the Push med ankle brace treatment group did not complete 4 weeks treatment due to skin irritation. The recurrence rate was 17% in a one-year period and 3% of participants got re-injured during the treatment period.

Return to sports / work: There was only one study that examined the return to sports or return to work. No significant difference was found between lace-up brace, tape and semi-rigid brace [30].

Ankle mobility or range of motion and Patient satisfaction: No trial assessed those outcomes.

Semi-rigid ankle support, posterior rigid support or other external assistance made up of firm thermoplastic elements

Four high methodological quality trials [10,27,28,32] and two low methodological quality trials [30,31] reported on this topic. All six studies were level of evidence grade II according to the NHMRC scale.

Pain: Cook et al. [10] compared the bandage with Aircast and Bledsoe boot and showed no significant difference. A low quality study by Prado et al. [31] examined the effect of Aircast brace compared with the immobilisation walking boot and showed that there were no significant differences ($p=0.0348$). Van den Bekerom et al. [30] also mentioned that the VAS score was not different in semi-rigid brace than tape and lace-up brace.

Swelling: No trial evaluated this outcome.

Functions: Best et al. [32] examined the effect of 2 semi-rigid braces ["Malleo TriStep"(MTS) and "Aircast Air-stirrup"(AC)]. FAOS and AOFAS scores were not different between the two groups. The AC group had shorter shuttle run and longer drop jump durations than MTS, whereas the MTS group could run faster in a zig zag run and jump higher in vertical jump test. The balance test did not show any differences between the two interventions. Differences between the two groups were marginal.

Cook et al. [10] described how the Aircast and Bledsoe, compared with tubular bandage, had no notable difference at 4 weeks in FAOS and SF-12 scales. At 12 weeks, the Aircast brace was improved considerably compared to the tubular bandage in FAOS subscale QOL and SF-12 mental scale, however, no significant difference was found between the tubular bandage and Bledsoe boot. At 9 months, no significant differences had been seen between all groups. Another high quality study found that the Aircast brace had greater effectiveness than the Tubigrip in FAOS ankle function at 3 months but the Bledsoe boot did not show an advantage over the Tubigrip. Aircast and Bledsoe had a higher SF12 score than Tubigrip and cast at 3 months. At 9 months, there were no significant differences between these groups [27].

Lardenoye et al. [28] expressed that the Karlsson score of semi-rigid brace and tape was not different. Pardo et al. [31] reported that AOFAS functional score was expressively improved in functional brace over the immobilised boot at week 3 ($p=0.0348$) and week six ($p=0.027$), nevertheless no differences were found at week 12. The study by van den Bekerom et al. [30] found that the Karlsson score and Tenger score were not significantly different in tape, lace-up brace and semi-rigid brace. Nonetheless, the FAOS sub-scale 'sport' score reduced significantly in the semi-rigid brace compared to the lace-up brace ($p=0.02$).

Ankle mobility or range of motion: Only one high quality study evaluated ankle mobility as an outcome. No significant difference was found in tape and semi-rigid group at 5 and 13-week follow-ups [28].

Complications and side effects: Two high quality studies described that skin complications (14.5%) [18], cellulitis, suspected DVT and pulmonary embolism were found in participants treating

with Aircast brace [10]. Cellulitis was also found in the Bledsoe boot treatment group [10]. Another high quality study found that deep-vein thrombosis, pulmonary embolism and cellulitis occurred in Air-cast group, but only cellulitis was reported in the Bledsoe boot group [27].

Return to sports / work: The low quality study assessed the return to sports or return to work outcome between the semi-rigid brace, tape and lace-up brace. No difference was found among these groups [30].

Patient Satisfaction: Benefit questionnaires results of Cook et al. [10] pointed out that the Aircast and Bledsoe braces had more beneficial effects than bandage. Data from Lardenoye et al. [28] also showed that patient satisfaction was significantly higher in semi-rigid brace ($p<00.5$) than tape.

Discussion

The aim of this systematic review was to appraise the effectiveness of various functional treatments for adults with acute ankle sprains, using evidence from clinical research trials. The mean PEDro scale of the included studies was 6.6/10 and nine studies were level of evidence (grade II) and only one study was rated as grade III-2. Therefore, the quality of the studies was acceptable. All studies included in the systematic review were clinical trials, but only Lardenyoe et al. [28] blinded the randomization process to either the therapist or subjects. This might be intended to avoid the bias of clinicians or participants choosing the interventions. However, it is probable that for other studies it was not possible to blind the therapists or patients due to the nature of delivering a clinical treatment.

Four high quality studies described stockings and bandages with regards to pain. One study showed the stocking significantly reduced pain compared to the bandage [26], however another study found no difference with the stocking and placebo [24]. Similarly, the bandage failed to prove more effective in terms of pain than the below knee cast [10]. Nonetheless, the bandage reduced pain to a greater extent than POP [25]. From the three studies concerning the bandage [4,25,26], only one study found the effectiveness of it [25]. For the stocking, it seems to be more effective in reducing pain and the management of swelling than the bandage in one high quality study [26]. Moreover, the stocking had a shorter return to sports period than the placebo, though no difference was found in the swelling management [24].

In terms of functional outcome, two high quality trials [10,27] found that the bandage was not as effective as the Aircast brace and the below knee cast, but had similar results to the Bledsoe boot. In a high quality study, the stocking was considerably more effective at improving functional outcome than the bandage [26], while another high quality study found the bandage was more effective than the POP [25]. In addition to stockings having better functional outcomes than bandages, the former was more effective at improving ROM and return to sport/work outcome than the latter [24,26]. Within the studies included, stockings were also found to have higher patient satisfaction and no complications [26], whilst in contrast there were reported complications for bandages [10,27] and lower patient satisfaction [10]. From the pooled data of this review, the stocking was found to be more effective at improving pain, swelling, functional outcomes, ROM, and return to sport/work, and had higher patient satisfaction than the bandage.

One high quality study [28] and two low quality studies [29,30] reported the taping treatment. The two low quality trials stated that the taping failed to prove more effective than the Push med brace and the semi-rigid brace with regards to outcomes of pain, swelling, function and ROM [29,30]. The high quality study similarly found the same result in terms of function and ROM when compared with the semi-rigid brace and the patient satisfaction was also markedly low in the taping [28]. All of these 3 trials, which evaluated the effectiveness of the tape, found complications such as skin problems and recurrence [28,29,30]. From the data of the high quality study, 59% of the taping group experienced complications and complication rate was significantly higher than the semi-rigid brace [28]. From the findings of this review, there was no evidence that taping was more effective than other functional interventions in the treatment of acute ankle sprains. Furthermore, the prevalence of complications is greatest for taping. From the clinical point of view, clinicians should be cautious about the complications from the application of tape and this should be used as a second-line intervention if there is an availability of other effective functional treatments.

Two low quality trials considered the management of acute ankle sprains with lace-up support. When the lace-up support was compared with the tape and the semi-rigid brace, no significant differences were found regarding pain, swelling and return to sports outcomes [29,30]. One study evaluated that the lace-up support was more effective than the semi-rigid brace in the 'sport' sub-scale of FAOS [30], while another study found no significant difference seen between the lace-up and tape [29]. Only higher in the 'sport' sub-scale of FAOS is difficult to interpret the lace-up brace was more effective than the semi-rigid brace [30]. Skin complication (39%) and recurrence (17%) were prevalent in treatment by lace-up support [29]. Despite the previous review by Kerkhoffs et al. [16] reporting the lace-up support had better effectiveness in swelling than other functional treatments, this review did not find an obvious clinical benefit of it and only complications were observed. This review only found two low quality studies focusing on lace-up support, so that efficacy of it is controversial and more high quality RCTs for the lace-up support are needed.

This review found six trials investigating the semi-rigid ankle support, posterior rigid support or thermoplastic external assistance. In terms of pain outcome, one high quality trial [10] and two low quality trials [30,31] found no significant differences between different interventions (Aircast and Bledsoe boot; Aircast and immobilisation boot; and tape, semi-rigid brace and lace-up support). ROM was not different between the tape and the semi-rigid brace, and return to sport/work rates of the tape, semi-rigid brace and lace-up support were also similar [28,30]. Two high quality trials found that patient satisfaction was significantly higher in the Aircast brace and the semi-rigid brace than the bandage and the tape [10,28]. In terms of functional outcome, two high quality studies expressed that Aircast had a better recovery rate than bandage [10,27]. Another two high quality studies stated in functional outcomes the semi-rigid brace was not more effective than tape [31], and the Aircast (AC) and Malleo-TriStep (MTS) were not different [32]. The low quality trial found that the semi-rigid brace was better in functional recovery than the immobilization boot [31], but in another trial, the semi-rigid brace did not get better result than the lace-up on a FAOS sub-scale [30]. Cellulitis mostly happened in the Bledsoe boot, but skin complications, suspected DVT and suspected pulmonary embolism were reported in the Air-cast brace [10,27,28]. From the findings of this review, the semi-rigid brace and the Air-cast had better functional recovery. For the management of acute ankle sprains, the semi-rigid or posterior rigid support group had higher patient satisfaction and functional result. It is likely that these rigid supports protect from the sides of the sprained ankle and the patient's confidence might be increased during the wearing of them. Moreover,

these rigid braces allow some degrees of planter movements that they might promote better function outcome.

The study did not consider the effect that training status or body mass had on outcomes after receiving a functional treatment. Given that the ankle joint supports an individual's body mass, often unilaterally during movements (e.g. running, jump landing), different outcomes may occur in untrained individuals or overweight populations. It is also possible that prolonged pain, instability and/or inflammation will slow the recovery process and lead to individual's detraining and/or increasing body mass. Such confounding factors were not considered by the included studies, but could be examined in future work.

Conclusion

In conclusion, the stocking was more effective than the bandage in reducing pain, swelling and improving functional outcomes, in addition to producing higher patient satisfaction than the bandage. Similarly, the Aircast has faster functional recovery than the bandage. No evidence was found for the effectiveness of the tape, and patient satisfaction was low and complication rates were high. For the lace-up support, there was no strong evidence to judge the effectiveness, although skin complications were prevalent. The semi-rigid or posterior rigid support groups were better for functional recovery and had higher patient satisfaction rates, however some complications were uncovered. Therefore, the semi-rigid or posterior rigid support group and stocking were more effective functional interventions for acute ankle sprain treatment.

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