Journal of Athletic Training 2020;55(8):789–800
doi: 10.4085/1062-6050-0093.20

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Compression Wrapping for Acute Closed Extremity Joint Injuries: A Systematic Review

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Objective: Current prehospital recommendations for an acute closed extremity joint injury (ACEJI) are to apply compression in some manner. However, the effectiveness of compression is unclear. We performed a systematic review to summarize and synthesize the evidence for the use of a compression bandage for ACEJI in the prehospital setting.

Data Sources: Cochrane Library, PubMed, and Embase were searched for relevant literature in November 2019.

Study Selection: Controlled trials involving adults in the prehospital setting with a recent ACEJI were included when compressive, nonimmobilizing interventions, feasible in a first aid setting, were applied and compared with no compression or any noncompressive intervention, such as braces, splints, or noncompressive stockings. Articles in all languages were included if an English abstract was available.

Data Extraction: Data on study design, study population, intervention, outcome measures, and methodologic quality were extracted from each included article.

Data Synthesis: Eight studies out of 1193 possibly relevant articles were included. All authors examined compression in the treatment of acute ankle sprains; no studies involved compression for the treatment of other ACEJIs. No difference in the major outcomes of pain reduction or swelling, ankle-joint function, or range of motion could be demonstrated. For the outcome of recovery time, no benefit was shown when comparing compression with no compression. Evidence was insufficient to inform a conclusion about the outcomes of time to return to work or sport. All evidence was of low to very low certainty.

Conclusions: The evidence for the use of a compression wrap was limited to patients with closed ankle injuries. In this systematic review, we could not demonstrate either a beneficial or harmful effect from the application of a compression or elastic bandage compared with no compression or a noncompressive stocking, splint, or brace as a first aid treatment in the prehospital environment.

Key Words: sprains, strains, first aid

Key Points

- The potential benefit from the use of a compression bandage for acute closed extremity injuries (ACEJIs) in a first aid or prehospital setting is unclear.
- Evidence was insufficient to recommend for or against compression wraps for ACEJIs.
- More well-designed studies in the prehospital setting are needed to provide insight into the usefulness of compression bandages for ACEJIs in a first aid setting.

In the prehospital setting, acute closed extremity joint injury (ACEJI) without damage to the overlying skin can occur due to either a significant or nonsignificant mechanism of injury and is commonly referred to as a "painful, swollen, or deformed" joint.[1] Included in this nomenclature are ligamentous, muscular, and skeletal injuries. These closed joint injuries often require assessment by an emergency department clinician, a sports physician, or physiotherapist in a sports injury clinic; a general practitioner in the primary care setting; or an athletic trainer in a sports injury clinic or primary care setting.[2–5] Before a formal clinical assessment of a patient with an ACEJI is performed and appropriate management is implemented, some level of initial recognition and management by a first aid provider in the prehospital setting is warranted.[1,6]

Sports health care professionals, and athletic trainers in particular, advocate for the immediate application of rest, ice, compression, and elevation (RICE) for simple ACEJIs. They are arguably the only health care professionals who can consistently apply these interventions within minutes because they are often present at the time of injury.[7] Although RICE is commonly applied by health care professionals, first aid providers are taught a different version of RICE: rest, immobilization (with compression or a splint), cold, and elevation.[1,6] Adding protection to RICE yields PRICE, whereas protection, optimal loading, ice, compression, and elevation (POLICE) emphasizes the need for optimal loading or replacing rest with a balanced and incremental rehabilitation program in which early activity encourages early recovery.[8] More recently, protection, elevation, avoiding

Table 1. Inclusion and Exclusion Criteria

Item	Inclusion	Exclusion
Population	Adults in the prehospital setting who presented with a closed extremity joint injury (ie, a suspected sprain or strain) that occurred within the last 72 h	Children and adults with a fracture, dislocation, or an injury not affecting the joint
Intervention	Compressive, nonimmobilizing interventions, such as compression bandage or wrap, elastic bandage or wrap, tubular compression bandage, or elastic stockings	Interventions that immobilize the joint, noncompressive (tubular) bandages, and compression devices that are not feasible in a prehospital setting
Comparison	No treatment or any treatment that does not provide compression (eg, elevation of the injured limb, a brace, a splint, or tape)	Any intervention not feasible in a prehospital setting (eg, plaster cast)
Outcome	Critical outcomes: reduction in pain and swelling or edema Important outcomes: recovery time, range of motion, joint function and adverse events	
Study design	Randomized controlled trials and nonrandomized studies (interrupted time series, controlled before-and-after studies, cohort studies)	Unpublished studies (eg, conference abstracts, trial protocols) and animal studies
Timeframe and language	All years and all languages, as long as an English abstract was available	Articles in a language other than English, for which no English abstract was available

anti-inflammatories, compression, education and load, optimism, vascularization, and exercise (PEACE & LOVE) was introduced.[9] In this scenario, PEACE should be the emphasis in the prehospital setting, and LOVE describes care during the subsequent days. One commonality among these mnemonics is the use of compression.

Compression of a closed joint injury has been reported to decrease or accelerate the time needed to achieve maximal joint range of motion (ROM)[10] or support other interventions such as cryotherapy (eg, cold packs).[11] Compression also results in partial or total joint immobilization for mild to moderate ankle sprains.[12] Furthermore, compression produced by an elastic bandage is assumed to increase tissue pressure, thereby reducing excessive edema and hematoma formation and preventing possible hypoxic damage to surrounding tissues.[13]

Literature[12–14] on the use of compression in the treatment of ACEJIs has primarily focused on the ankle. A lateral ankle sprain caused by excessive plantar flexion and inversion is a frequent closed joint injury[15,16] encountered by first aid providers. In the United States, 23 000 to 27 000 ankle sprains are estimated to occur each day, equating to roughly 1 sprain per 10 000 people daily.[17,18] In the United Kingdom, the crude incidence rate of ankle sprains in accident and emergency (A&E) units is approximately 52.7 injuries per 10 000 people, upward of 60.9 (95% confidence interval [CI] = 59.4, 62.4) when adjusted for the proportion of patients without a diagnostic code when assessed in A&E units.[19]

For people with a sedentary lifestyle, such injuries may be minimally disruptive; however, for athletes and those working in more physically demanding jobs, a closed joint injury, such as an ankle sprain, may have lifelong serious effects.[20] Without optimal and evidence-based care (both prehospital and posthospital), patients who sustain initial ankle sprains can "demonstrate high recurrence rates, prolonged symptoms, diminished quality of life, reduced physical activity levels across the lifespan, and propensity to develop chronic ankle instability."[7(p529)] In fact, despite the frequent occurrence of lateral ankle sprains, only approximately 50% of individuals who sustained such injuries sought medical attention.[21]

The current first aid recommendation for an individual with a closed extremity joint injury is to apply compression.[1,7] However, the effectiveness of compression is unclear, particularly in a first aid setting.[22] We performed a systematic review of the literature to evaluate clinical and functional outcomes in adults with ACEJIs when treated with a compression bandage compared with not using a compression bandage.

The specific study question, written in population, intervention, comparison, outcome (PICO) format, was as follows: In adults with a closed extremity joint injury, does the use of a compression bandage, compared with not using a compression bandage, change pain, swelling, recovery time, ROM, joint function, or adverse events? This systematic review was conducted as part of the development of evidence-based treatment recommendations by the First Aid Task Force of the International Liaison Committee on Resuscitation (ILCOR).

METHODS

This systematic review was carried out according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.[23] A protocol was submitted at PROSPERO (#CRD42020153123).

Search Strategy

The following databases were searched for relevant studies: the Cochrane Library, MEDLINE (using the PubMed.com interface), and Embase (using the Embase.com interface). Search strategies were developed by 2 reviewers (V.B., D.C.B.), and both index terms and text words were used. We searched the databases for all dates through November 3, 2019. Search strategies can be found in the Appendix.

Study Selection

After removing duplicates, 2 reviewers (V.B., D.C.B.) independently screened the titles and abstracts and then evaluated the full texts for relevance. Any discrepancies were discussed, and if no consensus could be reached, a third reviewer (D.Z. or E.S.) was consulted. The inclusion and exclusion criteria are shown in Table 1.

Data Extraction

Data concerning study design, study population, intervention, outcome measures, and study quality were extracted by 2 reviewers independently (V.B. and D.C.B.). Data are presented as standardized mean differences (SMDs) with 95% CIs for continuous outcomes and by risk ratios (RRs) with 95% CIs for dichotomous outcomes. If only raw data were available, SMDs and RRs with their 95% CIs were calculated using Review Manager (version 5.3; The Cochrane Collaboration, London, UK)[24]. As suggested by Cohen,[25] SMDs of around 0.2 were considered a *small effect*; 0.5, a *moderate effect*; and 0.8, a *large effect*. When SMDs were not available, mean differences (MDs) were presented. Significant *P* values were $<.05$.

Quality Assessment

We used the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach[26] to determine the certainty of evidence for each outcome. The GRADE approach assesses the limitations in study design, indirectness (research that does not directly compare the interventions of interest delivered to the populations of interest), imprecision (due to low sample size, wide CIs, or lack of data), inconsistency (examination of heterogeneity), and publication bias. The certainty of evidence can be downgraded due to shortcomings in each of these domains. The limitations in study design were independently examined by 2 reviewers (V.B., D.C.B.) using the Cochrane Collaboration Risk of Bias 2 (RoB 2) tool[27] for randomized controlled trials (RCTs) and the Risk Of Bias In Non-randomised Studies of Interventions (ROBINS-I) tool for nonrandomized studies.[28] In both RoB 2 and ROBINS-I, the initial evaluation of quality for the body of evidence of all included studies was high. The final level of evidence can be graded as high, moderate, low, or very low.

RESULTS

Study Identification and Selection

A total of 1193 references were identified with the search strategies. After removal of duplicates, the titles and abstracts of 636 articles were screened for eligibility (see Table 1), followed by full-text screening of 75 articles. At this stage, 35 articles were excluded based on study design (mostly narrative reviews or ongoing trials without published results), 6 on population (not a joint injury, healthy volunteers without actual injury, or not an acute injury), 22 on intervention (eg, compression bandage as preventive measure, compression as only a part of the treatment), 3 on outcome (none of the prioritized outcomes were reported), and the full text of 1 publication could not be obtained. Eight studies were assessed in the systematic review. The Figure gives an overview of the study-selection process.

Study Characteristics

An overview of study characteristics is provided in Table 2. Six studies were RCTs,[20,29–33] whereas 2 were nonrandomized trials.[34,35] Only 3 studies were published in the last 10 years (2011,[20] 2014,[29] and 2015[34]), 2 studies were published in 2005[31] and 2006,[30] and 3 studies were published before 2000 (1984,[35] 1991,[33] and 1995[32]). All investigations included patients with ankle sprains and were performed in an in-hospital setting.

The interventions were class 2 compression stockings (pressure of 15–20.3 mm Hg) in 1 study,[29] elastic wrap or bandage in 5 studies,[20,30,31,33,34] compression bandage in 2 studies,[32,35] and a Tubigrip bandage (Mölnlycke Health Care, Norcross, GA) in 1 study.[20] These interventions were compared with a noncompressive stocking, an Aircast Air Stirrup or ankle brace (DJO Global Inc, Lewisville, TX), a splint, no treatment, or elevation of the foot.

Study Results

Pain. The synthesized findings are available in Table 3. In 3 RCTs[20,29,31] and 2 nonrandomized trials,[34,35] the effect of a compression or elastic bandage on pain was assessed. Researchers in 2 RCTs[20,31] and 1 nonrandomized trial[34] reported the outcome of "reduction of pain," measured on a visual analog scale. Reduction in pain did not differ when a compression or elastic bandage was compared with a splint, an Aircast brace, or no support (SMD = 0.41, 95% CI = –0.80, 1.61, $P = .51$[34]; SMD = 0.05, 95% CI = –0.61, 0.71, $P = .88$[20]; SMD = 0.64, 95% CI = –0.04, 1.32, $P = .07$,[31] respectively). Linde et al[35] demonstrated no difference in being free from pain while walking after 4 days (RR = 1.28, 95% CI = 0.78, 2.11, $P = .33$) or 8 days (RR = 1.39, 95% CI = 0.98, 1.95, $P = .006$). Moreover, Bendahou et al[29] showed no difference in time to recovery of normal painless walking ($P = .20$), pain at rest (SMD = –0.32, 95% CI = –0.68, 0.05, $P = .09$), or pain with walking (SMD = –0.14, 95% CI = –0.50, 0.22, $P = .45$) after 6 to 9 days.

Swelling. Swelling, measured as a change in ankle volume (mL), ankle swelling (cm), or bimalleolar circumference (cm), was studied in 3 randomized trials[29,31,33] and 1 nonrandomized trial.[34] No reduction in swelling was evident in 2 RCTs and 1 nonrandomized trial (SMD = –0.14, 95% CI = –0.50, 0.22, $P = .45$[29]; SMD = 0.55, 95% CI = –0.13, 1.22, $P = .11$[31]; SMD = 0.34, 95% CI = –0.22, 0.89, $P = .23$,[34] respectively) when comparing a compression or an elastic bandage with a splint, no treatment, or an Aircast ankle brace. In their RCT, Rucinski et al[33] found less reduction in swelling when an elastic bandage was applied than with no compression (SMD = 2.02, 95% CI = 0.90, 3.15, $P = .0004$).

Ankle-Joint Function. Ankle-joint function, measured using the Karlsson and Peterson score,[36] was evaluated in 3 randomized trials.[20,31,32] In 1 study,[31] researchers identified an increase in ankle-joint function after 10 days (SMD = –0.77, 95% CI = –1.45, –0.08, $P = .03$) and 1 month (SMD = –0.71, 95% CI = –1.40, –0.03, $P = .04$), where as another study[20] revealed no difference after 10 days (SMD = –0.34, 95% CI = –1.16, 0.49, $P = .42$) or 1 month (SMD = –0.29, 95% CI = –1.11, 0.53, $P = .49$) when comparing an elastic bandage with an Aircast ankle brace or no support. Leanderson and Wredmark[32] found no difference in ankle-joint function after 3 to 5 days, 2 weeks, or 4 weeks when they compared a compression bandage with an Air Stirrup ankle brace ($P > .05$).

Range of Motion. The authors of only 1 RCT[32] examined the effect of a compression bandage versus an

Table 2. Characteristics of Included Studies Continued on Next Page

Reference, Country	Study Design	Population	Comparison	Outcomes
Bendahou et al[29] (2014), France	RCT	117 individuals (66 males and 51 females, 18–55 y; mean age = 30.5 ± 8.5 y) with sprained ankles who presented to the ED within 48 h after ankle trauma; 57 patients received compressive stocking, 60 patients received placebo (ie, noncompressive stockings).	Intervention: Class 2 compression stocking, pressure between 15 and 20.3 mm Hg. Control: Noncompressive stocking. All patients received the RICE protocol in the ED, were provided with the same immobilization, and received analgesia (oral acetaminophen).	Bimalleolar circumference (cm), midfoot circumference (cm), return to work, return to sport.
Beynnon et al[30] (2006), USA	RCT	Participants presenting to ED within 72 h after ankle trauma. Grade 1 sprains: n = 52. Grade 2 sprains: n = 93. Grade 3 sprains: n = 27. Only data from primary and secondary outcomes (follow up 21 d or until healing) were extracted.	Intervention: Elastic wrap (grade 1 or 2 trauma). Control 1: Air Stirrup ankle brace (grade 1 or 2 trauma). Control 2: Air Stirrup ankle brace with wrap (grade 1 or 2 trauma). Control 3: Cast (grade 1 or 3 trauma). [Data from controls 2 and 3 were not extracted].	Pain at rest after 6–9 d (VAS), pain at walking after 6–9 d (VAS), time to return to normal walking, time to return to stair climbing, time to return to walking with full weight bearing, full weight bearing without pain.
Bilgic et al[34] (2015), Turkey	Non-RCT	51 patients (22 females, 29 males) presenting to ED with complaint of ankle sprain. (Mean age = 26.24 ± 8.41 y in elastic bandage group, 32.15 ± 12.74 y in splint group.) Follow up: 7 d.	Intervention: Elastic bandage. Control: Splint (nonspecific).	Reduction of pain (VAS), ankle volume change (mL).
Boyce et al[31] (2005), UK	RCT	35 patients presenting within 24 h to A&E departments of 2 district general hospitals in Scotland with moderate or severe ankle sprains. 17 patients in elastic bandage group (11 males, 6 females, mean age = 35.3 y); 18 patients in Aircast ankle brace[a] group (10 males, 8 females, mean age = 32.6 y), follow up: 10 d and 1 mo.	Intervention: Elastic support bandage. Control: Aircast ankle brace.	Reduction of pain (VAS), difference in ankle swelling (cm), ankle-joint function (Karlsson and Peterson score).
Leanderson and Wredmark[32] (1995), Sweden	RCT	73 consecutive patients (48 men, 25 women, mean age = 28 y) with ankle joint supination trauma of grades 2 and 3 presenting within 24 h after injury. 39 patients were treated with an Aircast ankle brace, 34 with compression bandage.	Intervention: Compression bandage. Control: Air Stirrup ankle brace.[a]	Ankle-joint function (Karlsson and Peterson score), ROM, return to work.
Linde et al[35] (1984), NA	Nonrandomized trial	100 patients with ankle sprain no more than 24 h old. Follow up: 3–5 d and 7–9 d. Median age = 27 (17–75) y in compression bandage group; 30 (16–72) y in no-treatment group.	Intervention: Elastic compression bandage around foot, ankle, and leg for 3–5 d. Pressure exerted by the bandage averaged 11.6 mm Hg (9–16 mm Hg). Control: No treatment.	Free from walking pain after 4 and 8 d, difference in ankle swelling, change in inflammation score.
O'Connor and Martin[20] (2011), Ireland	RCT	60 patients with acute ankle injury presenting within 24 h to ED. 20 patients were treated with Tubigrip bandage[b] (mean age = 30.3 y, 66% male), 20 patients with Elastoplast bandage[c] (mean age = 31.8 y, 70% males), and 20 patients received no support (mean age = 26.4 y, 56% males). Intention-to-treat analysis.	Intervention 1: Tubigrip bandage ("compression"). Intervention 2: Elastoplast bandage ("compression").	Reduction of pain (VAS), ankle-joint function (Karlsson and Peterson score), return to work.

Table 2. Continued From Previous Page

Reference, Country	Study Design	Population	Comparison	Outcomes
Control: No support.				
Rucinski et al[33] (1991), USA	RCT	30 individuals (26 males and 4 females, age = 18–28 y) with sprained ankles presenting at least 24 h after injury. 10 patients received an elastic wrap, 10 received intermittent compression, and 10 were treated with elevation only.	Intervention 1: Elastic wrap (“compression”): “ace wrap” was applied, foot elevated 45° for 30 min. The elastic wrap was applied from metatarsal heads to a position approximately 12.7 cm above the malleoli. Intervention 2: Intermittent compression (“compression device”): a nylon, single cell, lower leg pneumatic appliance applied to injured ankle, foot elevated 45° for 30 min. Control: Only elevation: foot elevated 45° for 30 min. [Data from intermittent compression were not extracted].	Ankle volume change (mL).

Abbreviations: A&E, accident and emergency; ED, emergency department; NA, not available; RCT, randomized controlled trial; RICE, rest, ice, compression, elevation; ROM, range of motion; VAS, visual analog scale.

[a] Aircast and Air Stirrup: DJO Global Inc (Lewisville, TX).
[b] Mölnlycke Health Care (Norcross, GA).
[c] Beiersdorf Australia Ltd (North Ryde, NSW, Australia).

Table 3. Synthesis of Findings and Certainty Assessment According to the Grading of Recommendations, Assessment, Development, and Evaluation Method Extended on Next Page

Certainty Assessment							No. of Patients	
No. of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	Compression Bandage	No Compression Bandage
Reduction of pain (assessed with VAS)								
3	2 RCTs + 1 non-RCT	Serious	Not serious	Serious	Serious	None	62	60
Free from walking pain (follow up: 4 d)								
1	Non-RCT	Serious	Not serious	Serious	Serious	None	21/44 (47.7%)	16/43 (37.2%)
Free from walking pain (follow up: 8 d)								
1	Non-RCT	Serious	Not serious	Serious	Serious	None	31/40 (77.5%)	19/34 (55.9%)
Pain at rest (follow up: 6–9 d; assessed with VAS)								
1	RCT	Not serious	Not serious	Serious	Serious	None	57	60
Pain at walking (follow up: 6–9 d; assessed with VAS)								
1	RCT	Not serious	Not serious	Serious	Serious	None	57	60
Swelling								
4	3 RCTs + 1 non-RCT	Serious	Not serious	Serious	Serious	None	109	114
Ankle-joint function (follow up: 3–5 d)								
1	RCT	Serious	Not serious	Serious	Serious	None	39	34
Ankle-joint function (follow up: 10 d)								
2	RCTs	Serious	Not serious	Serious	Serious	None	37	34
Ankle-joint function (follow up: 2 wk)								
1	RCT	Serious	Not serious	Serious	Serious	None	39	34
Ankle-joint function (follow up: 1 mo)								
3	RCTs	Serious	Not serious	Serious	Serious	None	76	68
Range of motion (follow up: 3–5 d)								
1	RCT	Serious	Not serious	Serious	Serious	None	39	34
Range of motion (follow up: 2 wk)								
1	RCT	Serious	Not serious	Serious	Serious	None	39	34
Range of motion (follow up: 1 mo)								
1	RCT	Serious	Not serious	Serious	Serious	None	39	34
Time to return to normal walking (grade 1)								
1	RCT	Serious	Not serious	Serious	Serious	None	52 participants[c]	
Time to return to normal walking (grade 2)								
1	RCT	Serious	Not serious	Serious	Serious	None	93 participants[c]	
Return to work								
3	RCT	Serious	Not serious	Serious	Serious	None	116	110
Return to sport								
1	RCT	Not serious	Not serious	Serious	Serious	None	31	27

Abbreviations: CI, confidence interval; MD, mean difference; NA, not available; RCT, randomized controlled trial; RR, risk ratio; SMD, standardized mean difference; VAS, visual analog scale.

[a] Significant ($P < .05$).

[b] The CI could not be calculated because the standard deviations were not described.

[c] Number of participants in each group was unknown.

[d] Absolute effect (ie, MD and CI) could not be calculated because the data were expressed as median values.

Table 3. Extended From Previous Page

Effect (95% CI)				
Relative	Absolute	Certainty	Importance	Reference
NA	SMD = 0.41 SD higher (0.8 lower to 1.61 higher). SMD = 0.64 SD higher (0.04 lower to 1.32 higher). SMD = 0.05 SD higher (0.61 lower to 0.71 higher).	⊕◯◯◯ Very low	Critical	Bilgic et al[34] (2015) Boyce et al[31] (2005) O'Connor and Martin[20] (2011)
RR = 1.28 (0.78–2.11)	104 more per 1000 (from 82 fewer to 413 more).	⊕◯◯◯ Very low	Critical	Linde et al[35] (1984)
RR = 1.39 (0.98–1.95)	218 more per 1000 (from 11 fewer to 531 more).	⊕◯◯◯ Very low	Critical	Linde et al[35] (1984)
NA	SMD = 0.32 SD lower (0.86 lower to 0.05 higher).	⊕⊕◯◯ Low	Critical	Bendahou et al[29] (2014)
NA	SMD = 0.14 lower (0.50 lower to 0.22 higher).	⊕⊕◯◯ Low	Critical	Bendahou et al[29] (2014)
NA	SMD = −0.14 SD higher (0.50 lower to 0.22 higher). SMD = 0.34 SD higher (0.22 lower to 0.89 higher). SMD = 0.55 SD higher (0.13 lower to 1.22 higher). SMD = 2.02 SD higher (0.90 higher to 3.15 higher).[a]	⊕◯◯◯ Very low	Critical	Bendahou et al[29] (2014) Bilgic et al[34] (2015) Boyce et al[31] (2005) Rucinski et al[33] (1991)
NA	MD = 3 higher.[b]	⊕◯◯◯ Very low	Important	Leanderson and Wredmark[32] (1995)
NA	SMD = 0.77 SD lower (1.45 lower to 0.08 lower).[a] SMD = 0.08 SD higher (0.58 lower to 0.73 higher).	⊕◯◯◯ Very low	Important	Boyce et al[31] (2005) O'Connor and Martin[20] (2011)
NA	MD = 4 lower.[b]	⊕◯◯◯ Very low	Important	Leanderson and Wredmark[32] (1995)
NA	SMD = 0.71 SD lower (1.40 lower to 0.78 lower).[a] SMD = 0.13 SD higher (0.53 lower to 0.78 higher). MD = 2 lower.[b]	⊕◯◯◯ Very low	Important	Boyce et al[31] (2005) O'Connor and Martin[20] (2011) Leanderson and Wredmark[32] (1995)
NA	MD = 7% higher.[b]	⊕◯◯◯ Very low	Important	Leanderson and Wredmark[32] (1995)
NA	MD = 0% higher.[b]	⊕◯◯◯ Very low	Important	Leanderson and Wredmark[32] (1995)
NA	MD = 2% lower.[b]	⊕◯◯◯ Very low	Important	Leanderson and Wredmark[32] (1995)
NA	MD = 0.83 days higher.[b]	⊕◯◯◯ Low	Important	Beynonn et al[30] (2006)
NA	MD = 0.83 days higher.[b]	⊕◯◯◯ Low	Important	Beynonn et al[30] (2006)
NA	Median = 3.8 d lower.[d] SMD = 0.50 SD lower (1.17 lower to 0.16 higher). Median = 1 d lower.[d]	⊕◯◯◯ Very low	Important	Leanderson and Wredmark[32] (1995) O'Connor and Martin[20] (2011) Bendahou et al[29] (2014)
NA	Median = 22 d lower.[a]	⊕⊕◯◯ Low	Important	Bendahou et al[29] (2014)

Air Stirrup ankle brace on ROM. No change occurred in active ROM after 3 to 5 days, 2 weeks, or 4 weeks.

Return to Function. Beynonn et al[30] measured the time to return to normal walking, time to return to stair climbing, and time to return to full weight bearing using an elastic wrap or an Air Stirrup ankle brace. None of the outcomes differed between interventions.

The time to return to work was measured in 3 randomized studies.[20,29,32] One RCT[32] showed a benefit for the use of an Air Stirrup ankle brace compared with a compression

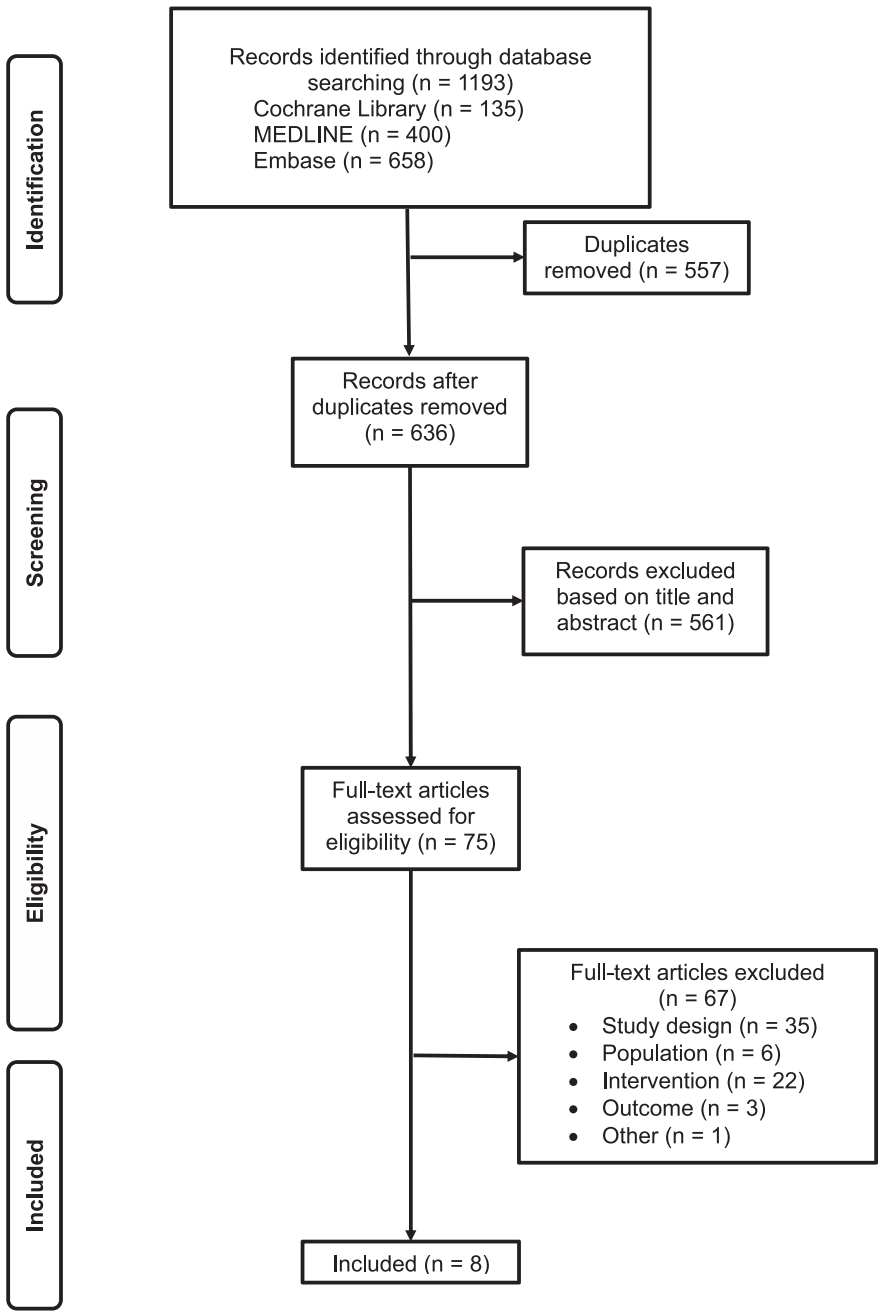

Figure. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart of study selection.

bandage (median difference = –3.8 days, $P < .05$). In 2 other studies,[20,29] investigators failed to show a benefit for a compression bandage versus no compression bandage (SMD = –0.50, 95% CI = –1.17, 0.16, $P = .14$) or noncompressive stockings (median difference = –1 day, $P = .20$).

Bendahou et al[29] also studied the time to return to sport and demonstrated a benefit for the use of a compression bandage versus noncompressive stockings (median difference = –22 days, $P < .02$).

Limitations of the Included Studies

Randomized Controlled Trials. An overview of the risk of bias of the RCTs, as assessed with the RoB 2 tool, is given in Table 4. Three studies[29–31] had an adequate randomization process; of these, 2 studies[29,30] also had adequate allocation-concealment procedures. In 3 studies,[20,32,33] the researchers mentioned that they randomized the participants without further explanation, and in 4 studies,[20,31–33] the researchers did not indicate if allocation to the treatment groups was blinded. All investigations had a low risk of bias due to missing outcome data. In most studies, participants and people applying the interventions were aware of the assigned intervention, although blinding was often not possible due to the nature of the interventions (eg, elastic bandage compared with an ankle brace). The lack of blinding might have been influential in the work of Beynnon et al[30] because the patients assessed the outcome; knowledge of the intervention might have affected the assessments. The authors of only 1 study[29] published their

Table 4. Overview of Risk of Bias of Randomized Controlled Trials, Assessed With the Cochrane Risk of Bias 2 Tool[a]

Study	Intervention	Comparison	Randomization Process	Deviations From Intended Interventions	Missing Outcome Data	Outcome Measurement	Selection of Reported Result	Overall
Bendahou et al[29] (2014)	Compressive stocking	Noncompressive stocking	+	+	+	+	+	+
Beynonn et al[30] (2006)	Elastic wrap	Aircast ankle brace[b]	+	+	+	?	?	?
Boyce et al[31] (2005)	Elastic support bandage	Aircast ankle brace	+	?	+	+	?	?
Leanderson and Wredmark[32] (1995)	Compression bandage	Aircast ankle brace	?	?	+	+	?	?
O'Connor and Martin[20] (2011)	Elastoplast bandage	No support	?	?	+	+	?	?
Rucinski et al[33] (1991)	Elastic wrap	Elevation	?	?	+	+	?	?

[a] Symbols: +, low risk; ?, some concerns.
[b] DJO Global Inc (Lewisville, TX).

protocol. No other researchers indicated if a prespecified plan for analysis was available. However, we had no reason to believe the results were selected from multiple outcome measures or multiple analyses of the data. One study[29] had an overall low risk of bias; concerns about the risk of bias were present for all other studies.

Nonrandomized Trials. An overview of the risk of bias of the non-RCTs, as assessed with ROBINS-I, is shown in Table 5. Both nonrandomized trials had a risk of bias due to confounding. In Bilgic et al,[34] the choice of treatment was at the discretion of the on-shift physician or resident doctor, which could have introduced serious bias. Both investigations had a low risk of bias due to the selection of the participants, classification of the interventions, and deviations from the intended interventions. Linde et al[35] displayed a fairly high loss to follow up (13% at first follow up and 26% at second follow up), leading to a moderate risk of bias due to missing outcomes data. In both cases, the outcome assessors were not blinded to the interventions, which may have led to a serious risk of bias in the measurement of subjective outcomes (eg, pain). Finally, no indication of selective reporting was evident.

Certainty of the Body of Evidence

The assessed certainty of the body of evidence is detailed in Table 3. The certainty of evidence was downgraded for most outcomes due to limitations in study designs. Furthermore, the certainty of the evidence was downgraded due to indirectness because all studies took place in a hospital setting. The overall certainty was further downgraded for imprecision due to limited sample sizes or large variability of results. Therefore, the certainty of evidence was low to very low for all outcomes.

DISCUSSION

Compression is a common prehospital intervention for the management of ACEJIs (eg, sprains and strains). However, the effectiveness of compression in the first aid treatment of these injuries has been questioned.

Compression is advocated for treating ACEJIs such as ankle sprains to limit swelling[7,37] and to improve quality of life.[37] In theory, compression, both circumferential and sequential, is applied to limit the amount of edema caused by the exudation of fluid from the damaged capillaries[38–40] and prevent possible hypoxic damage to surrounding tissues.[20]

With this review, we sought to identify the best available evidence to inform organizations on the use of compression in a prehospital (first aid) setting for the initial management of a patient with an ACEJI. Of 1193 references identified initially, researchers in 8 studies compared compression of acute ankle injuries (sprains) with the use of a noncompressive stocking, splint, ankle brace, elevation of the injured ankle, or no treatment. We found no investigations of compression for other closed extremity injuries to joints such as the wrist or knee, limiting the results of this review to ankle-joint injuries. All included studies were of low to very low certainty according to the GRADE system, reducing our confidence in the estimate of effects. Our findings must be considered with this restriction in mind.

Previous researchers focused on compression applied with cryotherapy,[41,42] RICE,[14,43] or compression alone, but with applications beyond those available to first aid providers in the prehospital setting.[12,13,37]

van den Bekerom at al[14] performed a systematic review examining the effectiveness of applying RICE therapy within 72 hours after an ankle sprain. They included a

Table 5. Overview of Risk of Bias of Nonrandomized Controlled Trials, Assessed With Risk Of Bias In Nonrandomized Studies of Interventions Tool[a]

Study	Intervention	Comparison	Confounding	Participant Selection	Intervention Classification	Deviations From Intended Interventions	Missing Outcome Data	Outcome Measurement	Selection of Reported Result	Overall
Bilgic et al[34] (2015)	Elastic bandage	Splint	−	+	+	+	+	?	+	−
Linde et al[35] (1984)	Elastic compression bandage	No treatment	?	+	+	+	?	−	+	−

[a] Symbols: +, low risk of bias; ?, moderate risk of bias; −, serious risk of bias.

single study of compression therapy, which demonstrated that the combination of elastic bandaging and intermittent pneumatic compression was better than elastic bandaging alone in decreasing edema and reducing pain.[44] However, importantly, this finding is not applicable in the prehospital setting due to the unavailability of intermittent pneumatic compression units.

Fousekis et al[13] conducted a systematic review to evaluate the effectiveness of elastic bandaging in orthopaedic and sports injury prevention and rehabilitation. Moderate-certainty evidence suggested improved ankle proprioception (ie, enhanced kinesthesia and neuromuscular control) in participants who used elastic bandages, but the evidence was insufficient to support the use of elastic bandages to improve other outcomes, such as joint ROM and stability and functional outcome after injury. For the important outcome of ROM, these results are consistent with ours, failing to show a benefit from a compression bandage versus a noncompressive ankle brace.[32]

The systematic review of Seah and Mani-Babu[12] addressed the effectiveness of managing ankle sprains (acute and chronic) in the community. Functional treatment options for patients with mild to moderate ankle sprains (including elastic bandaging, soft casting, taping, or orthoses with associated coordination training) produced statistically better outcomes than immobilization for multiple measures.

In the current review, we focused on applications available to first aid providers in the prehospital setting. We could not demonstrate a benefit for the critical outcome of reduced pain during walking or at rest when comparing a compression bandage with no compression or with noncompressive stockings, splints, or braces (Air Stirrup ankle brace).[20,29,31,34,35] For the critical outcome of decreased swelling or edema, the authors of 3 studies[29,31,34] showed no benefit when comparing a compression bandage with noncompressive stockings, splints, or braces. However, in 1 study,[33] researchers found less reduction in swelling with an elastic bandage than with no treatment. Yet this was a small investigation with only 10 participants in each group, which restricts the interpretation of the results. Also, in both treatment arms, the ankle was kept elevated at an angle of 45°, which might have influenced swelling.[45]

One RCT[32] yielded less benefit for the important outcome of time to return to work when the use of a compression bandage was compared with an Air Stirrup ankle brace. The authors of 2 other randomized studies[20,29] demonstrated no difference in the time to return to work when comparing the use of a compression bandage with no treatment or noncompressive stockings. For the outcome of time to return to sport, 1 randomized trial[29] showed a benefit with the use of a compression bandage versus noncompressive stockings. Nonetheless, the findings from these individual studies are not considered adequate to support a recommendation for the use of compression bandages for patients with ankle-joint injuries.

The strength of this review was the rigorous and transparent use of the PRISMA and GRADE methods to identify the best available evidence for the use of a compression bandage by a first aid provider for an ACEJI in the prehospital setting. To our knowledge, this was the first systematic review to evaluate the use of compression as a standalone intervention for patients with ACEJIs. Although first aid training programs teach RICE and others advocate the use of compression to minimize swelling in ACEJIs,[7] the evidence on the use of compression wrap alone as a treatment for closed extremity joint injuries is limited.

As pointed out by van den Bekerom et al,[14] no information can be provided about the best way, amount, and duration of compression or the position in which the compression treatment should occur. This is especially true in the prehospital setting because of the level of training and expertise of the providers available during the emergent situation. First aid, or the aid offered before advanced medical care or equipment arrives, varies nationally and internationally.

To help clinicians and guideline developers make informed decisions based on evidence, the GRADE Evidence-to-Decision (EtD) framework is a useful tool. It helps in the development of recommendations that consider the evidence for an intervention in light of desirable and undesirable effects, the certainty of the evidence, values, resource requirements, cost, equity, and acceptability.[46] We used the GRADE EtD framework to discuss the evidence identified through this systematic review with the ILCOR First Aid Task Force. Concern was expressed regarding the potential for improper application of a compression bandage by unskilled lay providers for closed injuries, such as to the ankle joint, in the prehospital setting. The evidence evaluated in this review does not support the use of compression wraps for acute ankle sprains by lay providers in a first aid setting; however, there was also no evidence of harm from compression bandaging.

LIMITATIONS

The aim of our review was to identify the evidence for the use of a compression bandage by first aid providers in a prehospital setting, but all research considered in this review was performed in a hospital setting. Therefore, the certainty of evidence was downgraded for indirectness. Furthermore, all types of noncompressive techniques that can be used in a first aid setting were included as comparisons. This may have led to confounding of the results. Also, we only identified studies of patients with ankle sprains. Whether the results would be applicable to other joints, such as the wrist, knee, or elbow, is unknown.

In most studies, the authors provided no explanation of how much pressure was applied using the compression or elastic bandages, how the wrap was applied (proximal to distal or distal to proximal), whether the pressure was circumferential or sequential, and how long the compression bandage was worn. All of these can be confounding factors. Additionally, a potential limitation is that a first aid provider, or even a health care professional, may not be able to correctly apply a compression bandage.

Some deviations from the review protocol occurred. First, we decided to include adults and exclude children because of heightened concern for fracture in children with immature bones. Second, the protocol excluded the use of tubular bandages (eg, Tubigrip) and compression stockings. The rationale was that these interventions would be too painful to apply immediately after an acute sprain or strain. However, after discussion with the ILCOR First Aid Task

Force members, we determined that these interventions would be feasible, and they were therefore included, as long as compression was applied.

FUTURE DIRECTIONS

Future research is needed to investigate the use of compression bandages for closed extremity joint injuries other than ankle sprains (ie, those affecting the wrist or knee). More work is required to assess if the application of a compression bandage compared with doing nothing results in greater satisfaction among patients and care providers. Also, how much pressure is needed to produce physiological changes in the body is unclear. No information is available on the economic effects (direct and indirect medical costs, lost wages due to inability to work) of using compression bandages for closed extremity joint injuries. Finally, what benefit compression bandages may have when used in combination with other adjunct therapies in the prehospital setting is unknown.

CONCLUSIONS

The evidence for the use of compression wrap as a treatment for closed extremity joint injuries was limited and of low to very low certainty due to limitations in study design, indirectness, and imprecision. The only evidence we identified was related to ankle sprains. We were unable to demonstrate a beneficial or harmful effect from the application of a compression or elastic bandage compared with no compression or a noncompressive stocking, splint, or brace as a first aid treatment in the prehospital environment. Further out-of-hospital and first aid studies are required to investigate the usefulness of compression bandages for patients with closed extremity joint injuries.

ACKNOWLEDGMENTS

Drs Borra and De Buck are employees of the Belgian Red Cross and receive no other funding. One activity of the Belgian Red Cross is to provide first aid training to laypeople. This work was made possible through funding from the Foundation for Scientific Research of the Belgian Red Cross (Mechelen, Belgium). The American Heart Association and ILCOR supplied the resources to assemble the Task Force and manage records and data.

In addition to Drs Borra, Berry, Zideman, and Singletary, members of the ILCOR First Aid Task Force included Jason C. Bendall, Jestin N. Carlson, Pascal Cassan, Wei-Tien Chang, Nathan P. Charlton, Therese Djarv, Matthew Douma, Jonathan L. Epstein, David S. Markenson, Daniel Meyran, Peter Morley, Aaron Orkin, Tetsuya Sakamoto, Janel Swain, and Jeffrey A. Woodin.

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Appendix. Search Strategies

PubMed

1. "Sprains and strains"[Mesh] OR "Soft Tissue Injuries"[Mesh] OR "athletic injuries"[Mesh] OR strain*[TIAB] OR sprain*[TIAB] OR distortion*[TIAB] OR rupture*[TIAB] OR "ankle injuries"[Mesh] OR "knee injuries"[Mesh] OR "wrist injuries"[Mesh] OR "tendon injuries"[Mesh:NoExp] OR overexertion[TIAB] OR ((ankle[TIAB] OR knee[TIAB] OR wrist[TIAB] OR elbow[TIAB]) AND (injur*[TIAB]))
2. "Compression Bandages"[Mesh] OR ((compression[TIAB] OR elastic[TIAB]) AND (bandag*[TIAB] OR wrap*[TIAB] OR dressing*[TIAB] OR stocking*[TIAB] OR sleeve*[TIAB]))
3. 1 AND 2

Embase

1. 'sprain'/exp OR 'joint injury'/de OR 'ankle injury'/exp OR 'knee injury'/exp OR 'wrist injury'/exp OR 'elbow injury'/exp OR 'ligament and tendon injury'/exp OR 'muscle injury'/exp OR 'overexertion'/exp OR 'Soft Tissue Injury'/exp OR 'sport injury'/exp OR strain*:ab,ti OR sprain*:ab,ti OR distortion*:ab,ti OR rupture:ab,ti OR overexertion:ab,ti OR ((ankle:ab,ti OR knee:ab,ti OR wrist:ab,ti OR elbow:ab,ti) AND (injur*:ab,ti))
2. 'Compression Bandage'/exp OR 'compression stocking'/exp OR 'compression sleeve'/de OR ((compression:ab,ti OR elastic:ab,ti) AND (bandag*:ab,ti OR wrap*:ab,ti OR dressing*:ab,ti OR stocking:ab,ti OR sleeve:ab,ti))
3. 1 AND 2

Cochrane library

1. [mh "Sprains and strains"] OR [mh "Soft Tissue Injuries"] OR [mh "athletic injuries"] OR strain*:ti,ab,kw OR sprain*:ti,ab,kw OR distortion*:ti,ab,kw OR rupture*:ti,ab,kw OR [mh "ankle injuries"] OR [mh "knee injuries"] OR [mh "wrist injuries"] OR [mh ^"tendon injuries"] OR overexertion:ti,ab,kw OR ((ankle:ti,ab,kw OR knee:ti,ab,kw OR wrist:ti,ab,kw OR elbow:ti,ab,kw) AND (injur*:ti,ab,kw))
2. [mh "Compression Bandages"] OR ((compression:ti,ab,kw OR elastic:ti,ab,kw) AND (bandag*:ti,ab,kw OR wrap*:ti,ab,kw OR dressing*:ti,ab,kw OR stocking*:ti,ab,kw OR sleeve*:ti,ab,kw))
3. 1 AND 2