

BMJ Open Efficacy of acupuncture for whiplash injury: a systematic review and meta-analysis

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ABSTRACT

Objectives This study aimed to establish clinical evidence for acupuncture by analysing data from trials that demonstrated the efficacy of acupuncture for whiplash-associated disorder (WAD) with the following research question: Is acupuncture treatment effective for symptom alleviation in patients with WAD compared with other usual care?

Design A systematic review and meta-analysis.

Data sources PubMed, Ovid Medline, Embase, The Cochrane Library, China National Knowledge Infrastructure, ScienceOn, KMBASE, Korean Studies Information Service System, Korea Med, Oriental Medicine Advanced Searching Integrated System and Research Information Sharing Service were searched from their inception to 1 October 2023.

Eligibility criteria We included randomised controlled trials (RCTs) using acupuncture on patients with WAD. The outcomes were the pain visual analogue scale (VAS) score or numerical rating scale score for neck pain, the range of motion (ROM) of the neck, the Neck Disability Index and safety.

Data extraction and synthesis Two independent researchers analysed and extracted data from the selected literatures. The risk of bias and the quality of evidence were assessed according to the Cochrane Handbook for Systematic Reviews of Interventions and the Grading of Recommendations Assessment, Development, and Evaluation method, respectively.

Results A total of 525 patients with WAD from eight RCTs were included in this study. The meta-analysis revealed that the outcomes showed significant differences in the pain VAS score (standard mean difference (SMD): −0.57 (−0.86 to −0.28), $p < 0.001$) and ROM-extension (SMD: 0.47 (0.05 to 0.89), $p = 0.03$). The risk of bias assessment revealed that four studies published after 2012 (50%, 4 out of 8 studies) showed low bias in most domains. The pain VAS score was graded as having moderate certainty. **Conclusion** Acupuncture may have clinical value in pain reduction and increasing the ROM for patients with WAD. High-quality RCTs must be conducted to confirm the efficacy of acupuncture in patients with WAD.

Trial registration number PROSPERO CRD42021261595.

INTRODUCTION

Whiplash injury or whiplash-associated disorder (WAD) is caused by rapid

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This systematic review was reported as per the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines.
- ⇒ Data regarding acupuncture were collected to appraise the acupuncture procedure as part of the Standards for Reporting Interventions in Clinical Trials of Acupuncture.
- ⇒ Subgroup analysis was performed according to the type of acupuncture treatment to verify the effect size of each subgroup.
- ⇒ The Grading of Recommendations Assessment, Development and Evaluations method was used to evaluate the quality of the outcomes.
- ⇒ Grey literature and other supplementary searches were not conducted, which may result in missing studies and the risk of publication bias.

hyperextension or hyperflexion of the patient's head due to sudden acceleration or deceleration during a vehicle crash.¹ WAD can cause musculoskeletal symptoms, such as neck pain, stiffness and headache, as well as systemic symptoms, such as dizziness, psychological distress, depression, and sleep disturbances.^{2–3} Kim *et al*⁴ reported that 57% of patients involved in traffic accidents present with neck and back pain. Several conservative therapies can be used to relieve pain and discomfort in the cervical region, such as nerve block on the dysfunctional spinal articular process^{5–6}; however, it is difficult to predict the course and sequelae of WAD owing to its unique mechanism.^{7–8}

Acupuncture is used for the treatment of various musculoskeletal disorders, such as WAD,^{9–11} as it can target the neurological mechanisms to relieve physical pain via the release of opioids and 5-hydroxytryptamine in the brain reward/motivation circuit.¹² However, its effectiveness is yet to be recognised despite its usefulness in clinical practice.¹³ The Canadian and Australian WAD clinical practice guidelines (CPGs) do not

recommend acupuncture for treating WAD¹⁴; moreover, one of the guidelines does not conclude that acupuncture is effective.¹⁵ This lack of consensus can be attributed to the lack of research or evidence on acupuncture at the time of formulating these CPGs.

Therefore, this study aimed to establish clinical evidence for acupuncture by analysing data from trials that demonstrated the efficacy of acupuncture for the treatment of WAD with the following research question: Is acupuncture treatment effective for symptom alleviation in patients with WAD compared with other usual care? Moon *et al*¹⁶ published their systematic review (SR) in 2014; however, a meta-analysis was not conducted as part of their study. Lee *et al*¹⁷ published a protocol of an SR to verify the effect of acupuncture on WAD; however, no follow-up studies have been published. Therefore, in this study, we updated the previous SR¹⁶ by adding clinical studies published after 2014 and evaluated the quality of evidence on acupuncture through a meta-analysis and sensitivity analysis. Herein, this SR was reported as per the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines and referred to the Cochrane Handbook.^{18 19}

MATERIALS AND METHODS

Database selection and search strategy

The protocol of this SR was registered in the Prospective Register of Systematic Reviews (PROSPERO) database on 18 July 2021 (CRD42021261595).²⁰ Online databases, including PubMed, Ovid Medline, Embase, The Cochrane Library, China National Knowledge Infrastructure, ScienceOn, KMBASE, Korean Studies Information Service System, Korea Med, Oriental Medicine Advanced Searching Integrated System and Research Information Sharing Service were searched for studies on the efficacy of acupuncture for WAD from their inception to 1 October 2023. We did not limit our search by language or by publication date. Terms related to acupuncture and WAD from the Medical Subject Headings were used in the search strategy; the terms were translated into the language suitable for each database (online supplemental table 1). In addition, we checked the reference lists of all previously published SRs identified by the above methods, looking for cited relevant studies. However, we did not review conferences because of the validity of the findings reported in conference abstracts.²¹

Eligibility criteria

The studies included in this study were selected according to the following five criteria: study design, participants, intervention, comparison and outcomes. Randomised controlled trials (RCTs) that used acupuncture on patients with WAD were included regardless of their reporting type, blinding and language. In contrast, RCTs that did not target WAD or use acupuncture as an intervention were excluded. Additionally, non-RCTs, single-arm preclinical and postclinical trials, case-control

studies, case reports, laboratory studies (including in vivo and in vitro studies), letters and reviews were also excluded. Thereafter, the participants diagnosed with WAD, regardless of their race, age or sex, were identified. The diagnostic criteria for WAD were based on those of the Quebec Task Force, which classified patients according to their severity of signs and symptoms.²² The Quebec Task Force's diagnostic criteria are as follows:

Grade I: neck complaint of pain, stiffness or tenderness only. No physical sign(s).

Grade II: neck complaint AND musculoskeletal sign(s). Musculoskeletal signs include decreased range of motion and point tenderness.

Grade III: neck complaint AND neurological sign(s). Neurological signs include decreased range of motion and point tenderness.

Grade IV: neck complaint AND fracture or dislocation.

The treatment interventions were acupuncture treatment, including electroacupuncture (EA) and dry needling, and acupuncture combined with active treatment(s), which were compared with the same active treatment(s) in the control group. The treatments administered to the control group were limited to usual care, such as physiotherapy, medications, conventional treatments other than acupuncture and sham treatments. The primary outcome was the pain visual analogue scale (VAS) score or numerical rating scale score for neck pain, and the secondary outcomes were the range of motion (ROM) of the neck, the Neck Disability Index (NDI) and safety.²³

Data collection and analysis

Study selection

Two independent researchers (S-HL and M-SH) were involved in the study selection process. Study selection and deduplication were performed using Excel. In the case of disagreements during the process, the researchers proceeded to the next step after reaching a consensus through a discussion. After removing duplications, the titles and abstracts of the studies were screened to exclude those that did not meet the eligibility criteria. Subsequently, the full text of each selected study was fully reviewed for the final selection.

Data extraction and management

Two independent researchers (S-HL and M-SH) analysed and extracted the data from the selected literature. Data extraction and management were performed using Excel. Data regarding the country of origin, study design, sample size, participants, intervention, comparison, outcomes and results were summarised in a table. The outcomes of the primary endpoint were extracted. However, if the study did not present the primary endpoint, the outcomes of the first follow-up after the treatment were extracted. In addition, data regarding the type of acupuncture, acupoints, depth of needling, stimulation response, total sessions, frequency of sessions and retention time were collected to appraise the acupuncture procedure as part

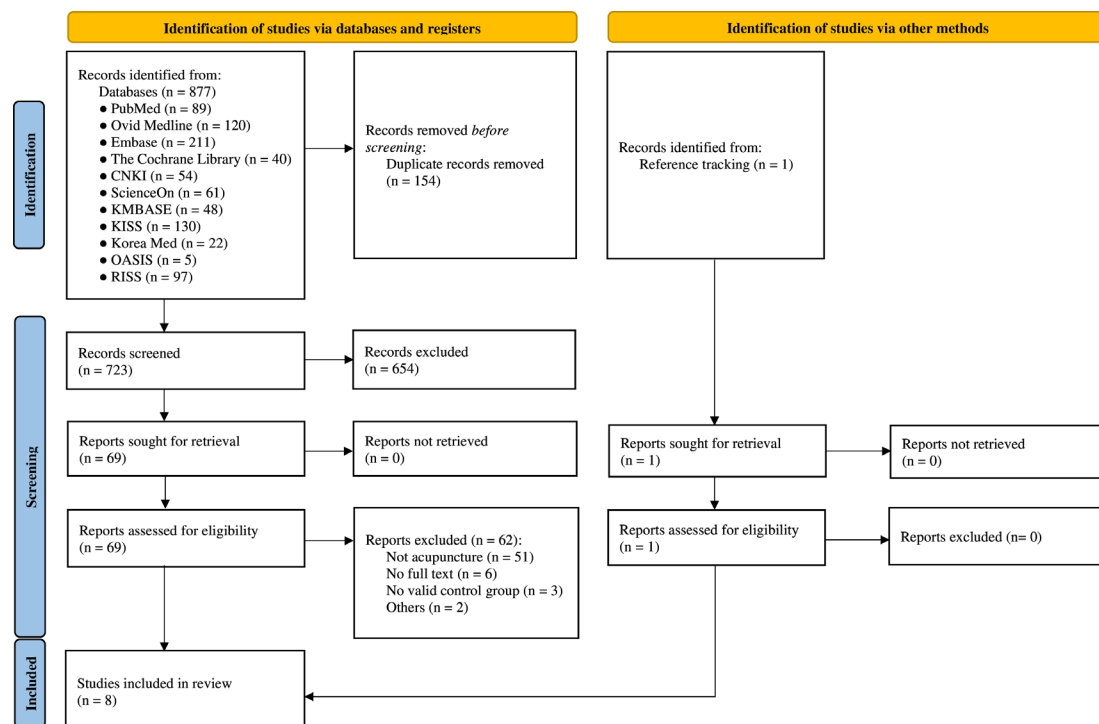


Figure 1 Preferred reporting items for systematic reviews and meta-analyses flowchart of the included studies.

of the Standards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA).^{24 25} In the case of missing standard mean difference (SMD) for changes from baseline, we tried to contact the original investigators to request further data. However, if it was impossible, we calculated a correlation coefficient from a study reported in considerable detail and imputed missing data in accordance with the established method.^{26 27}

Quality assessment

Two independent researchers (S-HL and M-SH) evaluated the quality of the selected studies according to the Cochrane RoB 2 tool in the Cochrane Handbook for Systematic Reviews of Interventions.¹⁹ The risk of bias assessment was performed based on the content described in the original text and the characteristics of the intervention. The Grading of Recommendations Assessment, Development and Evaluations (GRADE) method was used to evaluate the quality of the outcomes.²⁸ Each outcome was classified as not serious, serious or very serious according to the study design, risk of bias, inconsistency, indirectness, imprecision and other considerations. The certainty of the outcomes was categorised as high, moderate, low or very low. In the case of disagreements between researchers, agreement was reached through discussion with third and fourth researchers (B-CS and IH).

Statistical analysis

The meta-analysis was performed using the Review Manager V.5.4.1 (Cochrane) software. To determine the value of the effect size, SMD was used for continuous data and relative risk for dichotomous data. All data, including

dichotomous and continuous data, were presented with a 95% CI. Fixed-effects or random-effects models were used for the synthesis of data according to the heterogeneity of each meta-analysis. Heterogeneity (I^2) of less than 50% was considered negligible, and a fixed-effects model was used in such cases. If the heterogeneity exceeded 50%, a random-effects model was used to estimate the effect size. Subgroup analysis was performed according to the type of acupuncture treatment to verify the effect size of each subgroup. The 'leave-one-out' approach, where the meta-analysis is performed repeatedly while excluding the included literature individually, was performed for sensitivity analysis.²⁹ When a fixed-effects model was used for data synthesis, sensitivity analysis using a random-effects model was additionally performed to eliminate confounding effects. In addition, a funnel plot was generated to determine the presence of publication bias for the primary outcome.

Patient and public involvement

No patient involved.

RESULTS

Study selection

A total of 877 articles were retrieved from databases. After excluding 154 duplications, 295 studies unrelated to WAD, 163 non-RCT studies, 42 in vitro and in vivo studies and 154 irrelevant studies were excluded while screening of the title and abstract. The full text of the remaining 69 articles was reviewed, and 62 articles were excluded, including 51 articles that did not use acupuncture as an

Table 1 Data of clinical studies on acupuncture for WAD

First author (year)	Country of origin (period)	Design	Sample size	Participants	Intervention	Comparison	Outcomes	Results (effect size, p value)
Sterling <i>et al</i> (2015) ³⁰	Australia (2009–2012)	RCT	Total: 80 Exp.: 40 Con.: 40	WAD II	Atx.+ exercise	Sham atx.+exercise	1. NDI 2. ROM 3. Flex 4. Ext. 5. Rt. Rot. 6. Lt. Rot.	1. 0.10, p=0.67 2. -0.14, p=0.54 3. 0.08, p=0.71 4. -0.32, p=0.16 5. 0.26, p=0.24
Tobbackx <i>et al</i> (2012) ³¹	Belgium (01/2011 – 12/2011)	Crossover RCT	Total: 39	WAD I or II or III (chronic WAD persisting more than 3 months)	Atx.	Relaxation	1. NDI 2. Pain VAS	1. 0.17, p=0.47 2. 0.16, p=0.47
Kwak <i>et al</i> (2012) ³²	Korea (12/2009 – 10/2010)	RCT	Total: 40 Exp.: 20 Con.: 20	WAD (persisting more than 3 months)	Atx. + UC	UC (PTx.+exercise)	1. Pain VAS 2. ROM 3. Flex. 4. Ext. 5. Rt. Lat. Flex. 6. Lt. Lat. Flex 7. Rt. Rot. 8. Lt. Rot.	1. 0.78, p=0.02 2. -0.01, p=0.97 3. 0.73, p=0.03 4. 0.10, p=0.76 5. 0.25, p=0.43 6. 0.10, p=0.76 7. 0.16, p=0.61
Tough <i>et al</i> (2010) ³³	UK (05/2007 – 12/2007)	RCT	Total: 34 Exp.: 17 Con.: 17	WAD II (WAD persisting 2–16 weeks)	Atx. + Ptx.	Sham Atx.+Ptx.	1. Pain VAS 2. NDI	1. 0.76, p=0.03 2. 0.61, p=0.08
Aigner <i>et al</i> (1998) ¹⁶	Austria (NR)	RCT	Total: 61 Exp.: 28 Con.: 33	WAD I or II	Atx.	Med.	ROM	NR
Han <i>et al</i> (2011) ³⁴	Korea (03/2011 – 07/2011)	RCT	Total: 58 Exp.: 29 Con.: 29	WAD	EA+HM	Sham EA+HM	1. Pain VAS 2. NDI	1. 0.88, p=0.002 2. 0.57, p=0.03
Cameron <i>et al</i> (2011) ³⁵	Australia (03/2001 – 10/2004)	RCT	Total: 116 Exp.: 52 Con.: 64	WAD I or II (subacute or chronic WAD persisting more than 1 month)	EA	Sham EA	1. Pain VAS 2. NDI	1. 0.21, p=0.25 2. -0.49, p=0.009

Continued

Table 1 Continued

First author (year)	Country of origin (period)	Design	Sample size	Participants	Intervention	Comparison	Outcomes	Results (effect size, p value)
Kim <i>et al</i> (2020) ³⁶	Korea (07/2019 – 09/2019)	RCT	Total: 97 Exp.: 48 Con.: 49	WAD (within 7 days)	MSAT+IKM	IKM (Atx.+pharm. + CMT + HM)	1. Pain VAS 2. NDI 3. ROM 4. Flex. 5. Ext. 6. Rt. Lat. Flex. 7. Lt. Lat. Flex 8. Rt. Rot. 9. Lt. Rot.	1. 0.85, p<0.0001 2. 0.29, p=0.15 3) 1. 0.80, p=0.0001 2. 0.67, p=0.001 3. 1.01, p<0.001 4. 0.88, p<0.001 5. 1.44, p<0.001 6. 1.43, p<0.001

Atx., acupuncture therapy; CMT, Chuna manual therapy; Con., control; EA, electroacupuncture; Exp., experimental; Ext., extension; Flex., flexion; HM, herbal medicine; IKM, integrative Korean medicine treatment; Lat., lateral; Lt., left; Med., medication; MSAT, motion-style acupuncture treatment; NDI, Neck Disability Index; Pharm., pharmacopuncture; PTx., physiotherapy; RCT, randomised controlled trial; ROM, range of motion; Rot., rotation; Rt., right; UC, usual care; VAS, visual analogue scale; WAD, whiplash-associated disorder.

intervention, 6 articles without full text, 3 articles without a valid control group and 2 articles for other reasons. In addition, we included one study through reference tracking.¹⁶ Thus, eight studies were included in the final analysis (figure 1).

Study characteristics

A total of 525 patients with WAD were included in this study. Five studies^{16 30–33} compared acupuncture with sham acupuncture, usual care or medication, whereas two^{34 35} compared EA with sham EA. One study³⁶ compared motion-style acupuncture treatment (MSAT) with usual care. The country of origin of the studies varied: three in Korea,^{32 34 36} two in Australia,^{30 35} one each in Belgium,³¹ UK³³ and Austria.¹⁶ The recruitment period was less than 1 year in five studies,^{31–34 36} more than 4 years in two studies,^{30 35} and not reported in one study.¹⁶ Among the eight studies, one³¹ was designed as a crossover RCT. The pain VAS score was recorded in six studies,^{31–36} and the ROM was recorded in four studies.^{16 30 32 36} The NDI was recorded in six studies.^{30 31 33–36} The study by Aigner *et al*¹⁶ was described based on its reference in the SR by Moon *et al*,¹⁶ as the original text could not be accessed (table 1).

Standard for reporting acupuncture according to STRICTA

The eight studies were analysed using STRICTA (online supplemental table 2). Regarding the type of acupuncture, five studies^{16 30–33} used general acupuncture, two used EA^{34 35} and one used MSAT.³⁶ Five studies^{16 31 32 34 35} used specific acupoints, and three^{30 33 36} used muscle trigger points instead of acupoints. The depth of needling was mentioned only in four studies.^{32 34–36} For stimulation response, two studies^{31 32} induced a *deqi* sensation, two^{30 33} used pecking, two^{30 32} used techniques such as twirling and rotation, and two^{34 35} used electrical stimulation. Regarding the total number of sessions, more than six sessions were performed in most studies,^{30 32 34–36} only one session was performed in one study,³¹ and two to six sessions were performed in one study depending on the degree of improvement in the symptoms.³³ The frequency of sessions was unreported in one study,¹⁶ whereas sessions were performed one to three times a week in the remaining seven studies. The number of weeks varied from 1 to 6 weeks, and the retention time varied from 15 to 60 min.

Risk of bias assessment

The eight selected studies were analysed using the Cochrane RoB 2 tool. Six out of eight studies were identified as having low risk of bias with appropriate procedures for random sequence generation and allocation concealment.^{30–33 35 36} Regarding deviations from the intended interventions, four studies were rated as having low risk of bias,^{30 32 35 36} three as having some concerns^{31 33 34} and one as having high risk of bias.¹⁶ For missing outcome data, four studies were rated as having low risk of bias.^{31 32 34 36} In terms of bias in measurement of the outcome, except for one study that did not provide full text,¹⁶ all seven studies

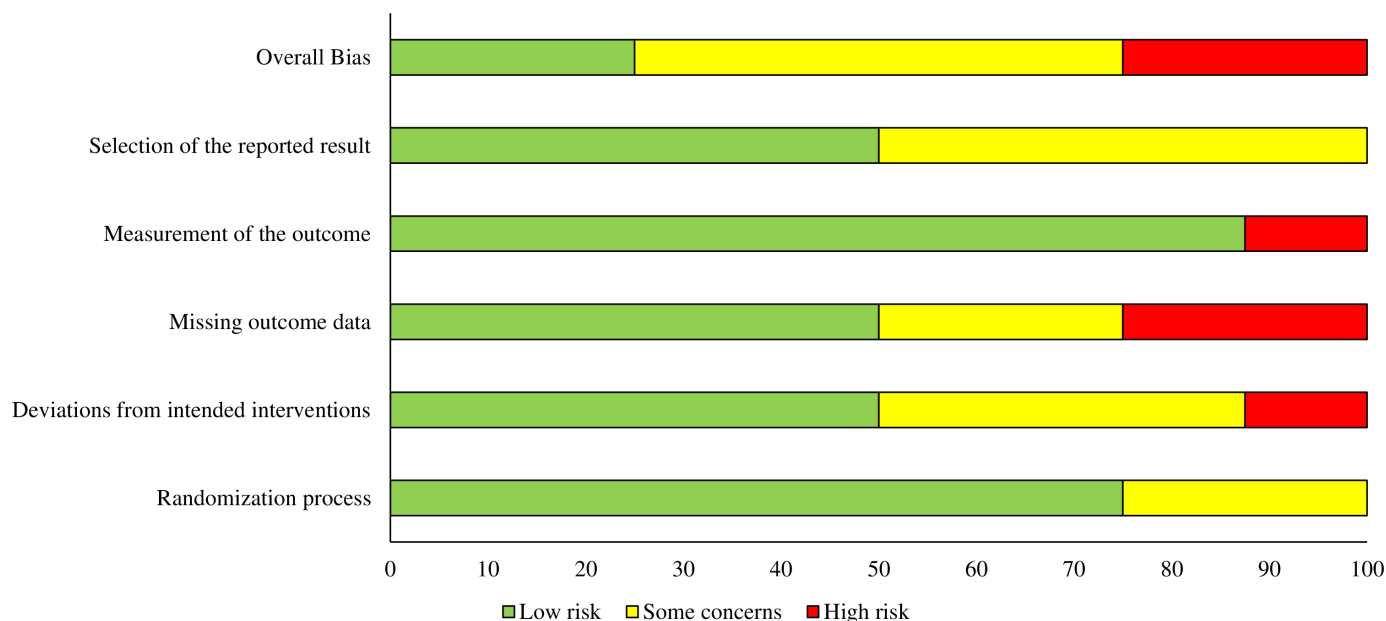


Figure 2 Summary in risk of bias 2.

were identified as having low risk of bias. In terms of the selection of the reported result, studies that reported a prespecified analysis plan were rated as having low risk of bias.^{30–32 36} Overall, two studies showed low risk of bias in all five components^{32 36} (figure 2, online supplemental figure 1).

Meta-analysis

A meta-analysis was performed with seven studies^{30–36} according to the outcomes, after excluding one study¹⁶ in which no comparison was made between the groups. The subgroups were divided into general acupuncture,

EA, and MSAT according to the type of acupuncture treatment.

Pain VAS score

The result of the meta-analysis for the pain VAS score revealed that acupuncture was effective in treating patients with WAD (SMD: -0.57 (-0.86 to -0.28), $p < 0.001$). The random-effects model was used for the analysis, as the heterogeneity (I^2) was 51%. Subgroup analysis revealed that general acupuncture and MSAT were effective in treating patients with WAD, whereas EA was ineffective (figure 3).

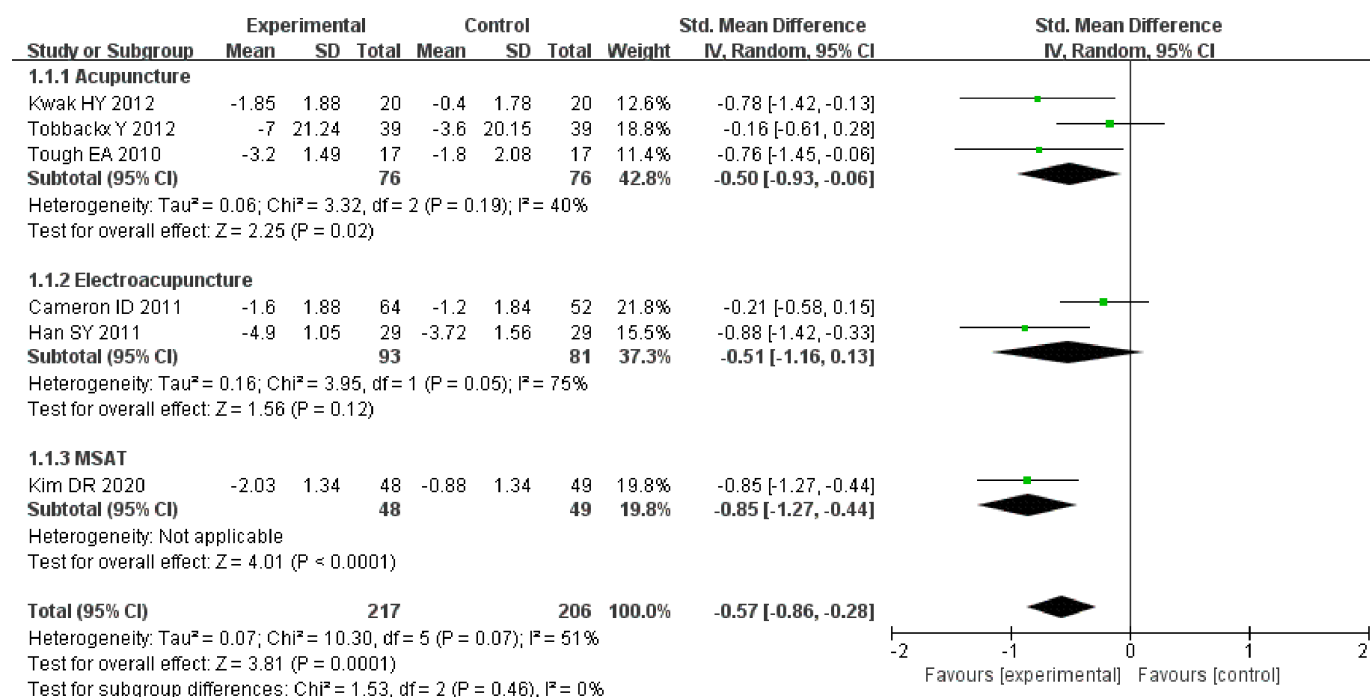


Figure 3 Forest plot of the meta-analysis for the pain visual analogue scale score.

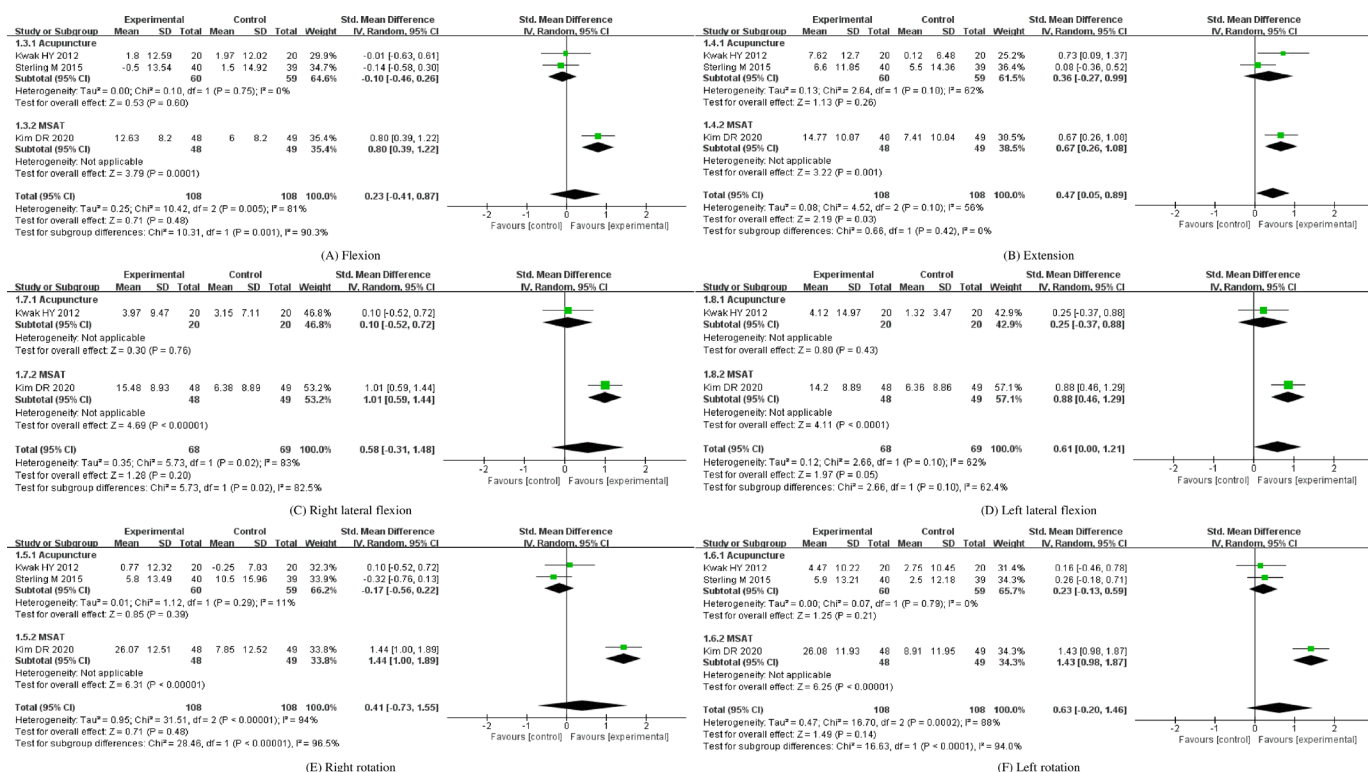


Figure 4 Forest plot of the meta-analysis for the range of motion.

Range of motion

Kwak *et al*³² and Kim *et al*³⁶ recorded the ROM for all directions, whereas Sterling *et al*³⁰ recorded the ROM for four directions: flexion, extension, right rotation and left rotation. The results of the meta-analysis for ROM revealed that acupuncture was effective in improving extension in patients with WAD (SMD: 0.47 (0.05 to 0.89), $p = 0.03$). The random-effects model was used for all directions of ROM, as the heterogeneity (I^2) was $>50\%$. Subgroup analysis showed that MSAT was effective in treating patients with WAD in all directions of ROM. However, general acupuncture was not effective for ROM in any direction (figure 4).

Neck Disability Index

The results of the meta-analysis for NDI revealed that acupuncture was ineffective in improving the NDI. The random-effects model was used for the analysis as the heterogeneity (I^2) was $>50\%$. Subgroup analysis revealed that all treatments were ineffective in improving the NDI (online supplemental figure 2).

Adverse events

Five studies^{30 32 33 35 36} reported adverse events (AEs), whereas three^{16 31 34} did not. Except for one case of moderate AE, all reported AEs were mild. Pruritus of unknown cause was reported in the study by Kim *et al*,³⁶ necessitating the administration of antihistamines by injection, cream and oral route. Other AEs caused by acupuncture included hives, dizziness, exacerbation of neck pain, bruising, fatigue and somatic reactions (sweating and low blood pressure); however,

these AEs were mild and were cured within a few days. AEs such as diarrhoea, soft stools, nausea, heartburn and vesicles were also reported; however, these were confirmed to be caused by interventions other than acupuncture.

Sensitivity analysis

A sensitivity analysis for the pain VAS score, ROM-flexion, ROM-extension, ROM-right rotation, ROM-left rotation and NDI was performed, whereas ROM-right lateral flexion and ROM-left lateral flexion were excluded as they were included only in two studies (online supplemental table 3).

Pain VAS score

The results of the meta-analysis of the pain VAS score changed to moderate heterogeneity when the study by Tobbackx *et al*³¹ was removed (SMD: -0.65 (-0.96 to -0.35), $p < 0.001$, I^2 : 44%).

Range of motion

The result of the meta-analysis of ROM-extension was maintained when the study by Sterling *et al*³⁰ was removed; however, the results were not maintained when the study by Kwak *et al*³² or Kim *et al*³⁶ was removed. In particular, there was no heterogeneity when the study by Sterling *et al*³⁰ was excluded. However, the results of the meta-analysis of ROM-flexion, ROM-right rotation and ROM-left rotation were not significantly affected as the p value was >0.05 even after removing the included studies one by one.

Neck Disability Index

The result of the meta-analysis of NDI changed to p value <0.05 and no heterogeneity when the study by Cameron *et al*³⁵ was removed (SMD: -0.29 (-0.51 to -0.08), $p = 0.007$, I^2 : 0%).

Evidence quality

The quality of evidence of the outcomes was assessed using GradePro GDT (online supplemental table 4).

Pain VAS score

Six studies ($n=423$) provided data regarding the pain VAS score. The risk of bias evaluation revealed high bias in one study; however, the effect on the estimate was considered inconclusive, and the confidence level of the evidence was not lowered. For inconsistency, the pain VAS score was downgraded by one level as its heterogeneity (I^2) was 51% . Thus, the quality of evidence on the pain VAS score was graded as 'moderate'.

Range of motion

Three studies ($n=216$) provided data regarding ROM-flexion, ROM-extension, ROM-right rotation and ROM-left rotation. Two studies ($n=137$) provided data regarding ROM-right lateral flexion and ROM-left lateral flexion. The risk of bias evaluation revealed some concerns in one study; however, the effect on the estimate was considered inconclusive, and the confidence level of the evidence was not lowered. In the evaluation of consistency, ROM-extension and ROM-left lateral flexion were downgraded by one level as their heterogeneity (I^2) was higher than 50% but lower than 75% . Similarly, ROM-flexion, ROM-right lateral flexion, ROM-right rotation and ROM-left rotation were downgraded by two levels as their heterogeneity (I^2) was $>75\%$. In the evaluation of imprecision, ROM-extension was downgraded by one level as the number of participants was less than 400. Similarly, ROM-flexion, ROM-right lateral flexion, ROM-left lateral flexion, ROM-right rotation and ROM-left rotation were degraded by two levels as the number of participants was less than 400 and their CI overlapped with no effect. Thus, ROM-extension was graded as 'low', and ROM-flexion, ROM-right lateral flexion, ROM-left lateral flexion, ROM-right rotation and ROM-left rotation were graded as 'very low'.

Neck Disability Index

Six studies ($n=462$) reported data regarding the NDI. The risk of bias evaluation revealed high bias in one study; however, the effect on the estimate was considered inconclusive, and the confidence level of the evidence was not lowered. For inconsistency, the NDI was downgraded by one level as its heterogeneity (I^2) was 69% . In the evaluation of imprecision, the NDI was downgraded by one level as the CI overlapped with no effect. Thus, the NDI was graded as 'low'.

Publication bias

Publication bias was evaluated using the funnel plot for the pain VAS score (online supplemental figure 3). The outcome was slightly asymmetric, meaning there was a little publication bias. However, as fewer than 10 studies were included, the power of the test is expected to be low.

DISCUSSION

This study revealed that acupuncture is effective in improving the pain VAS score and ROM-extension in patients with WAD. The analgesic effect of acupuncture is thought to relieve pain in patients with WAD. In addition, patients with WAD were able to effectively improve ROM-extension following acupuncture, as acupoints GB20, GB21, SI11, SI14, SI15 and TE15, which are used extensively in patients with WAD, are located in the posterior muscles of the cervical spine and upper thoracic spine. However, the NDI, ROM-flexion, ROM-right lateral flexion, ROM-left lateral flexion, ROM-right rotation and ROM-left rotation did not show significant differences; thus, future studies are required to prove the effectiveness of acupuncture for these outcomes.

In the risk of bias assessment, except for one study published before 2010,¹⁶ seven studies published after 2010 showed low bias in most domains.^{30–36} In addition, although participant blinding is difficult owing to the nature of acupuncture,³⁷ many studies have attempted to minimise this effect by utilising placebo interventions. Moreover, four studies^{30–32 36} published after 2012 showed some concerns in only two domains and low bias in all other domains, indicating that recent studies on acupuncture interventions are consistently designed with high quality.

In the sensitivity analysis of the pain VAS score, a significant effect was maintained even when the included studies were removed one by one. In this context, acupuncture showed significant effects in patients with WAD, despite differences in design, participants, interventions and comparisons among the studies. In addition, when the study by Tobbackx *et al*³¹ was removed, moderate heterogeneity was observed, meaning it was accountable for the substantial heterogeneity of the overall result. The crossover RCT design of Tobbackx *et al*³¹ is presumed to be the reason for the low effect size and high heterogeneity. For ROM-extension, there was no heterogeneity when the study by Sterling *et al*³⁰ was removed; thus, it could be assumed that the study was a potential source of heterogeneity. In the study by Sterling *et al*,³⁰ high-intensity ROM exercises, including craniocervical flexion training, neck extensor training, scapular training, posture re-education and sensorimotor exercises, were performed for 1 hour, which may have been the cause of heterogeneity. For the NDI, a significant effect appeared, and no heterogeneity

was obtained when the study by Cameron *et al*³⁵ was removed; therefore, the study was considered responsible for the between-study heterogeneity. It was presumed that the NDI SMD of the study favoured the control group since it was >0, affecting the overall effect size and heterogeneity.

A previous study¹⁶ that analysed the effectiveness of acupuncture in patients with WAD included studies published before 2014. This study differs from the previous study in the following ways. First, including two RCTs published after 2014, we analysed a total of eight RCTs. Accordingly, this study provided more objective and quantitative evidence by synthesising data on the efficacy of acupuncture for treating WAD. Second, the effect size of the pain VAS score, ROM and NDI was verified by performing a meta-analysis. The directionality of the treatment effect and whether the CI of the individual studies overlapped were assessed using a forest plot. Third, a sensitivity analysis was performed to confirm the robustness of the results. The effect of individual studies on heterogeneity (I^2) and effect size was analysed using the leave-one-out approach. Fourth, a subgroup analysis was conducted according to the type of acupuncture treatment. The effect size of each type of acupuncture treatment was verified by dividing them into general acupuncture, EA and MSAT subgroups. Fifth, the evidence quality of the pain VAS score, ROM, and NDI was assessed using the GRADE method. By presenting the certainty for each outcome, this study provided criteria that can be clinically referred to when using acupuncture for patients with WAD.

However, this study has some limitations. First, grey literature and other supplementary searches were not conducted, which may result in missing studies and the risk of publication bias. However, we attempted to minimise publication bias by reviewing the references of a previously published SR. Second, the original text of one study could not be accessed. Third, except for ROM-extension, the efficacy of acupuncture in improving ROM in other directions was evaluated as being 'very low'. This is an area that needs to be verified through further studies.

CONCLUSION

The results of this study suggest that acupuncture may have clinical value in the treatment of patients with WAD. In the future, high-quality RCTs, based on the aforementioned data, must generate evidence of higher quality than that in the present study to confirm the efficacy of acupuncture in patients with WAD.

Amendments In accordance with the reviewer's comment for revision, the RoB 2 tool and funnel plot were added to this review, unlike the proposed protocol. In addition, conference tracking was not conducted.

Contributors Conceptualisation: S-HL; formal analysis: S-YP and IH; funding acquisition: S-YP and E-HH; investigation: S-HL, IH, B-CS and M-SH; methodology: S-YP, IH, E-HH and B-CS; project administration: S-YP, IH, E-HH and M-SH;

supervision: B-CS and M-SH; writing original draft: S-HL; writing review and editing: S-HL, E-HH, B-CS and M-SH. M-SH is the guarantor.

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