

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (http://bmjopen.bmj.com).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

Efficacy of acupuncture for whiplash injury: A systematic review and meta-analysis

Journal:	BMJ Open
Manuscript ID	bmjopen-2023-077700
Article Type:	Original research
Date Submitted by the Author:	12-Jul-2023
Complete List of Authors:	Lee, Sang-Hyun; Pusan National University, Graduate School, Department of Korean Medicine Park, Sun-Young; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine Heo, In; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Hwang, Eui-Hyoung; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Shin, Byung-Cheul; Pusan National University School of Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Hwang, Man-Suk; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation
Keywords:	Systematic Review, Randomized Controlled Trial, COMPLEMENTARY MEDICINE, PAIN MANAGEMENT

SCHOLARONE™ Manuscripts

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Efficacy of acupuncture for whiplash injury: A systematic review and meta-analysis

Sang-Hyun Lee¹, Sun-Young Park², In Heo^{2,3}, Eui-Hyoung Hwang^{2,3}, Byung-Cheul Shin^{2,3}, Man-Suk Hwang^{2,3,*}

¹ Department of Korean Medicine, Graduate School, Pusan National University, Yangsan,

Gyeongnam, Republic of Korea

² 3rd Division of Clinical Medicine, School of Korean Medicine, Pusan National University,

Yangsan, Gyeongnam, Republic of Korea

³ Department of Korean Medicine Rehabilitation, Spine and Joint Center, Pusan National

University Korean Medicine Hospital, Yangsan, Gyeongnam, Republic of Korea

* Corresponding author:

Man-Suk Hwang

Department of Korean Medicine Rehabilitation, Spine and Joint Center, Pusan National

University Korean Medicine Hospital, Yangsan, Gyeongnam, Republic of Korea

Tel: +82-55-360-5970

Fax: +82-51-510-8437

Email: hwangmansuk@pusan.ac.kr

ABSTRACT

Objectives: Acupuncture is used for the treatment of various musculoskeletal disorders, including whiplash injury or whiplash-associated disorder (WAD). However, there is a lack of consensus regarding its effectiveness. This study aimed to establish clinical evidence for acupuncture by analyzing data from randomized controlled trials (RCTs) that demonstrated the efficacy of acupuncture for the treatment of WAD.

Design: A systematic review and meta-analysis.

Setting: Eleven online databases were searched for RCTs on the efficacy of acupuncture for WAD since their inception to June 2022.

Participants: The participants diagnosed with WAD, regardless of their race, age, or sex, were identified.

Interventions: The treatment interventions were acupuncture treatment, including electroacupuncture and dry needling, and acupuncture combined with active treatment(s), which were compared with the same active treatment(s) in the control group.

Primary and secondary outcome measures: The primary outcome was the pain visual analog 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, and safety.

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 scores (standard mean difference [SMD]: -0.48 [-0.67 to -0.28], p< 0.001), ROM-extension (SMD: 0.47 [0.20 to 0.75], p< 0.001), and ROM-left lateral flexion (SMD: 0.61 [0.01 to 1.21], p= 0.05). The risk of bias assessment revealed that most studies published after 2010 showed low bias. Moreover, the pain VAS score and ROM-extension were graded as having high 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 treating patients with WAD.

Trial registration number: PROSPERO CRD42021261595.

Keywords: Acupuncture; Whiplash injuries; Whiplash-associated disorder; Systematic review; Meta-analysis; Randomized controlled trial

Word Count: 3731

Article Summary

Strengths and limitations of this study

- This systematic review and meta-analysis were conducted 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 analyze the cause of heterogeneity.
- The Grading of Recommendations Assessment, Development and Evaluations method was used to evaluate the quality of the outcomes.
- Since fewer than ten studies were included, the publication bias could not be examined, and the original text of one study could not be accessed.

INTRODUCTION

Whiplash injury or whiplash-associated disorder (WAD) is caused by rapid 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 due 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 recognized despite its usefulness in clinical practice [13]. The Canadian and Australian WAD clinical practice guidelines (CPGs) do not recommend acupuncture for treating WAD [14]; 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 analyzing data from randomized controlled trials (RCTs) that demonstrated the efficacy of acupuncture for the treatment of WAD. 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 SR [16] by adding clinical studies published after 2014 and evaluated the quality of evidence on acupuncture

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 July 18, 2021 (CRD42021261595) [19]. 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 June 2022. 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 S1).

Eligibility criteria

The studies included in this study were selected according to the following five criteria: study design, participants, intervention, comparison, and outcomes. 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 pre- and post-clinical 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 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

Data collection and analysis

Study selection

Two independent researchers (SHL and MSH) were involved in the study selection process. 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 (SHL and MSH) analyzed and extracted the data from the selected literature. Data regarding the country of origin, study design, sample size, participants, intervention, comparison, outcomes, and results were summarized in a table. 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 of the Standards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA) [21, 22].

Quality assessment

Two independent researchers (SHL and MSH) evaluated the quality of the selected studies according to the risk of bias in the Cochrane Handbook for Systematic Reviews of Interventions [23]. In the case of "other sources of bias," the statistical homogeneity of

demographic information between the groups at the baseline was evaluated [24]. 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 [25]. 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 categorized as high, moderate, low, or very low.

Statistical analysis

The meta-analysis was performed using the Review Manager version 5.4.1 (Cochrane) software. To determine the value of the effect size, standard mean difference (SMD) was used for continuous data and relative risk for dichotomous data. All data, including dichotomous and continuous data, were presented with a 95% confidence interval (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 analyze the cause of heterogeneity (I^2). The "leave-one-out" approach, where the meta-analysis is performed repeatedly while excluding the included literature individually, was performed for sensitivity analysis [26]. In addition, funnel plots were generated to determine the presence of publication bias when more than 10 studies were included [27].

Patient and public involvement



RESULTS

Study selection

A total of 802 articles were retrieved. After excluding 146 duplications, 261 studies unrelated to WAD, 147 non-RCT studies, 39 in vitro and in vivo studies, and 141 irrelevant studies were excluded while screening of the title and abstract. Thus, 588 articles were excluded from the screening process. The full text of the remaining 68 articles was reviewed, and 60 articles were excluded, including 49 articles that did not use acupuncture as an intervention, 6 articles without full text, 3 articles without a valid control group, and 2 articles for other reasons. Thus, 8 studies were included in the final analysis (Figure 1).

Study characteristics

A total of 525 patients with WAD were included in this study. The country of origin of the studies varied: three in Korea [30, 32, 34], two in Australia [28, 33], one each in Belgium [29], UK [31], and Austria [16]. The recruitment period was less than one year in five studies [29-32, 34], more than four years in two studies [28, 33], and not reported in one study [16]. Among the eight studies, one [29] was designed as a crossover RCT. Regarding the intervention, five studies [16, 28-31] compared acupuncture with sham acupuncture, usual care, or medication, whereas two [32, 33] compared EA with sham EA. One study [34] compared motion-style acupuncture treatment (MSAT) with usual care. The pain VAS scores were recorded in six studies [29-34], and the ROM was recorded in four studies [16, 28, 30, 34]. The NDI was recorded in six studies [28, 29, 31-34]. The study by Aigner et al. was described based on its reference in the SR by Moon et al. [16], as the original text could not be accessed (Table 1).

ı		
2		
3		
1		
5 5 7 3		
)		
5		
7		
5		
)		
ı	ი	
	1	
	ı	
ı	2	
ı	3	
	012345678901	
	4	
ı	5	
ı	6	
	- -	
	/	
ı	8	
	a	
١	ر م	
_	U	
2	1	
2	2	
2	_	
_	3	
2	4	
)	5	
<u>'</u>	ر	
2	6	
2	7	
2	8	
_	-	
_	9	
3	0	
2	1	
	'	
Ś	2	
3	3	
2	0 1 2 3 4 5 6 7	
	-	
3	5	
3	6	
2	7	
	<i>'</i>	
3		
3	9	
	0	
1		
1	2	
1		
	4	
1	5	
1		
t	o	

First author (year)	Country of origin (period)	Design	Sample	Participants	Intervention	Comparison	mjopen-2023-077700 on by capyright, including	Outcomes	Results
Sterling et al (2015) [28]	Australia (2009 – 2012)	RCT	Total: 80 Exp.: 40 Con.: 40	WAD II	Atx. + exercise	Sham atx. + exe Relaxation UC (PTx. + exercise	17 January 2024. Downloaded (Enseignement Superieur (Ifor uses related to text and dat	1) NDI 2) ROM (1) Flex. (2) Ext. (3) Rt. Rot. (4) Lt. Rot.	1) Sig. (P<0.01) 2) (1) NS (2) NS (3) NS (4) NS
Tobbackx et al (2012) [29]	Belgium (01/2011 – 12/2011)	Crossover RCT	Total: 39	WAD I or II or III (chronic WAD persisting more than 3 months)	Atx.	Relaxation	rom http://bmjopen.bmj.com/ ABES) a mining, AI training, and sirr	1) NDI 2) pain VAS	1) Sig. (P<0.05) 2) Sig. (P<0.05)
Kwak et al (2012) [30]	Korea (12/2009 – 10/2010)	RCT	Total: 40 Exp.: 20 Con.: 20	WAD (persisting more than 3 months)	Atx. + UC	UC (PTx. + exercise	on June 8, 2025 ilar technologie	1) pain VAS 2) ROM (1) Flex.	1) Sig. (P<0.001) 2)

(2) Ext.
(3) Rt. Rot.
(4) Lt. Rot.
(5) Rt. Lat.
Flex.
(6) Lt. Lat.
Flex.

(P=0.015)

(2) Sig.

(1) NS

(P=0.961)

						elate	(3) Kt. Lat.	(P-0.013)
						d to	Plex.	(3) NS
						text	(6) Lt. Lat.	(P=0.113)
						and c	Flex.	(4) NS
						data m	d fron	(P=0.137)
						nining	n http	(5) NS
						, Al tı	://bm	(P=0.908)
						ainin in	jopen	(6) NS
						elated to text and data mining, Al training, and similar technologies. Sham Atx. + Ptx Med	.bmj.c	(P=0.075)
Tough et al	UK		Total: 34	WAD II		simil	Q 1) pain VAS	1) NS (P=0.67)
	(05/2007 –	RCT	Exp.: 17	(WAD persisting 2-	Atx. + Ptx.	Sham Atx. + Ptx.	2) NDI	2) NS (P=0.43)
(2010) [31]	12/2007)		Con.: 17	16 weeks)		hnolo	ور و ا	2) NS (F-0.43)
			Total: 61			es es	20 25 a	
Aigner et al	Austria	RCT	Exp.: 28	WAD I or Ⅱ	Atx.	Med.	2 1) ROM	1) NR
(1998) [16]	(NR)		Con.: 33	-			ence	, -
Han et al	Korea	RCT	Total: 58	WAD	EA + HM	Sham EA + HM	Di 1) pain VAS	1) Sig.
							<u> </u>	

				ВМЈ	Open		mjopen-2023-07 d by copyright, i		
(2011) [32]	(03/2011 – 07/2011)		Exp.: 29 Con.: 29				7700 on ncluding	2) NDI	(P=0.043) 2) NS
Cameron et al (2011) [33]	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	January 2024. Downloaded for Enseignement Superieur (Enseignement Superieur (r uses related to text and dat	1) pain VAS 2) NDI	1) Sig. (P=0.05) 2) NS
Kim et al (2020) [34]	Korea (07/2019 – 09/2019)	RCT	Total: 97 Exp.: 48 Con.: 49	WAD (within 7 days)	MSAT + IKM	IKM (Atx. + pharm. + HM)	from http://bmjopen.bmj.com/ on June 8, 2025 at Agence Bibliograp (ABES) ta mining, Al training, and similar technologies.	(4) Lt. Rot.(5) Rt. Lat.Flex.	1) Sig. (P=0.005) 2) NS (P=0.197) 3) (1) Sig. (P=0.001) (2) Sig. (P=0.003) (3) Sig. (P<0.001) (4) Sig.

Standard for reporting acupuncture according to STRICTA

The eight studies were analyzed using STRICTA (online supplemental table S2). Regarding the type of acupuncture, five studies [16, 28-31] used general acupuncture, two used EA [32, 33], and one used MSAT [34]. Five studies [16, 29, 30, 32, 33] used specific acupoints, and three [28, 31, 34] used muscle trigger points instead of acupoints. The depth of needling was mentioned only in four studies [30, 32-34]. For stimulation response, two studies [29, 30] induced a *deqi* sensation, two [28, 31] used pecking, two [28, 30] used techniques such as twirling and rotation, and two [32, 33] used electrical stimulation. Regarding the total number of sessions, more than six sessions were performed in most studies [28, 30, 32-34], only one session was performed in one study [29], and two to six sessions were performed in one study depending on the degree of improvement in the symptoms [31]. 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 one to six weeks, and the retention time varied from 15 to 60 min.

Risk of bias assessment

The eight selected studies were analyzed using the Cochrane Risk of Bias tool. Seven studies used an appropriate allocation procedure for random sequence generation [28-34]; one study could not be evaluated as the full text was not available [16]. Allocation concealment was performed in six studies [28-31, 33, 34]; however, it was unclear for the remaining two studies [16, 32]. Blinding of the participants and personnel was conducted in four studies using methods such as sham acupuncture and sham EA [28, 31-33]. The performance bias was high in one study in which MSAT was used only in the experimental group [34], one that was designed as a crossover RCT [29], one in which acupuncture was performed only in the experimental group [30], and one in which acupuncture and medication were compared [16].

 Blinding of the outcome assessment was low in four studies [28-30, 34]. Attrition bias was classified as low in six studies with intention-to-treat analysis [28-31, 33, 34] and one with no dropouts [32]. Attrition bias was categorized as unclear in one study as it was not mentioned [16]. Selective reporting bias was classified as low in four studies as the protocol was previously announced [28-30, 34]. Other sources of biases were classified as low in four studies [29, 30, 32, 34], unclear in three [16, 28, 31], and high in the remaining one [33]. In the studies by Tobbackx et al. [29], Kwak et al. [30], Han et al. [32], and Kim et al. [34], no significant difference was observed between the baseline characteristics of the groups; hence, the other sources of bias were classified as low. There was no mention of related information in the study by Aigner et al. [16]. In contrast, in the studies by Sterling et al. [28] and Tough et al. [31], the baseline characteristics were presented, but a comparison between groups was not performed; therefore, the other sources of bias were classified as unclear. In the study by Cameron et al. [33], a significant difference was observed between the groups in terms of the current analgesic medication, the pain rating index-total of the short-form McGill Pain Questionnaire, and the NDI at the baseline; therefore, the other sources of bias were classified as high (Figure 2).

Meta-analysis

A meta-analysis was performed with seven studies [28-34] according to the outcomes, after excluding one study [16] 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: -0.48 [-0.67 to -0.28], p< 0.001). The fixed-effects model was used for the analysis as the heterogeneity (I^2) was 13%. Subgroup analysis revealed that general acupuncture, EA, and MSAT were all effective in treating patients with WAD (Figure 3).

ROM

 Kwak et al. [30] and Kim et al. [34] recorded the ROM for all directions, whereas Sterling et al. [28] 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 and left lateral flexion in patients with WAD (extension - SMD: 0.47 [0.20 to 0.75], p< 0.001; left lateral flexion - SMD: 0.61 [0.01 to 1.21], p= 0.05). The fixed-effects model was used to analyze extension as the heterogeneity (I^2) was 45%. In contrast, the random-effects model was used to analyze flexion, right lateral flexion, left lateral flexion, right rotation, and left rotation 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).

NDI

The results of the meta-analysis for NDI revealed that acupuncture was ineffective in improving the NDI. The fixed-effects model was used for the analysis as the heterogeneity (I^2) was 13%. Subgroup analysis revealed that all treatments were ineffective in improving the NDI (online supplemental figure S1).

Adverse events

Five studies [28, 30, 31, 33, 34] reported adverse events (AEs), whereas three [16, 29, 32] 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. [34], 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 diarrhea, 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, and 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 S3).

Pain VAS score

The results of the meta-analysis of the pain VAS score were maintained with the p-values < 0.05 even after removing the included studies individually. The overall heterogeneity (I^2) of the pain VAS score was negligible (13%) and was maintained at < 50% even after removing the included studies individually.

ROM

The results of the meta-analysis of ROM-extension were maintained when the study by Kwak et al. [30] or Sterling et al. [28] was removed; however, the results were not maintained when

the study by Kim et al. [34] was removed. In particular, there was no heterogeneity when the study by Sterling et al. [28] 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.

NDI

 The result of the meta-analysis of NDI changed to the p-value < 0.05 and no heterogeneity, when the study by Cameron et al. [33] was removed (SMD: -0.22 [-0.43 to -0.01], p= 0.04, I^2 : 0%).

Evidence quality

The quality of evidence of the outcomes was assessed using GradePro GDT (online supplemental table S4).

Pain VAS score

Six studies (n = 423) provided data regarding the pain VAS score. The risk of bias evaluation revealed high bias in four studies; however, the effect on the estimate was considered inconclusive in all studies, and the confidence level of the evidence was not lowered. Thus, the quality of evidence on the pain VAS score was graded as "high."

ROM

Three studies (n = 215) 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 high bias in

 three studies; however, the effect on the estimate was considered inconclusive in all studies, and the confidence level of the evidence was not lowered. In the evaluation of consistency, ROM-flexion and ROM-left lateral flexion were downgraded by one level as their heterogeneity (I^2) was 71% and 62%, respectively. Similarly, 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 and ROM-left lateral flexion were downgraded by one level as the number of participants was less than 400. Similarly, ROM-flexion, ROM-right 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. The Z-score of ROM-extension was 3.41, and it was upgraded by one level in other considerations. Thus, ROM-extension was graded as "high," ROM-left lateral flexion was graded as "low," and ROM-flexion, ROM-lateral flexion, ROM-right rotation, and ROM-left rotation were graded as "very low."

NDI

Six studies (n = 461) reported data regarding the NDI. The risk of bias evaluation revealed high bias in three studies; however, the effect on the estimate was considered inconclusive in all studies, and the confidence level of the evidence was not lowered. 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 "moderate."

Publication bias

In accordance with the proposed protocol, publication bias was not examined as fewer than 10 studies were included [19].

DISCUSSION

This study revealed that acupuncture is effective in improving the pain VAS score, ROMextension, and ROM-left lateral flexion 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, further studies are required to validate the findings of ROM-left lateral flexion, as there were few participants and high heterogeneity (I²). Notably, the NDI, ROM-flexion, ROM-right 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 [28-34]. In addition, although participant blinding is difficult owing to the nature of acupuncture [35], many studies have attempted to minimize this effect by utilizing placebo interventions. Moreover, two studies [28, 34] published after 2015 showed high bias in only one domain 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. For ROM-extension, there was no heterogeneity when the study by Sterling et al. [28] was removed; thus, it could be assumed that the study was a potential source of heterogeneity. In the study by Sterling et al. [28], high-intensity ROM exercises, including craniocervical flexion training, neck extensor training, scapular training,

posture re-education, and sensorimotor exercises, were performed for 1 h, 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. [33] was removed; therefore, the study was considered responsible for the between-study heterogeneity. It was presumed that the NDI SMD of the study favored the control group since it was > 0, affecting the overall effect size and heterogeneity.

A previous study [16] that analyzed 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 analyzed a total of eight RCTs. Accordingly, this study provided more objective and quantitative evidence by synthesizing 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 was assessed using a forest plot. Third, sensitivity analysis was performed to confirm the robustness of the results. The effect of individual studies on heterogeneity (I^2) and effect size was analyzed using the leave-one-out approach method. 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, since fewer than ten studies were included, the publication bias could not be examined. Second, the original text of one study could not be accessed. Third, except for ROM-extension and ROM-left lateral flexion, 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 has 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 treating patients with WAD.

AUTHOR CONTRIBUTIONS

Sang-Hyun Lee: Conceptualization

Sun-Young Park: Funding acquisition

Sang-Hyun Lee and Man-Suk Hwang: Investigation

In Heo and Byung-Cheul Shin: Methodology

Eui-Hyuoung Hwang and Man-Suk Hwang: Project administration

Man-Suk Hwang: Supervision

Sang-Hyun Lee: Writing – original draft

Sang-Hyun Lee and Man-Suk Hwang: Writing – review & editing

FUNDING

This work was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea [grant number: HF21C0162].

DISCLAIMER

The funding source had no role in the design of the protocol, study search and selection, data

extraction and management, data interpretation, report writing, or the decision to submit the report for publication.

COMPETING INTERESTS

None.

PATIENT CONSENT FOR PUBLICATION

Not required.

PROVENANCE AND PEER REVIEW

Not commissioned; extremally peer reviewed.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

- 1. Spitzer WO, Skovron ML, Salmi LR, et al. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. *Spine (Phila Pa 1976)*. 1995;20:1s-73s.
- 2. Eck JC, Hodges SD, Humphreys SC. Whiplash: a review of a commonly misunderstood injury. *Am J Med*. 2001;110:651-6. doi: 10.1016/s0002-9343(01)00680-5.
- 3. Côté P, Hogg-Johnson S, Cassidy JD, et al. Initial patterns of clinical care and recovery from whiplash injuries: a population-based cohort study. *Arch Intern Med.* 2005;165:2257-63. doi: 10.1001/archinte.165.19.2257.
- 4. Kim N, Shin BC, Shin JS, et al. Characteristics and status of Korean medicine use in whiplash-associated disorder patients. *BMC Complement Altern Med.* 2018;18:124. doi: 10.1186/s12906-018-2188-7.
- 5. Curatolo M. Pharmacological and Interventional Management of Pain After Whiplash Injury. *J Orthop Sports Phys Ther.* 2016;46:845-50. doi: 10.2519/jospt.2016.6906.
- 6. Shaked G, Shaked D, Sebbag G, et al. The effect of steroid treatment on whiplash associated syndrome: a controlled randomized prospective trial. *Eur J Trauma Emerg Surg*. 2021;47:1115-22. doi: 10.1007/s00068-019-01282-3.
- 7. Suissa S, Harder S, Veilleux M. The relation between initial symptoms and signs and the prognosis of whiplash. *Eur Spine J.* 2001;10:44-9. doi: 10.1007/s005860000220.
- 8. Côté P, Cassidy JD, Carroll L, et al. A systematic review of the prognosis of acute whiplash and a new conceptual framework to synthesize the literature. *Spine (Phila Pa 1976)*. 2001;26:E445-58. doi: 10.1097/00007632-200110010-00020.
- 9. Hershman DL, Unger JM, Greenlee H, et al. Comparison of Acupuncture vs Sham Acupuncture or Waiting List Control in the Treatment of Aromatase Inhibitor-Related Joint Pain: A Randomized Clinical Trial. *JAMA Netw Open.* 2022;5:e2241720. doi:

- 10.1001/jamanetworkopen.2022.41720.
- 10. Büyükşireci DE, Demirsoy N, Mit S, et al. Comparison of the Effects of Myofascial Meridian Stretching Exercises and Acupuncture in Patients with Low Back Pain. *J Acupunct Meridian Stud.* 2022;15:347-55. doi: 10.51507/j.jams.2022.15.6.347.
- 11. Woo SH, Lee HJ, Park YK, et al. Efficacy and safety of thread embedding acupuncture for knee osteoarthritis: A randomized controlled pilot trial. *Medicine (Baltimore)*. 2022;101:e29306. doi: 10.1097/MD.0000000000029306.
- 12. Pan S, Wang S, Xue X, et al. Multidimensional Pain Modulation by Acupuncture Analgesia: The Reward Effect of Acupuncture on Pain Relief. *Evid Based Complement Alternat Med*. 2022;2022:3759181. doi: 10.1155/2022/3759181.
- 13. Chon TY, Lee MC. Acupuncture. *Mayo Clin Proc.* 2013;88:1141-6. doi: https://doi.org/10.1016/j.mayocp.2013.06.009
- 14. Bussières AE, Stewart G, Al-Zoubi F, et al. The Treatment of Neck Pain-Associated Disorders and Whiplash-Associated Disorders: A Clinical Practice Guideline. *J Manipulative Physiol Ther*. 2016;39:523-64.e27. doi: 10.1016/j.jmpt.2016.08.007.
- 15. State Insurance Regulatory Authority. Guidelines for the management of acute whiplash associated disorders for health professionals. Syndney: third edition. 2014.
- 16. Moon TW, Posadzki P, Choi TY, et al. Acupuncture for treating whiplash associated disorder: a systematic review of randomised clinical trials. *Evid Based Complement Alternat Med*. 2014;2014;870271. doi: 10.1155/2014/870271.
- 17. Lee S, Jo DH, Kim KH. Acupuncture for treating whiplash-associated disorder: A systematic review and meta-analysis protocol. *Medicine (Baltimore)*. 2018;97:e12654. doi: 10.1097/MD.0000000000012654.
- 18. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLoS Med.* 2021;18:e1003583. doi:

10.1371/journal.pmed.1003583.

- 19. Lee SH, Park HJ, Kim HT, et al. Efficacy of acupuncture for whiplash injury: A protocol for systematic review and meta-analysis. *Medicine (Baltimore)*. 2021;100:e27767. doi: 10.1097/MD.00000000000027767.
- 20. Shrestha D, Shrestha R, Grotle M, et al. Validation of the Nepali versions of the Neck Disability Index and the Numerical Rating Scale for Neck Pain. *Spine (Phila Pa 1976)*. 2021;46:E325-e32. doi: 10.1097/BRS.0000000000003810.
- 21. MacPherson H, Altman DG, Hammerschlag R, et al. Revised STandards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA): Extending the CONSORT statement. *J Evid Based Med*. 2010;3:140-55. doi: 10.1111/j.1756-5391.2010.01086.x.
- 22. Hammerschlag R, Milley R, Colbert A, et al. Randomized Controlled Trials of Acupuncture (1997-2007): An Assessment of Reporting Quality with a CONSORT- and STRICTA-Based Instrument. *Evid Based Complement Alternat Med.* 2011;2011. doi: 10.1155/2011/183910.
- 23. Cumpston M, Li T, Page MJ, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev.* 2019;10:Ed000142. doi: 10.1002/14651858.ED000142.
- 24. Babic A, Pijuk A, Brázdilová L, et al. The judgement of biases included in the category "other bias" in Cochrane systematic reviews of interventions: a systematic survey. *BMC Med Res Methodol*. 2019;19:77. doi: 10.1186/s12874-019-0718-8.
- 25. Caplan AM, Caplan L. The GRADE Method. *Rheum Dis Clin North Am.* 2022;48:589-99. doi: https://doi.org/10.1016/j.rdc.2022.04.002
- 26. Patsopoulos NA, Evangelou E, Ioannidis JP. Sensitivity of between-study heterogeneity in meta-analysis: proposed metrics and empirical evaluation. *Int J Epidemiol*. 2008;37:1148-57. doi: 10.1093/ije/dyn065.
- 27. Egger M, Davey Smith G, Schneider M, et al. Bias in meta-analysis detected by a simple,

graphical test. BMJ. 1997;315:629-34. doi: 10.1136/bmj.315.7109.629.

- 28. Sterling M, Vicenzino B, Souvlis T, et al. Dry-needling and exercise for chronic whiplash-associated disorders: a randomized single-blind placebo-controlled trial. *Pain*. 2015;156:635-43. doi: 10.1097/01.j.pain.0000460359.40116.c1.
- 29. Tobbackx Y, Meeus M, Wauters L, et al. Does acupuncture activate endogenous analgesia in chronic whiplash-associated disorders? A randomized crossover trial. *Eur J Pain*. 2013;17:279-89. doi: 10.1002/j.1532-2149.2012.00215.x.
- 30. Kwak H-Y, Kim J-I, Park J-M, et al. Acupuncture for Whiplash-associated disorder: A randomized, waiting-list controlled, pilot trial. *European Journal of Integrative Medicine*. 2012;4:e151-e8. doi: 10.1016/j.eujim.2011.12.008
- 31. Tough EA, White AR, Richards SH, et al. Myofascial trigger point needling for whiplash associated pain--a feasibility study. *Man Ther*. 2010;15:529-35. doi: 10.1016/j.math.2010.05.010.
- 32. Han S-Y, Lee J-Y, Park S-H, et al. A Clinical Study on Effect of Electro-acupuncture Treatment for Whiplash Injury Patients Caused by Traffic Accident. *J Kor Acup Mox Soc.* 2011;28:107-15.
- 33. Cameron ID, Wang E, Sindhusake D. A randomized trial comparing acupuncture and simulated acupuncture for subacute and chronic whiplash. *Spine (Phila Pa 1976)*. 2011;36:E1659-65. doi: 10.1097/BRS.0b013e31821bf674.
- 34. Kim D, Park KS, Lee JH, et al. Intensive Motion Style Acupuncture Treatment (MSAT) Is Effective for Patients with Acute Whiplash Injury: A Randomized Controlled Trial. *J Clin Med*. 2020;9. doi: 10.3390/jcm9072079.
- 35. Kim TH, Lee MS, Birch S, et al. Plausible Mechanism of Sham Acupuncture Based on Biomarkers: A Systematic Review of Randomized Controlled Trials. *Front Neurosci*. 2022;16:834112. doi: 10.3389/fnins.2022.834112.



FIGURE LEGENDS

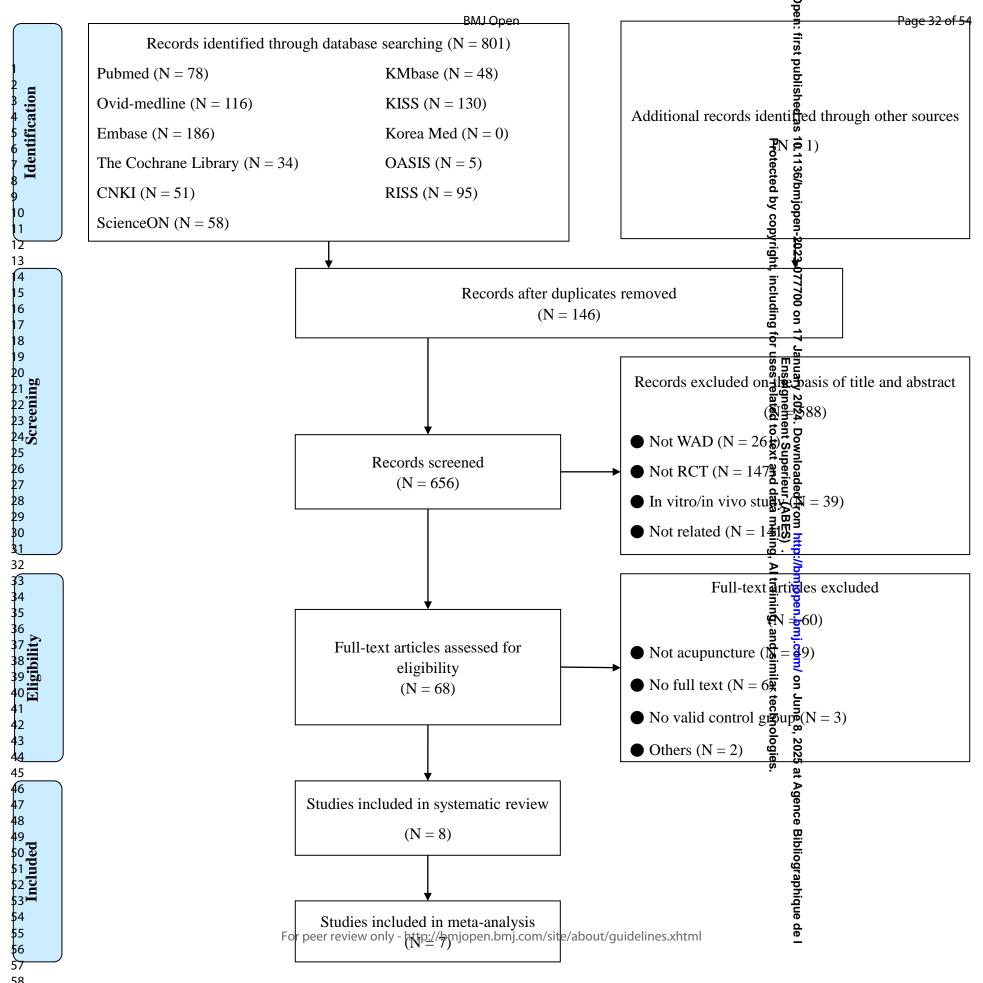
Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses

flowchart of the included studies

Figure 2. Risk of bias summary

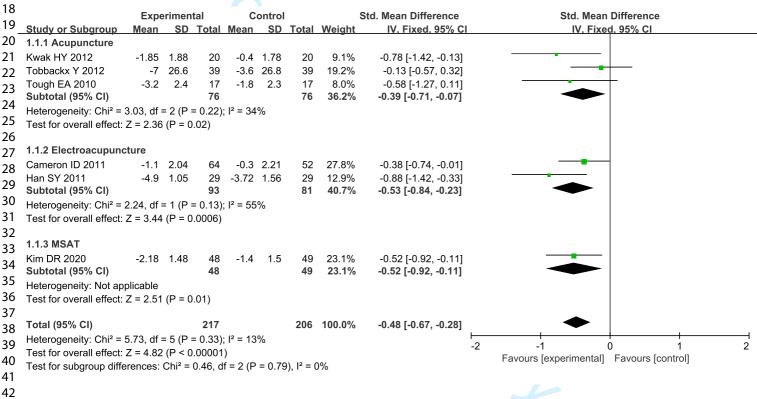
Figure 3. Forest plot of the meta-analysis for the pain visual analog scale

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



5Ω

Dpen: first published as 10.1136/bmjopen-2023-077700 on 17 January 2024. Downloaded from http://bmjopen.bmj.com/ on June 8, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, Al training, and similar technologies.



3					- 1					
Study or Subgroup Me	Experimental Control ean SD Total Mean SD			I. Mean Difference 7, Random, 95% Cl		Experimental Mean SD Total M	Control Mean SD Tot		td. Mean Difference IV, Fixed, 95% Cl	Std. Mean Difference IV, Fixed, 95% CI
⁴ Sterling M 2015	1.8 12.59 20 1.97 12.02 2 18.7 40 -0.1 16.5	38 35.2% 0.1	1 [-0.63, 0.61] 2 [-0.33, 0.56]	BMS	1.4.1 Acupuncture Kwak HY 2012 Sterling M 2015	7.32 12.7 20 6.5 13.6 40	4.5 16.1	20 18.1% 38 37.6%	0.70 [0.06, 1.34] 0.13 [-0.31, 0.58]	
'Test for overall effect: Z = 8	60 0; Chi² = 0.11, df = 1 (P = 0.74); l² = 0.40 (P = 0.69)	58 63.5% 0.0 7 : 0%	7 [-0.29, 0.43]	∕J Open: fi	Subtotal (95% CI) Heterogeneity: Chi ² = Test for overall effect:	60 2.03, df = 1 (P = 0.15); l ² Z = 1.70 (P = 0.09)		58 55.7%	0.32 [-0.05, 0.68]	
91.3.2 MSAT 12m DR 2020 12 13ubtotal (95% CI)	.63 8.2 48 6 8.2		30 [0.39, 1.22]	rst pub	1.4.2 MSAT Kim DR 2020			49 44.3%	0.67 [0.26, 1.08]	
12 Heterogeneity: Not applica 13 Hest for overall effect: Z = 14	48 able 3.79 (P = 0.0001)	49 36.5% 0.8	0 [0.39, 1.22]	lished as	Subtotal (95% CI) Heterogeneity: Not ap Test for overall effect:	-	,	49 44.3%	0.67 [0.26, 1.08]	
¹ Fotal (95% CI) ¹ <u>Geterogeneity:</u> Tau ^z = 0.1:	108 5; Chi²= 6.87, df= 2 (P = 0.03); l²=	107 100.0 % 0.3 3	3 [-0.19, 0.85]	Protect 136	Total (95% CI) Heterogeneity: Chi²=	108 3.64, df = 2 (P = 0.16); P		07 100.0%	0.47 [0.20, 0.75]	
Test for overall effect: Z = 18 19 19 19 19	1.25 (P = 0.21) nces: Chi² = 6.76, df = 1 (P = 0.009)		Favours [control] Favours [eaby	Test for overall effect:			37.9%		-2 -1 0 1 2 Favours [control] Favours [experimental]
20 21		(A) Flexion		copy				(B) Ex	xtension	
22	Experimental Control			. Mean Difference 91.		Experimental	Control		d. Mean Difference	Std. Mean Difference
24.7.1 Acupuncture	ean SD Total Mean SD T	Total Weight IV, Ran	dom, 95% Cl IV	Random, 95% CI t, 0777700	Study or Subgroup 1.8.1 Acupuncture	Mean SD Total I	Mean SD Tota	al Weight	IV, Random, 95% CI	IV, Random, 95% CI
26ubtotal (05% CI)	3.97 9.47 20 3.15 7.11 20		[-0.52, 0.72] [- 0.52, 0.72]	on 1	Kwak HY 2012 Subtotal (95% CI)	4.12 14.97 20 20		0 42.8% 0 42.8 %	0.25 [-0.37, 0.88] 0.25 [-0.37, 0.88]	-
Heterogeneity: Not applic 28 Pest for overall effect: Z =	able 0.30 (P = 0.76)			17 Januar Ense for uses	Heterogeneity: Not ap Test for overall effect:	-				
30 3 1₁7.2 MSAT 3∕§im DR 2020 15	5.48 8.93 48 6.38 8.89	49 53.2% 1.0°	1 [0.59, 1.44]	y 202. Pignen relate	1.8.2 MSAT Kim DR 2020	14.2 8.94 48	6.36 8.86 4	9 57.2%	0.87 [0.46, 1.29]	
3Subtotal (95% CI) 34eterogeneity: Not applic	48		[0.59, 1.44]	4. Dow nent Su dro tex	Subtotal (95% CI) Heterogeneity: Not ap	48 plicable	4	9 57.2%	0.87 [0.46, 1.29]	•
35est for overall effect: Z = 36	4.69 (P < 0.00001)			ownload t Superie text and	Test for overall effect:	Z= 4.10 (P < 0.0001)				
3 ਾotal (95% CI) 3 ੧ eterogeneity: Tau² = 0.3	68 85; Chi ^z = 5.73, df = 1 (P = 0.02); i ^z =		[-0.31, 1.48]	ed from	Total (95% CI) Heterogeneity: Tau² =	68 0.12; Chi² = 2.64, df = 1		9 100.0% ?%	0.61 [0.01, 1.21]	
³⁹ est for overall effect: 7 =	1.28 (P = 0.20) nces: Chi² = 5.73, df = 1 (P = 0.02),		Favours (d	ontrol] Favours [essemble]	Test for overall effect: Test for subgroup diff	Z = 1.98 (P = 0.05) erences: Chi² = 2.64, df:	= 1 (P = 0.10), l² =	: 62.1%		Favours [control] Favours [experimental]
42 43		(C) Right lateral f	lexion	bmjc Al tra				(D) Left la	teral flexion	
44 Study or Subgroup Me	Experimental Control ean SD Total Mean SD			I. Mean Difference : '		Experimental Mean SD Total N	Control Mean SD Tot		td. Mean Difference IV, Random, 95% CI	Std. Mean Difference IV, Random, 95% CI
T/	0.77 12.32 20 -0.25 7.83		0 [-0.52, 0.72]	and si	1.6.1 Acupuncture Kwak HY 2012			20 31.3%	0.16 [-0.46, 0.78]	_
Subtotal (95% CI)	6.2 19.5 40 6.8 17.9 60	58 66.0% 0.0°	3 [-0.48, 0.41] 1 [- 0.35, 0.37]	milar t	Sterling M 2015 Subtotal (95% CI)	60	!	38 34.4% 58 65.7 %	0.32 [-0.13, 0.77] 0.27 [-0.10, 0.63]	•
55est for overall effect: Z = 52 55.2 MSAT	0; Chi ² = 0.11, df= 1 (P = 0.74); l ² = 0.06 (P = 0.95)	= U%		June 8, 2 technolo	Heterogeneity: Tau² = Test for overall effect:	0.00; Chi ² = 0.17, df = 1 Z = 1.45 (P = 0.15)	(P = 0.68); I ^z = 0%	•		
∮∡ajim DR 2020 26	6.07 12.51 48 7.85 12.52 48		44 [1.00, 1.89]	2025 a	1.6.2 MSAT Kim DR 2020	26.08 11.93 48		49 34.3%	1.43 [0.98, 1.87]	
55ubtotal (95% CI) 5deterogeneity: Not application overall effect: Z =	able	49 34.0% 1.4	4 [1.00, 1.89]	Agence	Subtotal (95% CI) Heterogeneity: Not ap Test for overall effect:	48 plicable Z = 6.25 (P < 0.00001)	,	49 34.3%	1.43 [0.98, 1.87]	
58 5 5otal (95% CI) A d eterogeneity: Tau² = 0.79	108 0; Chi² = 23.86, df = 2 (P < 0.00001		1 [-0.48, 1.50]	Biblio	Total (95% CI)	108		07 100.0%	0.65 [-0.16, 1.46]	
Test for overall effect: Z=			-2 -1 Favours [Ó 1 प्र 2 control) Favours [exper gi nental]	Test for overall effect:	0.44; Chi² = 15.71, df = 2 Z = 1.58 (P = 0.11) erences: Chi² = 15.54, df			_	-2 -1 0 1 2 Favours [control] Favours [experimental]
		(E) Right rotat	ion F	ਸ਼ੁੱਛ ਫ or peer review only - ht			i – i (i ~ 0.0001).		t rotation	
			·	, 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	,					

4 5

6 7

8 9

10 11

12

13 14

15 16

17

18

19

20 21

22 23

24

25 26

27 28

29 30

31 32

33

34 35

36 37

38

39 40

41 42

43 44

45

46 47

48 49

50 51

52 53

54

55 56

57 58

59 60

Database: PubMed No. Search strategy Results whiplash OR acute whiplash injury* OR acute whiplash associated disorder* OR acute WAD OR acute whiplash associated disorder* II OR acute WAD II OR whiplash associated disorder* OR WAD OR whiplash associated disorder* II OR WAD II, OR whiplash OR whiplash injury* OR whiplash patient* OR whiplash syndrome* OR cervical spine disorder* OR cervical spine injury* OR "Accidents, Traffic" [Mesh] OR (("Motor Vehicles" [Mesh: NoExp] OR "Automobiles" [Mesh] OR #1 23,007 "Motorcycles" [Mesh] OR traffic[tiab] OR vehicle[tiab] OR vehicular[tiab] OR car[tiab] OR cars[tiab] OR automobile[tiab] OR automobiles[tiab] OR motorcycle[tiab] OR motorcycles[tiab] OR taxi[tiab] OR cab[tiab] OR road[tiab] OR pedestrian[tiab] OR pedestrians[tiab]) AND (accident[tiab] OR accidents[tiab] OR injury[tiab] OR injuries[tiab] OR crash[tiab] OR crashes[tiab] OR "Wounds and Injuries"[Mesh] OR "injuries"[Subheading])) AND (cervic* OR thoracic* OR lumba*) #2 38.405 acupuncture 6,738 #3 electroacupuncture #4 1,629 acupressure OR acupuncture Therapy [mh]) OR acupuncture points [mh]) OR acupuncture, ear [mh]) OR acupuncture [Text Word]) OR acupressure [Text Word]) OR electroacupuncture) OR electro acupuncture) OR electro-acupuncture) OR meridian* [Text Word]) OR needling [Text Word]) OR acu-#5 46,250 point*) OR acu point* [Text Word]) OR acupoint* [Text Word]) OR Acupuncture [mh]) OR electroacupuncture [mh]) OR acupuncture* [Text Word]) OR elctroacupuncture* [Text Word]) OR (acupuncture AND th[sh])) OR acupuncture[tiab]) OR acupuncture[mh]) OR acupuncture/th[mh] #6 #2 or #3 or #4 or #5 48,241 #1 and #6 #7 78 Database: Ovid Medline 1 exp Whiplash Injuries/ 3,371 2 3,187 whiplash.tw. 3 74 acute whiplash injury*.tw. 4 acute whiplash associated disorder*.tw. 66 5 acute WAD.tw. 59 977 6 WAD.tw.

7	whiplash patient*.tw.	198
8	whiplash syndrome*.tw.	182
9	cervical spine disorder*.tw.	216
10	cervical spine injury*.tw.	1,478
11	exp Accidents, Traffic/	46,806
12	exp Motor Vehicles/	23,048
13	exp Automobiles/	7,529
14	exp Motorcycles/	2,777
15	traffic.tw.	53,702
16	vehicle.tw.	125,682
17	vehicular.tw.	3,603
18	car.tw.	31,854
19	cars.tw.	8,493
20	automobile.tw.	6,131
21	automobiles.tw.	1,239
22	motorcycle.tw.	3,529
23	motorcycles.tw.	860
24	taxi.tw.	1,135
25	cab.tw.	3,401
26	road.tw.	43,424
27	pedestrian.tw.	4,658
28	pedestrians.tw.	3,434
29	accident.tw.	51,240
30	accidents.tw.	45,962
31	injury.tw.	737,087
32	injuries.tw.	236,793
33	crash.tw.	10,917
34	crashes.tw.	9,213
35	exp "Wounds and Injuries"/	977,757
36	or/29-35	1,579,963
37	or/11-28	275,281

39	36 and 37	75,471
40	38 or 39	80,163
41	acupuncture.mp.	32,013
42	electroacupuncture.mp.	6,378
43	acupressure.mp.	1,612
44	meridian.mp.	4,543
45	acupoint.mp.	3,677
46	exp acupuncture/	1,936
47	acupuncture.tw.	24,901
48	acupressure.tw.	1,338
49	electro acupuncture.mp.	907
50	meridian*.tw.	6,052
51	needling.tw.	3,536
52	acu-point*.mp.	33
53	acu point*.tw.	33
54	acupoint*.tw.	6,295
55	elctroacupuncture*.tw.	1
56	(acupuncture and th).mp.	75
57	or/41-56	41,125
58	40 and 57	116
Data	abase: Embase	
1	'automobiles'/exp	11,192
2	'motor vehicle'/exp	45,809
3	'accident, traffic'/exp	70,722
4	'motorcycle'/exp	3,328
5	vehicle:ta,ab,de	189,288
		142.266
6	traffic:ta,ab,de	142,366
7	vehicular:ta,ab,de	4,470
7		
	vehicular:ta,ab,de	4,470
7 8	vehicular:ta,ab,de car:ta,ab,de	4,470 68,570

12	motorcycle:ta,ab,de	5,453
13	motorcycles:ta,ab,de	1,025
14	taxi:ta,ab,de	1,393
15	cab:ta,ab,de	4,574
16	road:ta,ab,de	43,386
17	pedestrian:ta,ab,de	6,804
18	pedestrians:ta,ab,de	3,770
19	accident:ta,ab,de	546,272
20	accidents:ta,ab,de	52,651
21	injury:ta,ab,de	1,791,998
22	injuries:ta,ab,de	258,946
23	crash:ta,ab,de	11,746
24	crashes:ta,ab,de	9,529
25	'wounds and injuries'/exp	2,627,209
26	#19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25	3,381,722
27	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18	404,965
28	#26 AND #27	127,597
29	acupuncture	60,077
30	electroacupuncture	9,565
31	acupressure	2,813
32	acupoint	5,720
33	acupoint:ta,ab,de	5,143
34	'acupuncture analgesia'	2,299
35	'acupuncture therapy'	2,221
36	'acupuncture points'	2,228
37	'acupuncture, ear'	38
38	acupuncture:ta,ab,de	52,539
39	acupressure:ta,ab,de	2,724
40	electroacupuncture	9,565
41	'electro acupuncture'	1,386
42	meridian*:ta,ab,de	8,264

4

5

6

7 8

9 10

11 12

13

14

15

16 17

18 19

20

21 22

23 24

25 26

27 28

29

30 31

32 33

34 35

36

37 38

39 40

41 42

43

44 45

46 47

48 49

50 51

52

53 54

55 56

57 58

		I
#20	vehicle:ti,ab,kw	7,637
#21	vehicular:ti,ab,kw	53
#22	car:ti,ab,kw	3,677
#23	cars:ti,ab,kw	370
#24	automobile:ti,ab,kw	1,031
#25	automobiles:ti,ab,kw	75
#26	motor cycle*:ti,ab,kw	1,024
#27	taxi*:ti,ab,kw	227
#28	cab*:ti,ab,kw	10,072
#29	road*:ti,ab,kw	1,838
#30	pedestrian*:ti,ab,kw	213
#31	accident*:ti,ab,kw	22,223
#32	injur*:ti,ab,kw	67,393
#33	crash*:ti,ab,kw	696
#34	MeSH descriptor: [Wounds and Injuries] explode all trees	28,670
#35	Any MeSH descriptor in all MeSH products and with qualifier(s): [injuries - IN]	3,495
#36	cervic\$ or thoracic\$ or lumba\$	30,341
#37	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14	1,588
#38	#15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29	25,765
	or #30	Í
#39	#31 or #32 or #33 or #34 or #35	97,366
#40	#38 and #39	4,200
#41	#37 or #40	5,649
#42	#41 and #36	386
#43	acupuncture	18,418
#44	electroacupuncture	2,970
#45	acupressure	1,812
#46	meridian	1,222
#47	acupoint	2,903
#48	MeSH descriptor: [acupuncture] explode all trees	163
#49	MeSH descriptor: [acupuncture Analgesia] explode all trees	302
#50	MeSH descriptor: [acupuncture Therapy] explode all trees	5,269

#51	MeSH descriptor: [acupuncture points] explode all trees	2,244
#52	MeSH descriptor: [acupuncture, ear] explode all trees	216
#53	acupuncture:ti,ab,kw	16,436
#54	acupressure:ti,ab,kw	1,708
#55	electro acupuncture	923
#56	electro-acupuncture	712
#57	meridian*:ti,ab,kw	1,162
#58	needling:ti,ab,kw	2,606
#59	acu-point*	37
#60	acu point*:ti,ab,kw	231
#61	acupoint*:ti,ab,kw	4,417
#62	MeSH descriptor: [electroacupuncture] explode all trees	884
#63	elctroacupuncture*:ti,ab,kw	2
#64	acupuncture AND th	1,218
	#43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57	
#65	or #58 or #59 or #60 or #61 or #62 or #63 or #64	22,881
#66	#42 and #65	34
Data	base: China National Knowledge Infrastructure (CNKI)	
	(SU='traffic accident' OR SU='交通事故' OR SU='whiplash injury' OR SU='颈椎屈伸损伤' OR	
		l
	SU='whiplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR SU='	
	SU='whiplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR SU='	
1	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR	51
1		51
1	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR	51
	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' or SU='meridian' OR SU='经穴' or SU='acupoint'	51
	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' or SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针') base: ScienceOn	51
Data	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' or SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针')	51
Data	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' or SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针') base: ScienceOn	
Data 1	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' or SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针') base: ScienceOn 전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈	
Data 1	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' or SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针') base: ScienceOn 전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈 이침)	
Data Data	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' or SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针') base: ScienceOn 전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈 이침) base: KMBASE [ALL=교통사고]	58 852
Data I	颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' or SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针') base: ScienceOn 전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈 이침) base: KMBASE	58

3	[ALL=채찍질 손상]	0
4	[ALL=경항통]	88
5	[ALL=경추부 염좌]	4
6	[ALL=침]	13,948
7	[ALL=전침]	371
8	[ALL=이침]	78
9	[ALL=경혈]	322
10	((((([ALL=교통사고] OR [ALL=편타성 손상]) OR [ALL=채찍질 손상]) OR [ALL=경항통]) OR [ALL=경항통])	930
11	((([ALL=침] OR [ALL=전침]) OR [ALL=이침]) OR [ALL=경혈])	14,543
12	((((([ALL=교통사고] OR [ALL=편타성 손상]) OR [ALL=채찍질 손상]) OR [ALL=경항통]) OR [ALL=경항통]) AND ((([ALL=침] OR [ALL=전침]) OR [ALL=이침]) OR [ALL=경혈]))	48
Datal	pase: Korean Studies Information Service System (KISS)	
1	교통사고 and 침	126
2	교통사고 and 전침	4
3	교통사고 and 이침	0
4	교통사고 and 경혈	0
Datal	pase: Korea Med	
1	(((((("traffic"[ALL])) OR ("automobile"[ALL])) OR ("whiplash injury"[ALL])) OR ("whiplash associated disorder"[ALL])) OR ("cervical spine disorder"[ALL])) OR ("cervical spine injury"[ALL])	1,648
2	(((("acupuncture"[ALL])) OR ("electroacupuncture"[ALL])) OR ("meridian"[ALL])) OR ("acupoint"[ALL])	526
3	(("(((((("(traffic"[ALL])) OR ("automobile"[ALL])) OR ("whiplash injury"[ALL])) OR ("whiplash associated disorder"[ALL])) OR ("cervical spine disorder"[ALL])) OR ("cervical spine	0

First author	T		Depth of	Stimulation	rigi 23 Total	Frequency and
(year) ^{ref}	Type of acupuncture	Acupoints	needling	response	right, including for us	Retention
Sterling et al		Posterior muscles of the			on 17	Frequency: 2
_	General acupuncture	cervical spine and upper	NR	Pecking, Twirling	7 Jan E E or us	times/week X 3 week
(2015) [28]		thoracic spine			uary 2 nseigr	Retention: 30 minute
		Choose from GV14,			024.	
		C1-C7, GB20, SI11,			Downlor Support Suppor	
		GB21, TE15, SI14,			loade berieu	Frequency: 1
Tobbackx et al		BL17, SP10, SI3,) ID	Dani assastian	id fro ur (AE	
(2012) [29]	General acupuncture	BL64, TE5, GB41,	NR	Deqi sensation	m htt 3ES)	time/week X 1 week
		Shiqizhuixia, Ear Zero			p://bn g, Al t	Retention: 20 minute
		point, Ear Jerome point,			njoper	
		Ear C0.			January 2024. Downloaded from http://bmjopen.bmj.cpm/ on June 8, 2025 a Enseignement Superieur (ABES).	
Kwak et al	General acupuncture	SI2, SI3, SI5, SI7, SI14,	1.0-2.0 cm	Deqi sensation,	sim 6	Frequency: 3
(2012) [30]		SI15, LI11, BL10,		Rotating	on Jւ ilar te	times/week X 2 week
		BL12, BL13, BL14,			ine 8,	Retention: 15 minute
		BL60, BL62, BL66,			, 2025 ologies	
		GB20, GB21, GB40,			at Age s.	
					ence	
					nce Bibliographique de l	
					ograp	

Page 45 of 54

				5	Ž	
		GB41, TE5, TE15		including for	777700 on	
Tough et al		Myofascial trigger		<u></u>	~l	Frequency: 1
_	General acupuncture	points in muscles in and	NR	Pecking (6-7 times 💆 🗖	2-6	time/week X 2-6 times
(2010) [31]		around the neck		Pecking (6-7 times e.g.neme	uary 20	Retention: NR
Aigner et al		TD 5 01(1.1) 11	N.D.	teement to NR	2	ND
(1998) [16]	General acupuncture Electroacupuncture MSAT dards for Reporting Interventions in	TB5, SI6 bilaterally	NR	NR to text and days and days Electrical frequences	: DNR wnlo	NR
Han et al		ST25, GB20, GB21,		Electrical frequences:	a d e d	Frequency: 2
	Electroacupuncture	SI11, SI14, SI15, Ashi	1.0-2.0 cm	300 Hz		times/week X 4 weeks
(2011) [32]		points		ning,	n http:/	Retention: 15 minute
		16	9,	Electrical frequency:	b	Frequency: 2
Cameron et al	5 1	GB39, GB20, LI14, SI6	1015	Electrical frequence 2-5 Hz	ope De	times/week X 6 weeks
(2011) [33]	Electroacupuncture	bilaterally	1.0-1.5 cm	Electrical intensity	- 512 ■ 	Retention: 20 – 60
				1.5 volts	om/ oı	minutes
Kim et al		3 points at trapezius		ar tec	n Jun	Frequency: 2
	MSAT	•	0.5-1.0 cm	NR hnol	June & 2025	times/day X 3 days
(2020) [34]		muscle		Electrical intensity and similar technologies.	2025 a	Retention: 15 minute
STRICTA: Standa	ards for Reporting Interventions in C	linical Trials of Acupuncture;	MSAT: Motion-sty	le acupuncture treatment	O .	[
					ic e Bi	
				•	bliog:	
					nce Bibliographique de l	
				·	d d	
	For pee	r review only - http://bmjoper	n.bmj.com/site/abo	out/guidelines.xhtml	0	

Supplemental table S3. Sensitivity analysis of whiplash-associated disorder

G. 1 ' 1	Pooled	95% Confidence in	1	12(0/)	
Study omitted	estimate	Lower	Upper	p-value	<i>I</i> ² (%)
Pain VAS					
Kwak HY 2012	-0.45	-0.65	-0.24	<0.0001	17
Tobbackx Y 2012	-0.56	-0.78	-0.35	< 0.00001	0
Tough EA 2010	-0.47	-0.67	-0.27	< 0.00001	29
Cameron ID 2011	-0.52	-0.75	-0.29	< 0.00001	25
Han SY 2011	-0.42	-0.63	-0.21	< 0.0001	0
Kim DR 2020	-0.47	-0.69	-0.24	< 0.0001	30
ROM – flexion					
Kwak HY 2012	0.46	-0.21	1.14	0.17	79
Sterling M 2015	0.43	-0.37	1.22	0.29	78
Kim DR 2020	0.07	-0.29	0.43	0.69	0
ROM – extension					
Kwak HY 2012	0.42	0.12	0.73	0.006	67
Sterling M 2015	0.68	0.34	1.03	0.0001	0
Kim DR 2020	0.32	-0.05	0.68	0.09	51
ROM – right rotation	on				
Kwak HY 2012	0.71	-0.74	2.15	0.34	95
Sterling M 2015	0.79	-0.53	2.11	0.24	92
Kim DR 2020	0.01	-0.35	0.37	0.95	0
ROM – left rotation	1				
Kwak HY 2012	0.87	-0.21	1.96	0.11	91
Sterling M 2015	0.81	-0.42	2.05	0.20	90
Kim DR 2020	0.27	-0.10	0.63	0.15	0
NDI					
Sterling M 2015	-0.14	-0.34	0.06	0.18	30
Tobbackx Y 2012	-0.14	-0.34	0.06	0.16	29

-0.12	-0.32	0.07	0.20	30
-0.22	-0.43	-0.01	0.04	0
-0.07	-0.26	0.13	0.51	0
-0.08	-0.29	0.12	0.44	18
	-0.22 -0.07	-0.22 -0.43 -0.07 -0.26	-0.22 -0.43 -0.01 -0.07 -0.26 0.13	-0.22 -0.43 -0.01 0.04 -0.07 -0.26 0.13 0.51

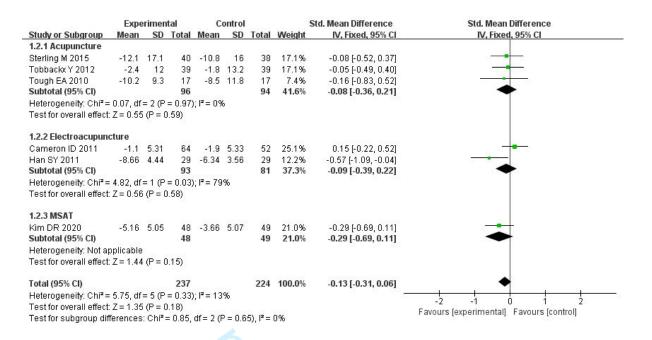
VAS: Visual analog scale; ROM: Range of motion; NDI: Neck disability index



			Certainty asse	essment			No. of pat	tients	Effect 2023	
No. of studies	Study	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Experimental	Control	Effect 20 21 22 23 24 25 26 27 26 27 26 27 26 27 27 27 27 27 27 27 27 27 27 27 27 27	Certaint
Pain VAS									17 Ja	
6	RCT	Not serious	Not serious	Not serious	Not serious	Strong	217	206	T January 267 lower to 0.28 Enseignement Superior Lower) The second of	⊕⊕⊕€ High
ROM-flexion	1			U /-					x up eria	
3	RCT	Not serious	Serious*	Not serious	Very serious [†]	None	108		B. m. 19 lower to 0.85	Ф000
		Serious			serious				higher)	Very lov
ROM-extens	ion									
3	RCT	Not serious	Not serious	Not serious	Serious‡	Strong association	108	107	MD 0.47 higher (2 higher to 0.75 higher higher)	⊕⊕⊕⊕ High
ROM-right la	ateral flexion	1							June 8	
2	RCT	Not	Very serious§	Not serious	Very	None	68	69	MD 0.58 higher	⊕000
				For peer revie	w only - http://k	omjopen.bmj.com	ı/site/about/guide	elines.xhtml	Agence Bibliographique c	

mjopen-2023

		serious			serious†				(631 lower to 1.48	Very low
ROM-left l	ateral flexion							<u> </u>	17 Janua	
2	RCT	Not serious	Serious*	Not serious	Serious [‡]	None	68	69	(Control 1.48 (C	⊕⊕⊖⊖ Low
ROM-right	rotation							2	oade erieu	
3	RCT	Not	Very serious§	Not serious	Very	None	108	107	ASMD 0.51 higher	Ф000
		serious			serious [†]			9	higher)	Very low
ROM-left r	otation								be n.	
3	RCT	Not	Very serious§	Not serious	Very	None	108	107	MD 0.65 higher (216 lower to 1.46	# 000
		serious			serious [†]				higher)	Very low
NDI									6 8 0 8	
6	RCT	Not	Not serious	Not serious	Serious¶	None	237	224	(231 lower to 0.06	@## 0
		serious							higher)	Moderate
*: Downgra	ded one level	due to incon	sistency (I ² , 50–75	5%)					ibliog	
									nce higher) Bibliographique de l	
				For peer reviev	v only - http://b	mjopen.bmj.com/	/site/about/quid	elines.xhtml	ue de	



Supplemental figure S1. Forest plot of the meta-analysis for the neck disability index



PRISMA 2020 Checklist

age 53 of 54		BMJ Open BMJ open	
PRIS	MA 2	BMJ Open BMJ Open 020 Checklist	
Section and Topic	Item #	Checklist item nc 77	Location where item is reported
TITLE	"	<u> </u>	itom to reported
Title	1	Identify the report as a systematic review.	1
ABSTRACT		or 7	
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2-3
INTRODUCTION		es s	
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	4
Objectives	4	Describe the rationale for the review in the context of existing knowledge. Provide an explicit statement of the objective(s) or question(s) the review addresses.	4-5
METHODS		ចិត្តិក្	
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6-7
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consults she that such as the searched or consulted.	6 Supple table 1
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6 Supple table 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many were screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each sport, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of actionation tools used in the process.	7-8
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each gutcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	7
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	7
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how matey reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or preservation of results.	8
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study ter tention characteristics and comparing against the planned groups for each synthesis (item #5)).	Figure 1.
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summery statistics, or data conversions.	7-8
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7-8
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was persemed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	8
[13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analys , meta-regression).	7-8
<u> </u>	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	8
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases. For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	8

Page 54 of 54



47

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item 0777	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	8
RESULTS		For 7	
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to អ្នាកាម្មីmber of studies included in the review, ideally using a flow diagram.	10 Figure 1.
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	10 Figure 1.
Study characteristics	17	Cite each included study and present its characteristics.	10 Table 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	15-16 Figure 2.
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an precision (e.g. confidence/credible interval), ideally using structured tables or plots.	16-17 Figure 3,4. Supple figure 1
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	15-17 Figure 2,3,4. Supple figure 1.
· ·	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary stimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	16-17 Figure 3,4. Supple figure 1
) 	20c	Present results of all investigations of possible causes of heterogeneity among study results.	18-19 Supple table 3
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	18-19 Supple table 3
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	20
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	19-20 Supple table 4
DISCUSSION		6	
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	21-22
1	23b	Discuss any limitations of the evidence included in the review.	22-23
	23c	Discuss any limitations of the review processes used.	22-23
	23d	Discuss implications of the results for practice, policy, and future research.	21-23
OTHER INFORMA	TION		
Registration and	24a	Provide registration information for the review) inclutating registernal maj ลอบา egisteration from the review was not registered.	3

BMJ Open



PRISMA 2020 Checklist

Р	age 55 of 54		BMJ Open	cted b	36/bm i	
1 2		SMA 2	020 Checklist	cted by copyrigh	36/bm jopen-2023	
3 4	Section and Topic	Item #	Checklist item	t, inc	-0777	Location where item is reported
5	protocol	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.		0 0	3
6 7		24c	Describe and explain any amendments to information provided at registration or in the protocol.	<u> </u>	5	N/A
8		25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in	t <u>r</u> e re	wiew.	23-24
9 1	Competing of interests	26	Declare any competing interests of review authors.	Ense Ises r	nuar r	24
1 1 1	Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection form included studies; data used for all analyses; analytic code; any other materials used in the review.	gæmen elagted to	extracted from	24
1	0 10.1136/bmj.n/1	1cKenzie	JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for r For more information, visit: http://www.prisma-statement.org/	Subject of	systematic reviews. BM	J 2021;372:n71. doi:
1 1			For more information, visit: http://www.prisma-statement.org/	rieur (ABES) . nd data mining, Al training, and similar technologies.	<u>č</u> - †	
1				m. E	o B	
2	0			nio Nio	#	
2				ც. გ	http://bmiopen.bmi.com/ on June 8.	
2				#		
2				aini	O D B	
2				ŋg,	5	
2				an	<u>3</u> .	
2				<u>s</u> .	C O D	
2				<u>m.</u>	0	
3				ar t	<u></u>	
3				ech	L D e	
3					∞	
3				gi ¦	2 202	
3				ž (5 a	
3						
3				,	Xen	
3					<u>ce</u>	
3					<u> </u>	
4					 oc	
4				1	Agence Bibliographique de l	
4					hic	
4				-	ŭ e	
4			For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	;	o e	
4 4			1 of peer retrest only maps, strijopenion, stee, about gaidelines. Antini	•	_	

BMJ Open

Efficacy of acupuncture for whiplash injury: A systematic review and meta-analysis

Journal:	BMJ Open
Manuscript ID	bmjopen-2023-077700.R1
Article Type:	Original research
Date Submitted by the Author:	24-Oct-2023
Complete List of Authors:	Lee, Sang-Hyun; Pusan National University, Graduate School, Department of Korean Medicine Park, Sun-Young; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine Heo, In; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Hwang, Eui-Hyoung; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Shin, Byung-Cheul; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Rehabilitation Hwang, Man-Suk; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation
Primary Subject Heading :	Complementary medicine
Secondary Subject Heading:	Complementary medicine
Keywords:	Systematic Review, Randomized Controlled Trial, COMPLEMENTARY MEDICINE, PAIN MANAGEMENT

SCHOLARONE™ Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Efficacy of acupuncture for whiplash injury: A systematic review and meta-analysis

Sang-Hyun Lee¹, Sun-Young Park², In Heo^{2,3}, Eui-Hyoung Hwang^{2,3}, Byung-Cheul Shin^{2,3}, Man-Suk Hwang^{2,3,*}

¹ Department of Korean Medicine, Graduate School, Pusan National University, Yangsan, Gyeongnam, Republic of Korea

² 3rd Division of Clinical Medicine, School of Korean Medicine, Pusan National University, Yangsan, Gyeongnam, Republic of Korea

³ Department of Korean Medicine Rehabilitation, Spine and Joint Center, Pusan National University Korean Medicine Hospital, Yangsan, Gyeongnam, Republic of Korea

* Corresponding author:

Man-Suk Hwang

Department of Korean Medicine Rehabilitation, Spine and Joint Center, Pusan National University Korean Medicine Hospital, Yangsan, Gyeongnam, Republic of Korea

Tel: +82-55-360-5970

Fax: +82-51-510-8437

Email: hwangmansuk@pusan.ac.kr

ABSTRACT

Objectives: This study aimed to establish clinical evidence for acupuncture by analyzing 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 to 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 October 1, 2023. Eligibility criteria: We included randomized controlled trials (RCTs) using acupuncture on patients with WAD. The outcomes were the pain visual analog 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 analyzed 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.

Keywords: Acupuncture; Whiplash injuries; Whiplash-associated disorder; Systematic review; Meta-analysis; Randomized controlled trial

Word Count: 3788

Article Summary

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.

INTRODUCTION

Whiplash injury or whiplash-associated disorder (WAD) is caused by rapid 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 recognized despite its usefulness in clinical practice [13]. The Canadian and Australian WAD clinical practice guidelines (CPGs) do not recommend acupuncture for treating WAD [14]; 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 analyzing 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 to 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

SR [16] 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 July 18, 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 October 1, 2023. 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 S1). 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 its potential to introduce bias.

Eligibility criteria

The studies included in this study were selected according to the following five criteria: study design, participants, intervention, comparison, and outcomes. Randomized 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 pre- and post-clinical 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 [21]. 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 analog 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 [22].

Data collection and analysis

Study selection

Two independent researchers (SHL and MSH) 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 (SHL and MSH) analyzed 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 summarized in a table. 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 of the Standards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA) [23, 24]. 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 [25, 26].

Quality assessment

Two independent researchers (SHL and MSH) 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 [27]. 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 categorized as high, moderate, low, or very low. In the case of disagreements between researchers, agreement was reached through discussion with third and fourth researchers (BCS, IH).

Statistical analysis

The meta-analysis was performed using the Review Manager version 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% confidence interval (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 [28]. 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 intervention, 6 articles without full text, 3 articles without a valid control group, and 2 articles for other reasons. In addition, we included 1 study through reference tracking [16]. Thus, 8 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, 29-32] compared acupuncture with sham acupuncture, usual care, or medication, whereas two [33, 34] compared EA with sham EA. One study [35] compared motion-style acupuncture treatment (MSAT) with usual care. The country of origin of the studies varied: three in Korea [31, 33, 35], two in Australia [29, 34], one each in Belgium [30], UK [32], and Austria [16]. The recruitment period was less than one year in five studies [30-33, 35], more than four years in two studies [29, 34], and not reported in one study [16]. Among the eight studies, one [30] was designed as a crossover RCT. The pain VAS score was recorded in six studies [30-35], and the ROM was recorded in four studies [16, 29, 31, 35]. The NDI was recorded in six studies [29, 30, 32-35]. The study by Aigner et al. was described based on its reference in the SR by Moon et al. [16], as the original text could not be accessed (Table 1).

							<u> </u>	
First author (year)	Country of origin (period)	Design	Sample	Participants	Intervention	Comparison	en-2023-@77700 on 1 capyright@including 1	Results (Effect size, P-value)
Sterling et al (2015) [29]	Australia (2009 – 2012)	RCT	Total: 80 Exp.: 40 Con.: 40	WAD II	Atx. + exercise	Sham atx. + exercise	7 January 2024. Downtoade This eignement Superier R R (1) Fred to text and (2) (3) (3) (3)	1) 0.10, P=0.67 2) (1) -0.14, P=0.54 (2) 0.08, P=0.71 (3) -0.32, P=0.16 (4) 0.26, P=0.24
Tobbackx et al (2012) [30]	Belgium (01/2011 – 12/2011)	Crossover RCT	Total: 39	WAD I or II or III (chronic WAD persisting more than 3 months)	Atx.	Relaxation	gd from http://bmjopgn.bmj.com/ of (ABES) . Aptraining, Aptraining, and similar page (ABES) . 1) N 2) page (ABES) .	1) 0.17, P=0.47 2) 0.16, P=0.47
Kwak et al (2012) [31]	Korea (12/2009 – 10/2010)	RCT	Total: 40 Exp.: 20 Con.: 20	WAD (persisting more than 3 months)	Atx. + UC	UC (PTx. + exercise)	1) path VAS tecom 8, 2025 (1) Report	1) 0.78, P=0.02 2) (1) -0.01, P=0.97

Table 1. Data of clinical studies on acupuncture for whiplash-associated disorder BMJ Open

mjopen-2023-

							1) pauding 1 7 2 No for 2) No for	1) 0.85, P<0.0001 2) 0.29, P=0.15
						IKM	3) R Q Mins	3)
Kim et al	Korea		Total: 97	WAD		(Atx. +	(1) Fto gary 20	(1) 0.80, P=0.0001
(2020) [35]	(07/2019 –	RCT	Exp.: 48	(within 7 days)	MSAT + IKM	pharm. +	7 January 2024. Doo MEnseignement & or Oses Felates to t	(2) 0.67, P=0.001
(2020) [30]	09/2019)		Con.: 49	(11111111 / 441)5)		CMT + HM)	(3) Ref. Leas. Flex.	(3) 1.01, P<0.001
						Civit + trivi)	(2) Date 1. Dog	(4) 0.88, P<0.001
							(5) Rati (12 cg).	(5) 1.44, P<0.001
							≧.m [⇒]	
treatment; IKM NDI: Neck disa	I: Integrative Ko	orean medi OM: Range	cine treatment; Ple of motion; Flex.	narm.: Pharmacopund	cture; CMT: Chuna ı	manual therapy; F	HM: Herral and medicine JM: Herral and medicine July 1 (1) (1) (1) (1) (1) (1) (1) (1) (1) (e; VAS: Visual analog s
treatment; IKM NDI: Neck disa	f: Integrative Ko	orean medi OM: Range	cine treatment; Ple of motion; Flex.	narm.: Pharmacopund	cture; CMT: Chuna ı	manual therapy; F	ociated this order; MS IM: Heridal medicine Left; Land Lateral; A	SAT: Motion-style acup
treatment; IKM NDI: Neck disa	f: Integrative Ko	orean medi OM: Range	cine treatment; Ple of motion; Flex.	narm.: Pharmacopund	cture; CMT: Chuna ı	manual therapy; F	ociated this order; MS	(6) 1.43, P<0.001 GAT: Motion-style acup e; VAS: Visual analog s tx.: Acupuncture therap

Standard for reporting acupuncture according to STRICTA

The eight studies were analyzed using STRICTA (online supplemental table S2). Regarding the type of acupuncture, five studies [16, 29-32] used general acupuncture, two used EA [33, 34], and one used MSAT [35]. Five studies [16, 30, 31, 33, 34] used specific acupoints, and three [29, 32, 35] used muscle trigger points instead of acupoints. The depth of needling was mentioned only in four studies [31, 33-35]. For stimulation response, two studies [30, 31] induced a *deqi* sensation, two [29, 32] used pecking, two [29, 31] used techniques such as twirling and rotation, and two [33, 34] used electrical stimulation. Regarding the total number of sessions, more than six sessions were performed in most studies [29, 31, 33-35], only one session was performed in one study [30], and two to six sessions were performed in one study depending on the degree of improvement in the symptoms [32]. 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 one to six weeks, and the retention time varied from 15 to 60 min.

Risk of bias assessment

The eight selected studies were analyzed 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 [29-32, 34, 35]. Regarding deviations from the intended interventions, four studies were rated as having low risk of bias [29, 31, 34, 35], three as having some concerns [30, 32, 33], and one as having high risk of bias [16]. For missing outcome data, four studies were rated as having low risk of bias [30, 31, 33, 35]. In terms of bias in measurement of the outcome, except for one study that did not provide full text [16], all seven studies were identified as having low risk of bias. In terms of the selection of the reported result, studies that reported a pre-specified analysis plan were rated as having low risk of bias

Meta-analysis

 A meta-analysis was performed with seven studies [29-35] according to the outcomes, after excluding one study [16] 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).

ROM

Kwak et al. [31] and Kim et al. [35] recorded the ROM for all directions, whereas Sterling et al. [29] 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).

NDI

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 S2).

Adverse events

Five studies [29, 31, 32, 34, 35] reported adverse events (AEs), whereas three [16, 30, 33] 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. [35], 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 diarrhea, 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 S3).

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. [30] was removed (SMD: -0.65 [-0.96 to -0.35], p<0.001, I^2 : 44%).

ROM

The result of the meta-analysis of ROM-extension was maintained when the study by Sterling et al. [29] was removed; however, the results were not maintained when the study by Kwak et al. [31] or Kim et al. [35] was removed. In particular, there was no heterogeneity when the study by Sterling et al. [29] 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.

NDI

The result of the meta-analysis of NDI changed to the p-value < 0.05 and no heterogeneity when the study by Cameron et al. [34] 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 S4).

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 (l^2) was 51%. Thus, the quality of evidence on the pain VAS score was graded as "moderate."

ROM

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."

NDI

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

Publication bias

Publication bias was evaluated using the funnel plot for the pain VAS score (online supplemental figure S3). 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 [29-35]. In addition, although participant blinding is difficult owing to the nature of acupuncture [36], many studies have attempted to minimize this effect by utilizing placebo interventions. Moreover, four studies [29-31, 35] 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. [30] 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. [30] 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. [29] was removed; thus, it could

be assumed that the study was a potential source of heterogeneity. In the study by Sterling et al. [29], high-intensity ROM exercises, including craniocervical flexion training, neck extensor training, scapular training, posture re-education, and sensorimotor exercises, were performed for 1 h, 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. [34] was removed; therefore, the study was considered responsible for the between-study heterogeneity. It was presumed that the NDI SMD of the study favored the control group since it was > 0, affecting the overall effect size and heterogeneity.

A previous study [16] that analyzed 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 analyzed a total of eight RCTs. Accordingly, this study provided more objective and quantitative evidence by synthesizing 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 analyzed using the leave-one-out approach method. 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 minimize 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.

AUTHOR CONTRIBUTIONS

Sang-Hyun Lee: Conceptualization

Sun-Young Park: Funding acquisition

Sang-Hyun Lee and Man-Suk Hwang: Investigation

In Heo and Byung-Cheul Shin: Methodology

Eui-Hyuoung Hwang and Man-Suk Hwang: Project administration

Man-Suk Hwang: Supervision

Sang-Hyun Lee: Writing – original draft

Sang-Hyun Lee and Man-Suk Hwang: Writing – review & editing

FUNDING

This work was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health

& Welfare, Republic of Korea [grant number: HF21C0162].

DISCLAIMER

 The funding source had no role in the design of the protocol, study search and selection, data extraction and management, data interpretation, report writing, or the decision to submit the report for publication.

COMPETING INTERESTS

None.

PATIENT CONSENT FOR PUBLICATION

Not required.

PROVENANCE AND PEER REVIEW

Not commissioned; extremally peer reviewed.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

AMENDMENT

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.

REFERENCES

- 1. Spitzer WO, Skovron ML, Salmi LR, et al. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. *Spine (Phila Pa 1976)*. 1995;20:1s-73s.
- 2. Eck JC, Hodges SD, Humphreys SC. Whiplash: a review of a commonly misunderstood injury. *Am J Med*. 2001;110:651-6. doi: 10.1016/s0002-9343(01)00680-5.
- 3. Côté P, Hogg-Johnson S, Cassidy JD, et al. Initial patterns of clinical care and recovery from whiplash injuries: a population-based cohort study. *Arch Intern Med.* 2005;165:2257-63. doi: 10.1001/archinte.165.19.2257.
- 4. Kim N, Shin BC, Shin JS, et al. Characteristics and status of Korean medicine use in whiplash-associated disorder patients. *BMC Complement Altern Med.* 2018;18:124. doi: 10.1186/s12906-018-2188-7.
- 5. Curatolo M. Pharmacological and Interventional Management of Pain After Whiplash Injury. *J Orthop Sports Phys Ther.* 2016;46:845-50. doi: 10.2519/jospt.2016.6906.
- 6. Shaked G, Shaked D, Sebbag G, et al. The effect of steroid treatment on whiplash associated syndrome: a controlled randomized prospective trial. *Eur J Trauma Emerg Surg*. 2021;47:1115-22. doi: 10.1007/s00068-019-01282-3.
- 7. Suissa S, Harder S, Veilleux M. The relation between initial symptoms and signs and the prognosis of whiplash. *Eur Spine J.* 2001;10:44-9. doi: 10.1007/s005860000220.
- 8. Côté P, Cassidy JD, Carroll L, et al. A systematic review of the prognosis of acute whiplash and a new conceptual framework to synthesize the literature. *Spine (Phila Pa 1976)*. 2001;26:E445-58. doi: 10.1097/00007632-200110010-00020.
- 9. Hershman DL, Unger JM, Greenlee H, et al. Comparison of Acupuncture vs Sham Acupuncture or Waiting List Control in the Treatment of Aromatase Inhibitor-Related Joint Pain: A Randomized Clinical Trial. *JAMA Netw Open.* 2022;5:e2241720. doi:

10.1001/jamanetworkopen.2022.41720.

- 10. Büyükşireci DE, Demirsoy N, Mit S, et al. Comparison of the Effects of Myofascial Meridian Stretching Exercises and Acupuncture in Patients with Low Back Pain. *J Acupunct Meridian Stud.* 2022;15:347-55. doi: 10.51507/j.jams.2022.15.6.347.
- 11. Woo SH, Lee HJ, Park YK, et al. Efficacy and safety of thread embedding acupuncture for knee osteoarthritis: A randomized controlled pilot trial. *Medicine (Baltimore)*. 2022;101:e29306. doi: 10.1097/MD.0000000000029306.
- 12. Pan S, Wang S, Xue X, et al. Multidimensional Pain Modulation by Acupuncture Analgesia: The Reward Effect of Acupuncture on Pain Relief. *Evid Based Complement Alternat Med*. 2022;2022:3759181. doi: 10.1155/2022/3759181.
- 13. Chon TY, Lee MC. Acupuncture. *Mayo Clin Proc.* 2013;88:1141-6. doi: https://doi.org/10.1016/j.mayocp.2013.06.009
- 14. Bussières AE, Stewart G, Al-Zoubi F, et al. The Treatment of Neck Pain-Associated Disorders and Whiplash-Associated Disorders: A Clinical Practice Guideline. *J Manipulative Physiol Ther*. 2016;39:523-64.e27. doi: 10.1016/j.jmpt.2016.08.007.
- 15. State Insurance Regulatory Authority. Guidelines for the management of acute whiplash associated disorders for health professionals. Syndney: third edition. 2014.
- 16. Moon TW, Posadzki P, Choi TY, et al. Acupuncture for treating whiplash associated disorder: a systematic review of randomised clinical trials. *Evid Based Complement Alternat Med*. 2014;2014:870271. doi: 10.1155/2014/870271.
- 17. Lee S, Jo DH, Kim KH. Acupuncture for treating whiplash-associated disorder: A systematic review and meta-analysis protocol. *Medicine (Baltimore)*. 2018;97:e12654. doi: 10.1097/MD.0000000000012654.
- 18. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLoS Med*. 2021;18:e1003583. doi:

- 10.1371/journal.pmed.1003583.
- 19. Cumpston M, Li T, Page MJ, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev.* 2019;10:Ed000142. doi: 10.1002/14651858.ED000142.
- 20. Lee SH, Park HJ, Kim HT, et al. Efficacy of acupuncture for whiplash injury: A protocol for systematic review and meta-analysis. *Medicine (Baltimore)*. 2021;100:e27767. doi: 10.1097/MD.00000000000027767.
- 21. TRACsa: Trauma and Injury Recovery. Clinical guidelines for best practice management of acute and chronic whiplash-associated disorders. Adelaide, Australia: South Australian Centre for Trauma and Injury Recovery (TRACsa); 2008.
- 22. Shrestha D, Shrestha R, Grotle M, et al. Validation of the Nepali versions of the Neck Disability Index and the Numerical Rating Scale for Neck Pain. *Spine (Phila Pa 1976)*. 2021;46:E325-e32. doi: 10.1097/BRS.0000000000003810.
- 23. MacPherson H, Altman DG, Hammerschlag R, et al. Revised STandards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA): Extending the CONSORT statement. *J Evid Based Med*. 2010;3:140-55. doi: 10.1111/j.1756-5391.2010.01086.x.
- 24. Hammerschlag R, Milley R, Colbert A, et al. Randomized Controlled Trials of Acupuncture (1997-2007): An Assessment of Reporting Quality with a CONSORT- and STRICTA-Based Instrument. *Evid Based Complement Alternat Med.* 2011;2011. doi: 10.1155/2011/183910.
- 25. Abrams KR, Gillies CL, Lambert PC. Meta-analysis of heterogeneously reported trials assessing change from baseline. *Stat Med.* 2005; 24: 3823–44. doi: https://doi.org/10.1002/sim.2423
- 26. Follmann D, Elliott P, Suh I, et al. Variance imputation for overviews of clinical trials with continuous response. *J Clin Epidemiol*. 1992; 45: 769–73. doi: https://doi.org/10.1016/0895-4356(92)90054-q

- 28. Patsopoulos NA, Evangelou E, Ioannidis JP. Sensitivity of between-study heterogeneity in meta-analysis: proposed metrics and empirical evaluation. *Int J Epidemiol*. 2008;37:1148-57. doi: 10.1093/ije/dyn065.
- 29. Sterling M, Vicenzino B, Souvlis T, et al. Dry-needling and exercise for chronic whiplash-associated disorders: a randomized single-blind placebo-controlled trial. *Pain*. 2015;156:635-43. doi: 10.1097/01.j.pain.0000460359.40116.c1.
- 30. Tobbackx Y, Meeus M, Wauters L, et al. Does acupuncture activate endogenous analgesia in chronic whiplash-associated disorders? A randomized crossover trial. *Eur J Pain*. 2013;17:279-89. doi: 10.1002/j.1532-2149.2012.00215.x.
- 31. Kwak H-Y, Kim J-I, Park J-M, et al. Acupuncture for Whiplash-associated disorder: A randomized, waiting-list controlled, pilot trial. *European Journal of Integrative Medicine*. 2012;4:e151-e8. doi: 10.1016/j.eujim.2011.12.008
- 32. Tough EA, White AR, Richards SH, et al. Myofascial trigger point needling for whiplash associated pain--a feasibility study. *Man Ther*. 2010;15:529-35. doi: 10.1016/j.math.2010.05.010.
- 33. Han S-Y, Lee J-Y, Park S-H, et al. A Clinical Study on Effect of Electro-acupuncture Treatment for Whiplash Injury Patients Caused by Traffic Accident. *J Kor Acup Mox Soc.* 2011;28:107-15.
- 34. Cameron ID, Wang E, Sindhusake D. A randomized trial comparing acupuncture and simulated acupuncture for subacute and chronic whiplash. *Spine (Phila Pa 1976)*. 2011;36:E1659-65. doi: 10.1097/BRS.0b013e31821bf674.
- 35. Kim D, Park KS, Lee JH, et al. Intensive Motion Style Acupuncture Treatment (MSAT) Is Effective for Patients with Acute Whiplash Injury: A Randomized Controlled Trial. *J Clin Med*.

2020;9. doi: 10.3390/jcm9072079.

36. Kim TH, Lee MS, Birch S, et al. Plausible Mechanism of Sham Acupuncture Based on Biomarkers: A Systematic Review of Randomized Controlled Trials. *Front Neurosci*. 2022;16:834112. doi: 10.3389/fnins.2022.834112.

FIGURE LEGENDS

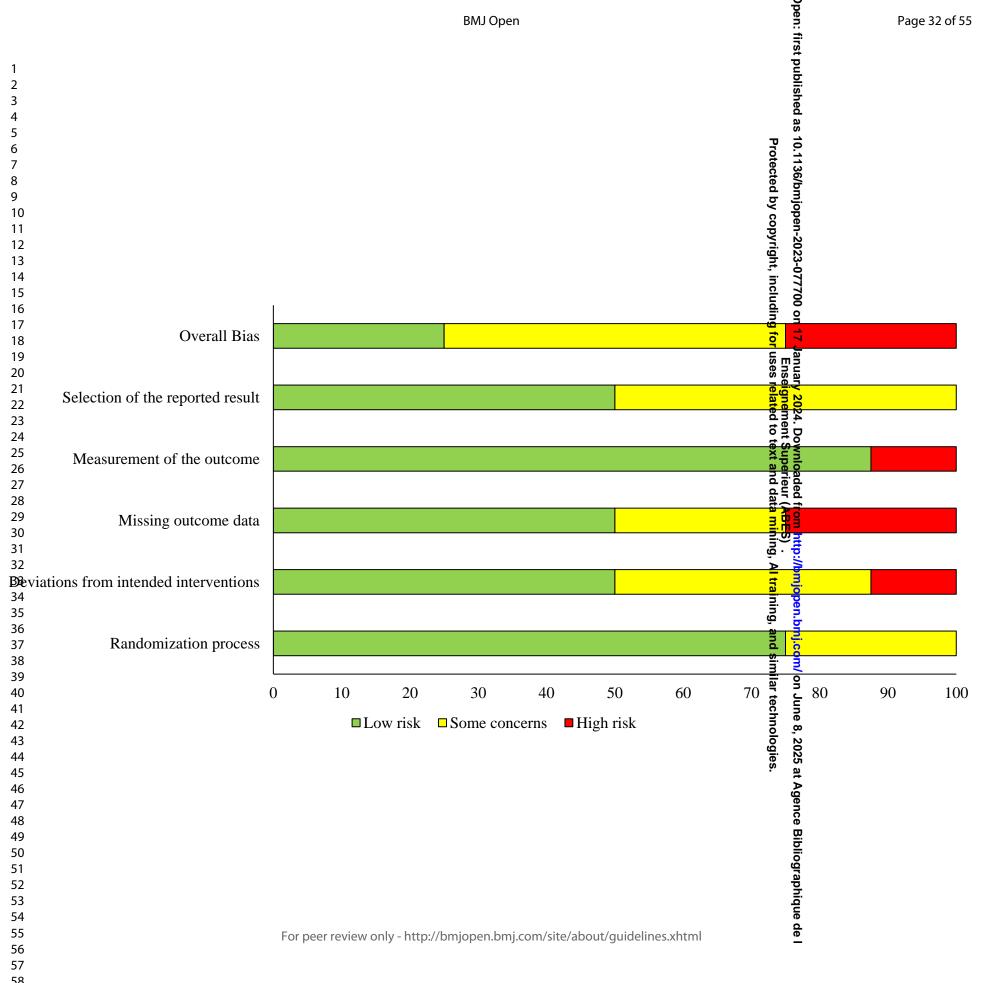
Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses

flowchart of the included studies

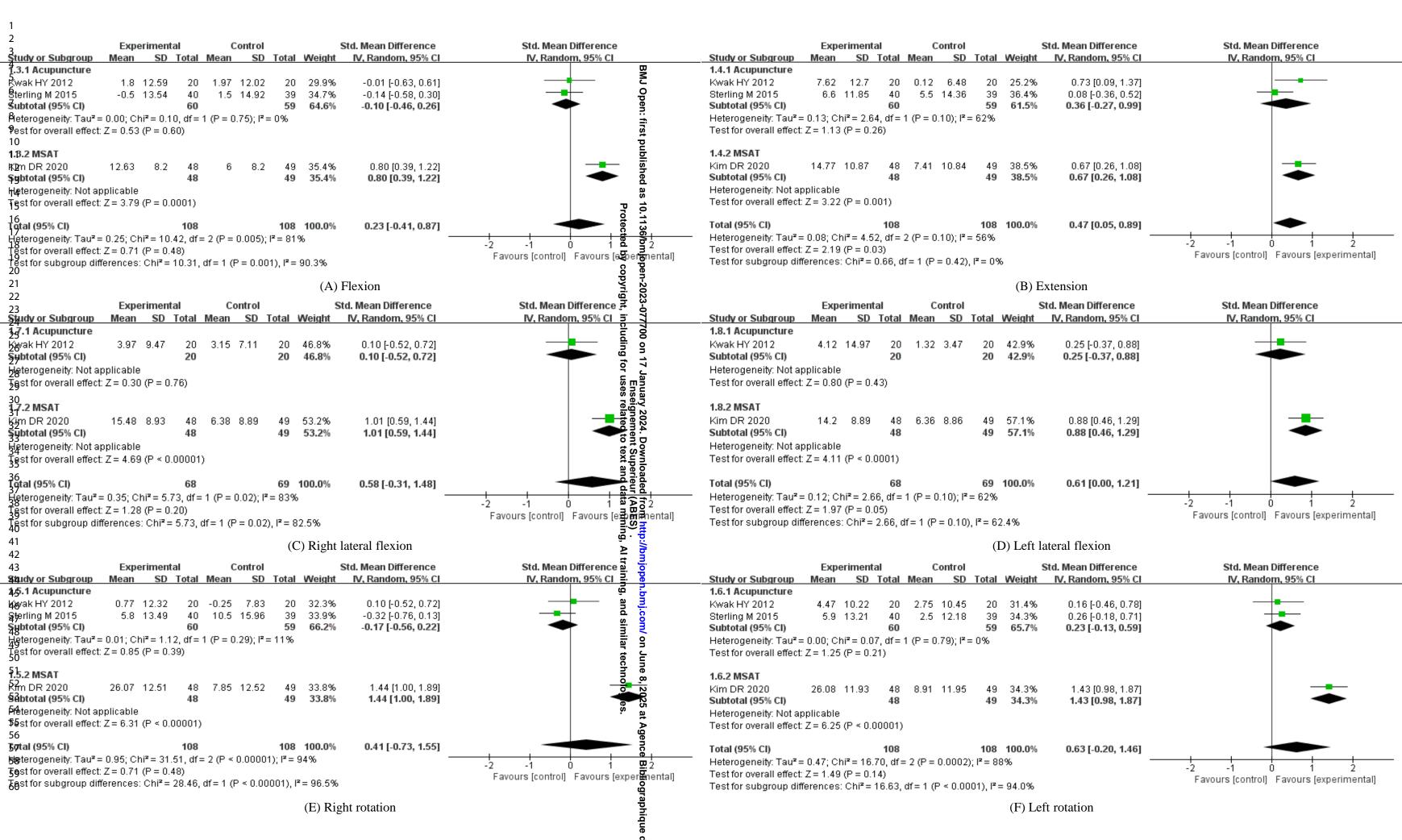
Figure 2. Summary in risk of bias 2

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

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



33 of 55							BN	1J Open)pen: fir	
									pen: first published as	
									shed a	
									s 10.11	
									136/bn ected	
									njopen by cop	
									10.1136/bmjopen-2023-0 Protected by copyright,	
		erimenta			ontrol			Std. Mean Difference	Std. Mean D#ference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Randon¥ 958 CI	
1.1.1 Acupuncture Kwak HY 2012	-1.85	1.88	20	-0.4	1.78	20	12.6%	-0.78 [-1.42, -0.13]	ing	
Tobbackx Y 2012		21.24	39		20.15	39	18.8%			
Tough EA 2010	-3.2	1.49	17	-1.8		17	11.4%		——⊸us En	
Subtotal (95% CI)			76			76	42.8%	-0.50 [-0.93, -0.06]	es r	
Heterogeneity: Tau ² =				2 (P = 0)	l.19); l² :	= 40%			ign elar	
Test for overall effect:	Z= 2.25	(P = 0.0	2)						bed t	
1.1.2 Electroacupund									o te:	
Cameron ID 2011	-1.6	1.88	64	-1.2		52	21.8%		trio	
Han SY 2011 Subtotal (95% CI)	-4.9	1.05	29 93	-3.72	1.56	29 81	15.5% 37.3 %	-0.88 [-1.42, -0.33] - 0.51 [-1.16, 0.13]	ade	
Heterogeneity: Tau² = Test for overall effect:			5, df=	1 (P = 0	l.05); l² =		37.370	-0.01[-1.10, 0.10]	23-0对290 on 17 January 2024. Downloaded from http://bmjope Enseignement Superieur (ABES). tht, 新chading for uses related to text and data mining, AI training, Meandows and the standard mining of the standa	
1.1.3 MSAT									ling,	
Kim DR 2020	-2.03	1.34	48	-0.88	1.34	49	19.8%	-0.85 [-1.27, -0.44]	Al Da	
Subtotal (95% CI)			48			49	19.8%	-0.85 [-1.27, -0.44]	trai njo	
Heterogeneity: Not ap Test for overall effect:			001)						الم الم	
Total (95% CI)			217				100.0%	-0.57 [-0.86, -0.28]	.bmj.cor g, and si	
Heterogeneity: Tau² = Test for overall effect:				= 5 (P =	0.07); 1	°= 51%	•		-2 -1 0 0 0 1	2
Test for subgroup diff				f= 2 (P	= 0.46),	, I² = 0%	6		Favours [experimental] Ravotrs [control]	
									ichn e :	
									similar avours [experimental] Favours [experimental] Favours [experimental]	
)ies.	
										
									jenc	
									е <u>В</u>	
									blio	
									grap	
									hiq	
									Agence Bibliographique de l	
			For p	eer rev	iew only	y - http	://bmjop	en.bmj.com/site/about/	/guidelines.xhtml	



Supplemental table S1. Search strategy and terms used

No.	Search strategy	Results				
NO.	Search strategy	Results				
#1	whiplash OR acute whiplash injury* OR acute whiplash associated disorder* OR acute WAD OR acute					
	whiplash associated disorder* II OR acute WAD II OR whiplash associated disorder* OR WAD OR					
	$whiplash\ associated\ disorder*\ II\ OR\ WAD\ II,\ OR\ whiplash\ OR\ whiplash\ injury*\ OR\ \ whiplash\ patient*$					
	OR whiplash syndrome* OR cervical spine disorder* OR cervical spine injury* OR "Accidents,					
	Traffic" [Mesh] OR (("Motor Vehicles"[Mesh:NoExp] OR "Automobiles"[Mesh] OR	24,250				
-1	"Motorcycles" [Mesh] OR traffic[tiab] OR vehicle[tiab] OR vehicular[tiab] OR car[tiab]	24,230				
	OR automobile[tiab] OR automobiles[tiab] OR motorcycle[tiab] OR motorcycles[tiab] OR taxi[tiab]					
	OR cab[tiab] OR road[tiab] OR pedestrian[tiab] OR pedestrians[tiab]) AND (accident[tiab] OR					
	accidents[tiab] OR injury[tiab] OR injuries[tiab] OR crash[tiab] OR crashes[tiab] OR "Wounds and					
	Injuries"[Mesh] OR "injuries"[Subheading])) AND (cervic* OR thoracic* OR lumba*)					
‡2	acupuncture	42,653				
ŧ3	electroacupuncture	7,448				
‡ 4	acupressure	1,832				
	((((((((((((((((((((((((((((((((((((((
	OR acupuncture Therapy [mh]) OR acupuncture points [mh]) OR acupuncture, ear [mh]) OR					
	acupuncture [Text Word]) OR acupressure [Text Word]) OR electroacupuncture) OR electro					
# 5	acupuncture) OR electro-acupuncture) OR meridian* [Text Word]) OR needling [Text Word]) OR acu-	51,277				
	point*) OR acu point* [Text Word]) OR acupoint* [Text Word]) OR Acupuncture [mh]) OR					
	electroacupuncture [mh]) OR acupuncture* [Text Word]) OR eletroacupuncture* [Text Word]) OR					
	(acupuncture AND th[sh])) OR acupuncture[tiab]) OR acupuncture[mh]) OR acupuncture/th[mh]					
[‡] 6	#2 or #3 or #4 or #5	54,150				
<i>‡</i> 7	#1 and #6	89				
Data	pase: Ovid Medline (ovidsp.ovid.com; 1946-2023)					
	exp Whiplash Injuries/	3,423				
2	whiplash.tw.	3,292				
3	acute whiplash injury*.tw.	75				
ļ	acute whiplash associated disorder*.tw.	71				
i	acute WAD.tw.	66				
<u> </u>	WAD.tw.	1,038				

7	whiplash patient*.tw.	201
8	whiplash syndrome*.tw.	183
9	cervical spine disorder*.tw.	228
10	cervical spine injury*.tw.	1,571
11	exp Accidents, Traffic/	48,509
12	exp Motor Vehicles/	24,289
13	exp Automobiles/	7,798
14	exp Motorcycles/	2,900
15	traffic.tw.	58,851
16	vehicle.tw.	134,582
17	vehicular.tw.	4,046
18	car.tw.	36,938
19	cars.tw.	9,562
20	automobile.tw.	6,526
21	automobiles.tw.	1,392
22	motorcycle.tw.	3,814
23	motorcycles.tw.	931
24	taxi.tw.	1,261
25	cab.tw.	3,755
26	road.tw.	48,507
27	pedestrian.tw.	5,278
28	pedestrians.tw.	3,859
29	accident.tw.	53,887
30	accidents.tw.	48,861
31	injury.tw.	801,932
32	injuries.tw.	254,612
33	crash.tw.	11,757
34	crashes.tw.	9,905
35	exp "Wounds and Injuries"/	1,014,422
36	or/29-35	1,675,831
37	or/11-28	298,607
38	or/1-10	6,385

39	36 and 37	79,754
		·
40	38 or 39	84,652
41	acupuncture.mp.	34,547
42	electroacupuncture.mp.	7,050
43	acupressure.mp.	1,813
44	meridian.mp.	4,833
45	acupoint.mp.	4,164
46	exp acupuncture/	2,043
47	acupuncture.tw.	27,126
48	acupressure.tw.	1,523
49	electro acupuncture.mp.	951
50	meridian*.tw.	6,456
51	needling.tw.	3,936
52	acu-point*.mp.	33
53	acu point*.tw.	33
54	acupoint*.tw.	7,040
55	elctroacupuncture*.tw.	1
56	(acupuncture and th).mp.	79
57	or/41-56	44,775
58	40 and 57	120
Data	base: Embase (embase.com; 1947-2023)	
1	'automobiles'/exp	11,661
2	'motor vehicle'/exp	28,069
3	'accident, traffic'/exp	75,665
4	'motorcycle'/exp	3,664
5	vehicle:ta,ab,de	203,388
6	traffic:ta,ab,de	153,433
7	vehicular:ta,ab,de	4,909
8	car:ta,ab,de	77,435
9	cars:ta,ab,de	12,857
10	automobile:ta,ab,de	7,368
11	automobiles:ta,ab,de	1,524

12	motorcycle:ta,ab,de	5,934
13	motorcycles:ta,ab,de	1,104
14	taxi:ta,ab,de	1,535
15	cab:ta,ab,de	5,070
16	road:ta,ab,de	48,308
17	pedestrian:ta,ab,de	7,726
18	pedestrians:ta,ab,de	4,183
19	accident:ta,ab,de	593,740
20	accidents:ta,ab,de	56,438
21	injury:ta,ab,de	1,928,938
22	injuries:ta,ab,de	280,812
23	crash:ta,ab,de	12,698
24	crashes:ta,ab,de	10,253
25	'wounds and injuries'/exp	2,824,750
26	#19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25	3,658,250
	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14	2,020,220
27	OR #15 OR #16 OR #17 OR #18	427,543
28	#26 AND #27	136,545
29	acupuncture	65,725
30	electroacupuncture	10,710
31	acupressure	3,180
32	acupoint	6,816
33	acupoint:ta,ab,de	6,154
34	'acupuncture analgesia'	2,374
35	'acupuncture therapy'	2,500
36	'acupuncture points'	2,351
37	'acupuncture, ear'	42
38	acupuncture:ta,ab,de	56,629
39	acupressure:ta,ab,de	3,077
40	electroacupuncture	10,710
41	'electro acupuncture'	1,442
42	meridian*:ta,ab,de	9,056

43	needling:ta,ab,de	5,115
44	'acu point*'	50
45	acu AND point*:ta,ab,de	968
46	acupoint*:ta,ab,de	9,351
47	'acupuncture'/exp	57,828
48	'electroacupuncture'/exp	9,355
49	acupuncture*:ta,ab,de	56,660
50	electroacupuncture*:ta,ab,de	10,236
51	acupuncture.:ta,ab,de	56,629
52	#29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51	77,464
53	#28 AND #52	211
Data	base: The Cochrane Library (thecochranelibrary.com; 1993-2023)	
#1	whiplash	589
#2	acute whiplash injury*	139
#3	acute whiplash associated disorder*	97
#4	acute WAD	113
#5	acute whiplash associated disorder* II	37
#6	acute WAD II	44
#7	whiplash associated disorder*	297
#8	WAD	382
#9	whiplash associated disorder* II	69
#10	WAD II	76
#11	whiplash patient*	426
#12	whiplash syndrome*	98
#13	cervical spine disorder*	605
#14	cervical spine injury*	623
#15	MeSH descriptor: [Accidents, Traffic] explode all trees	547
#16	MeSH descriptor: [Motor Vehicles] explde all trees	361
#17	MeSH descriptor: [Automobiles] this term only	77
//10	MeSH descriptor: [Motorcycles] this term only	35
#18		

4 5

6

7 8

9 10

11 12

13

14

15

16 17

18 19

20

21 22

23 24

25 26

27

28

29

30 31

32 33

34

35

36

37 38

39 40

41

42 43

44 45

46 47

48 49

50

51 52

53 54

55 56

57

58

#51	MeSH descriptor: [acupuncture points] explode all trees	2,520
#52	MeSH descriptor: [acupuncture, ear] explode all trees	244
#53	acupuncture:ti,ab,kw	19,015
#54	acupressure:ti,ab,kw	2,062
#55	electro acupuncture	1,023
#56	electro-acupuncture	783
#57	meridian*:ti,ab,kw	1,399
#58	needling:ti,ab,kw	3,062
#59	acu-point*	43
#60	acu point*:ti,ab,kw	257
#61	acupoint*:ti,ab,kw	5,508
#62	MeSH descriptor: [electroacupuncture] explode all trees	1,161
#63	elctroacupuncture*:ti,ab,kw	4
#64	acupuncture AND th	1,248
	#43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57	
#65	or #58 or #59 or #60 or #61 or #62 or #63 or #64	26,713
#66	#42 and #65	40
Data	pase: China National Knowledge Infrastructure (CNKI) (cnki.net; 1993-2023)	
	(SU='traffic accident' OR SU='交通事故' OR SU='whiplash injury' OR SU='颈椎屈伸损伤' OR	
	(see many are see See See See See Many are see Many are	
	SU='whiplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR	
1	SU='颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR	54
	SU='針' or SU='electro acupuncture' OR SU='电針' OR SU='meridian' OR SU='经穴' or SU='acupoint'	
	or SU='acupuncture-ear' OR SU='耳针')	
Data	pase: ScienceOn (scienceon.kisti.re.kr; 2001-2023)	
1	전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈	(1
1	이침)	61
	·/	
Data	pase: KMBASE (kmbase.medric.or.kr; 1985-2023)	
1	[ALL=교통사고]	864

Datal	base: Oriental Medicine Advanced Searching Integrated System (OASIS) (oasis.kiom.re.kr; 19	63-2023)
1	교통사고 침	1
2	교통사고 전침	4
3	교통사고 이침	0
4	교통사고 경혈	0
Datal	base: Research Information Sharing Service (RISS) (riss.kr; 1988-2023)	
1	전체 : 교통사고 <and> 전체 : 침</and>	92
2	전체 : 교통사고 <and> 전체 : 전침</and>	4
3	전체 : 교통사고 <and> 전체 : 이침</and>	0
4	전체 : 교통사고 <and> 전체 : 경혈</and>	1

Supplemental	table S2. Appraisal of acup	uncture procedure based	on the revised	d SRICTA criteri	ρ ñ	
First author	T 0		Depth of	Stimulation	023 [[]	Frequency and
(year)	Type of acupuncture	Acupoints	needling	response	2023-OT7700	Retention
a. 1: 1		Posterior muscles of the			on 1	Frequency: 2
Sterling et al (2015)	General acupuncture	cervical spine and upper	NR	Pecking, Twirling	on 17 Janua Ens	times/week X 3 weeks
(2013)		thoracic spine			uary 2ທ າຣeign າຣ rela	Retention: 30 minute
		Choose from GV14,			024. eme	
		C1-C7, GB20, SI11,			Down Pot Sur To text	
		GB21, TE15, SI14,	NR		load berie and	
Tobbackx et al	General acupuncture	BL17, SP10, SI3,		Deqi sensation	ed fron	Frequency: 1 time/week X 1 week
(2012)	General acupulicture	BL64, TE5, GB41,		Deqi sensation	n ht niniir	
		Shiqizhuixia, Ear Zero			on 17 January 2024. Downloaded from http://bmjopen.bmj.com/ on June 8, Enseignement Superieur (ABES) . Ing for uses related to text and data mining, Al training, and similar techno	Retention: 20 minute
		point, Ear Jerome point,			jope raini	
		Ear C0.			n.bmj.	
		SI2, SI3, SI5, SI7, SI14,			sim	
Kwak et al	Consent communities	SI15, LI11, BL10,	1020	Deqi sensation,	/ on Jù	Frequency: 3
(2012)	General acupuncture	BL12, BL13, BL14,	1.0-2.0 cm	Rotating	ine s	times/week X 2 weeks
` '		BL60, BL62, BL66,		3	2025 logies	Retention: 15 minute
					<u>" a</u> >	

BMJ Open

Page 45 of 55

Supplemental table S3. The "leave-one-out" approach for sensitivity analysis of whiplash-associated disorder

Study omitted	Pooled	95% Confidence i	p-value	$I^{2}(\%)$	
Study offitted	estimate	Lower	Upper	p-varue	1 (70)
Pain VAS score					
Kwak HY 2012	-0.54	-0.87	-0.21	0.001	59
Tobbackx Y 2012	-0.65	-0.96	-0.35	< 0.0001	44
Tough EA 2010	-0.55	-0.87	-0.22	0.001	59
Cameron ID 2011	-0.65	-1.01	-0.29	0.0005	53
Han SY 2011	-0.47	-0.84	-0.11	0.01	61
Kim DR 2020	-0.45	-0.81	-0.10	0.01	53
ROM – flexion					
Kwak HY 2012	0.33	-0.59	1.26	0.48	89
Sterling M 2015	0.43	-0.37	1.22	0.29	78
Kim DR 2020	-0.10	-0.46	0.26	0.60	0
ROM – extension					
Kwak HY 2012	0.38	-0.19	0.96	0.19	73
Sterling M 2015	0.69	0.34	1.03	< 0.0001	0
Kim DR 2020	0.36	-0.27	0.99	0.26	62
ROM – right rotation	on				
Kwak HY 2012	0.56	-1.16	2.29	0.52	97
Sterling M 2015	0.79	-0.53	2.11	0.24	92
Kim DR 2020	-0.17	-0.56	0.22	0.39	11
ROM – left rotation	1				
Kwak HY 2012	0.85	-0.29	1.98	0.15	92
Sterling M 2015	0.81	-0.42	2.05	0.20	90
Kim DR 2020	0.23	-0.13	0.59	0.21	0
NDI					
Sterling M 2015	-0.19	-0.61	0.23	0.37	75

Tobbackx Y 2012	-0.18	-0.59	0.24	0.40	75
Tough EA 2010	-0.11	-0.46	0.25	0.56	71
Cameron ID 2011	-0.29	-0.51	-0.08	0.007	0
Han SY 2011	-0.09	-0.45	0.26	0.61	68
Kim DR 2020	-0.15	-0.56	0.26	0.48	73

VAS: Visual analog scale; ROM: Range of motion; NDI: Neck disability index



			Certainty	assessment			No. of pat	ients	mjopen-2023	
No. of	Study	Risk of	Inconsistency	Indivactors	Imprecision	Other	Experimental	Control	Absolute (95%	Certainty
studies	design	bias	meonsistency	munectness	imprecision	considerations	Experimental	Control	Absolute (95%) Including	
Pain VAS s	score								17 Jan E For us	
6	RCT	Not	Serious*	Not serious	Not serious	None	217	206	25 (15) 0.57 lower	⊕⊕⊕○
		serious							Egypower to 0.28 Egypower to 0.28 Egypower to 0.28 Egypower to 0.28 Egypower to 0.28	Moderate
ROM-flexi	ion			9/	- h				nload uperie xt and	
3	RCT	Not	Very serious§	Not serious	Very serious [†]	None	108	108	SEND 0.23 higher is 200 miles	⊕○○○
		serious							ong, · higher)	Very low
ROM-exte	nsion								minimum per second seco	
3	RCT	Not	Serious*	Not serious	Serious [‡]	None	108	108	98MD 0.47 higher and (0.95 higher to	⊕⊕○○
		serious							ब्रु 0 9 39 higher)	Low
ROM-righ	t lateral flex	xion							June 8,	
									2025 logie:	
									e at	
									Agence Bibliographique de l ⊑	
									Biblio	
									graph	
									nique	
				For peer r	review only - http:/	//bmjopen.bmj.cor	m/site/about/guid	delines.xhtn	ml e	

ige 49 of 55						BMJ Open			mjopen-2023-077700 op.17 January 2024-Down of text and data a by copyright, including for uses related to text and data a	
2	RCT	Not serious	Very serious§	Not serious	Very serious [†]	None	68	69	07 0.58 higher 0.58 higher 0.3 Plower to 1.48	Ф ООО
	eft lateral flex	ion							uses religions	Very low
2 2	RCT	Not serious	Serious*	Not serious	Very serious [†]	None	68	69	SMID 0.61 higher	⊕○○○
ROM-ri	ight rotation	serious			Do				Applications of the second data	Very low
3 3	RCT	Not serious	Very serious [§]	Not serious	Very serious [†]	None	108	108	nd data from 0.41 higher fieur (ABMS) the from 0.41 higher fieur (ABMS) the fieur (ABMS) th	⊕○○○
2							•		AI by man and the state of the	Very low
ROM-le	eft rotation								ı.bmj g, an	
3	RCT	Not	Very serious§	us [§] Not serious	Very serious [†]	None	108	108	% Mb 0.63 higher in 0.29 ower to 1.46	Ф000
)) 		serious							technology	Very low
) NDI									, 2025 a	
6	RCT	Not	Serious*	Not serious	Serious [¶]	None	237	225	SM 2 0.17 lower	⊕⊕○○
5 7 8		serious							ចំ	Low
)									ographique de l ⊞	
<u>)</u> } }				For peer r	eview only - http://	'bmjopen.bmj.cor	m/site/about/gu	iidelines.xht	ф ml ф	
,										

	<u>D1</u>	<u>D2</u>	<u>D3</u>	<u>D4</u>	<u>D5</u>	<u>Overall</u>
Aigner 1998	1	-	-	-	!	-
Cameron 2011	+	+	-	+	!	-
Han 2011	!	!	+	+	!	!
Kim 2020	+	+	+	+	+	+
Kwak 2012	+	+	+	+	+	+
Sterling 2015	+	+	!	+	+	!
Tobbackx 2012	+	!	+	+	+	!
Tough 2010	+	!	!	+	!	!

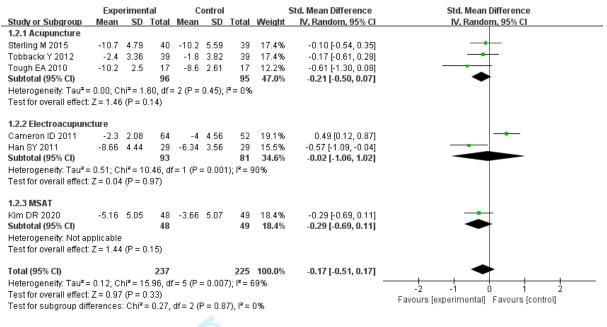
+	Low risk
!	Some concerns
	High risk

D3

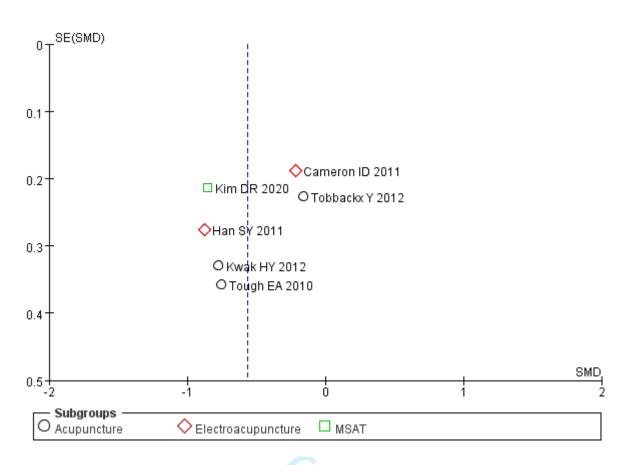
D4

- D1 Randomisation process
- D2 Deviations from the intended interventions
 - Missing outcome data
 - Measurement of the outcome
- D5 Selection of the reported result

Supplemental figure S1. Individual data of RoB 2



Supplemental figure S2. Forest plot of the meta-analysis for the neck disability index



Supplemental figure S3. Funnel plot for the pain visual analog scale score



PRISMA 2020 Checklist

		BMJ Open BMJ open	Page 54 of 55
PRIS	MA 2	020 Checklist Copyrigh	
Section and	Item #	Checklist item	Location where
Topic TITLE	#	<u>c 7</u> ud 00	item is reported
6 Title	1	Identify the report as a systematic review.	1
7 ABSTRACT		or 7	
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2-3
10 INTRODUCTION		9 D E	
11 Rationale	3	Describe the rationale for the review in the context of existing knowledge. Provide an explicit statement of the objective(s) or question(s) the review addresses.	4
12 Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	4-5
METHODS		to the contract of the contrac	
14 Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6-7
16 Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consult 👸 📆 entify studies. Specify the date when each source was last searched or consulted.	6 Supple table 1
18 Search strategy 19	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used. To BE A BE	6 Supple table 1
20 Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how mangered were screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each sport, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of action tools used in the process.	7-8
26 Data items 27	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each gutcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	6-7
28 29	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	6-7
30 Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how matery reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
32 Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	8
33 Synthesis 34 methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study ter tention characteristics and comparing against the planned groups for each synthesis (item #5)).	7-8
35 36	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summery statistics, or data conversions.	7-8
37	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7-8
38 39 40	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was per med, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	8-9
41	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analys , meta-regression).	8-9
42	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	8-9
43 Reporting bias 44 assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases. For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	8-9



PRISMA 2020 Checklist

Page 55 of 55		BMJ Open BMJ open	
PRIS	SMA 2	BMJ Open BMJ Open by copyrigh 2020 Checklist	
Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	8-9
RESULTS		for 7	
9 Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to sumber of studies included in the review, ideally using a flow diagram.	10 Figure 1.
1 1 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	10 Figure 1.
13 Study 14 characteristics	17	Cite each included study and present its characteristics.	10 Table 1
16 Risk of bias in 17 studies 18	18	Present assessments of risk of bias for each included study. and each from the control of the c	14-15 Figure 2. Supple figure 1
Results of individual studies 21	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	15-16 Figure 3,4. Supple figure 2
23 Results of 24 syntheses 25 26	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	15-17 Figure 2,3,4. Supple figure 1,2
27 28 29	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary stingate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	15-16 Figure 3,4. Supple figure 2
30 31	20c	Present results of all investigations of possible causes of heterogeneity among study results.	16-17 Supple table 3
32 33 34	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	16-17 Supple table 3
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	19 Supple figure 3
37 38 Certainty of 39 evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	17-19 Supple table 4
40 DISCUSSION		og	
4 Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	20-21
42	23b	Discuss any limitations of the evidence included in the review.	21-22
43	23c	Discuss any limitations of the review processes used.	21-22
	23d	υ.	20-22
44 45 46		Discuss any limitations of the review processes used.	+



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
OTHER INFORMA	TION	ud 00	
Registration and	24a	Provide registration information for the review, including register name and registration number, or state that the www. was not registered.	3
protocol	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	23
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the second sec	22-23
Competing interests	26	Declare any competing interests of review authors.	23
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms at extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	23
7 From: Page MJ, N 3 10.1136/bmj.n71 9 10 11 20 31 41 55 66 7 7 33 9 10 11 22 33 44 55 66 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	IcKenzie	Provide registration information for the review, including register name and registration number, or state that the provide registration information for the review, including register name and registration number, or state that the provide was not registered. Indicate where the review protocol can be accessed, or state that a protocol was not prepared. Describe and explain any amendments to information provided at registration or in the protocol. Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the protocol. Declare any competing interests of review authors. Report which of the following are publicly available and where they can be found: template data collection forms of the funders of a protocol was not prepared. JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for respective systematic reviews. By a protocol was not prepared. For more information, visit: http://www.prisma-statement.org/ For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	MJ 2021;372:n71. d

cted by copyrigi 36/bmjopen-2023

BMJ Open

Efficacy of acupuncture for whiplash injury: A systematic review and meta-analysis

Journal:	BMJ Open
Manuscript ID	bmjopen-2023-077700.R2
Article Type:	Original research
Date Submitted by the Author:	04-Dec-2023
Complete List of Authors:	Lee, Sang-Hyun; Pusan National University, Graduate School, Department of Korean Medicine Park, Sun-Young; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine Heo, In; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Hwang, Eui-Hyoung; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Shin, Byung-Cheul; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Rehabilitation Hwang, Man-Suk; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation
Primary Subject Heading :	Complementary medicine
Secondary Subject Heading:	Complementary medicine
Keywords:	Systematic Review, Randomized Controlled Trial, COMPLEMENTARY MEDICINE, PAIN MANAGEMENT

SCHOLARONE™ Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Sang-Hyun Lee¹, Sun-Young Park², In Heo^{2,3}, Eui-Hyoung Hwang^{2,3}, Byung-Cheul Shin^{2,3}, Man-Suk Hwang^{2,3,*}

¹ Department of Korean Medicine, Graduate School, Pusan National University, Yangsan,

Gyeongnam, Republic of Korea

² 3rd Division of Clinical Medicine, School of Korean Medicine, Pusan National University,

Yangsan, Gyeongnam, Republic of Korea

³ Department of Korean Medicine Rehabilitation, Spine and Joint Center, Pusan National

University Korean Medicine Hospital, Yangsan, Gyeongnam, Republic of Korea

* Corresponding author:

Man-Suk Hwang

Department of Korean Medicine Rehabilitation, Spine and Joint Center, Pusan National

University Korean Medicine Hospital, Yangsan, Gyeongnam, Republic of Korea

Tel: +82-55-360-5970

Fax: +82-51-510-8437

Email: hwangmansuk@pusan.ac.kr

ABSTRACT

Objectives: This study aimed to establish clinical evidence for acupuncture by analyzing 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 to 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 October 1, 2023. Eligibility criteria: We included randomized controlled trials (RCTs) using acupuncture on patients with WAD. The outcomes were the pain visual analog 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 analyzed 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.

Keywords: Acupuncture; Whiplash injuries; Whiplash-associated disorder; Systematic review; Meta-analysis; Randomized controlled trial

Word Count: 3831

Article Summary

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.

INTRODUCTION

Whiplash injury or whiplash-associated disorder (WAD) is caused by rapid 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 recognized despite its usefulness in clinical practice [13]. The Canadian and Australian WAD clinical practice guidelines (CPGs) do not recommend acupuncture for treating WAD [14]; 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 analyzing 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 to 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

SR [16] 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 July 18, 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 October 1, 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 S1). 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 its potential to introduce publication bias [21].

Eligibility criteria

The studies included in this study were selected according to the following five criteria: study design, participants, intervention, comparison, and outcomes. Randomized 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 pre- and post-clinical 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 analog 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 (SHL and MSH) 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 (SHL and MSH) analyzed 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 summarized 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 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 (SHL and MSH) 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 categorized as high,

moderate, low, or very low. In the case of disagreements between researchers, agreement was reached through discussion with third and fourth researchers (BCS, IH).

Statistical analysis

The meta-analysis was performed using the Review Manager version 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% confidence interval (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 intervention, 6 articles without full text, 3 articles without a valid control group, and 2 articles for other reasons. In addition, we included 1 study through reference tracking [16]. Thus, 8 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 study [36] 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], UK [33], and Austria [16]. The recruitment period was less than one year in five studies [31-34, 36], more than four years in two studies [30, 35], and not reported in one study [16]. Among the eight studies, one [31] 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. was described based on its reference in the SR by Moon et al. [16], as the original text could not be accessed (Table 1).

alia – RCT	Total: 80 Exp.: 40 Con.: 40	WAD II	Atx. + exercise	Sham atx. +	en-2023-677700 on 17 January 2024. Downsbaded from Enseignement Superieur (1) Out R R Hed to text and data Out C R R R R R R R R R R R R R R R R R R	(Effect size, P-value) 1) 0.10, P=0.67 2) (1) -0.14, P=0.54
– RCT	Exp.: 40	WAD II	Atx. + exercise	Sham atx. +	1) Norus 20 Res relation (1) F	2)
– RCT	Exp.: 40	WAD II	Atx. + exercise	Sham atx. +	2) Rossinary 20 release 20 (1) Fabor 20	
		WAD II	Atx. + exercise	Sham atx. +	(1) F整定 2	(1) -0.14 P=0.54
)24 led	(1) -0.14, 1 -0.34
	Committee			exercise		(2) 0.08, P=0.71
					(3) R Ž te ko a	(3) -0.32, P=0.16
					de en	(4) 0.26, P=0.24
		WAD I or II or			om http: \BES) . mining,	
um Crossover		ш			ng, Atl 1) NATI	1) 0.17, P=0.47
011 – RCT	Total: 39	(chronic WAD	Atx.	Relaxation	2) pa li n V A S	2) 0.16, P=0.47
11)		persisting more			n.bmj າg, ar	, ,
		than 3 months)			.com/ nd sim	
n RCT	Total: 40	WAD	Atx. + UC	UC	1) pa VAS	1) 0.78, P=0.02
009 –	Exp.: 20	(persisting more		(PTx. +		2)
10)	Con.: 20	than 3 months)		exercise)	(1) Fuex. 22	(1) -0.01, P=0.97
	Crossover 011 – RCT 111) RCT 009 –	Crossover 011 – Total: 39 RCT 111) RCT Total: 40 009 – Exp.: 20	Crossover RCT Total: 39 (chronic WAD persisting more than 3 months) RCT Total: 40 WAD Exp.: 20 (persisting more	Crossover RCT Total: 39 (chronic WAD persisting more than 3 months) RCT RCT Total: 40 WAD Atx. + UC Exp.: 20 (persisting more	Crossover RCT Total: 39 (chronic WAD Atx. Relaxation persisting more than 3 months) RCT Total: 40 WAD Atx. + UC UC	Crossover O11 - RCT Total: 39 (chronic WAD Atx. Relaxation Total: 39 (persisting more than 3 months) RCT RCT RCT RCT Total: 40 WAD Atx. + UC UC Total: 40 WAD Atx. + UC Exp.: 20 (persisting more (PTx. + 2) Rem exp. 20) RCT Total: 40 WAD Atx. + UC Relaxation O09 - Exp.: 20 (persisting more (PTx. + 2) Rem exp. 20)

Table 1. Data of clinical studies on acupuncture for whiplash-associated disorder BMJ Open

mjopen-2023-0

	Korea		Total: 97			IKM	t, including of the part of th	1) 0.85, P<0.0001 2) 0.29, P=0.15 3) (1) 0.80, P=0.0001
Kim et al (2020) [36]	(07/2019 – 09/2019)	RCT	Exp.: 48 Con.: 49	WAD (within 7 days)	MSAT + IKM	(Atx. + pharm. +	2024. Dog. Flex.	(2) 0.67, P=0.001 (3) 1.01, P<0.001
						CMT + HM)	and date mint	(4) 0.88, P<0.001 (5) 1.44, P<0.001
CI: Confidence	e interval: RCT:	Randomiz	zed controlled tria	l; Exp.: Experimenta	; Con.: Control; WA	AD: Whiplash-ass	9	(6) 1.43, P<0.001
							tra 😽	
treatment; IKN NDI: Neck dis	A: Integrative K ability index; R	orean med OM: Rang	icine treatment; Plee of motion; Flex.	harm.: Pharmacopun	cture; CMT: Chuna i	manual therapy; I	HM: Hermal medicine	e; VAS: Visual analog stx.: Acupuncture therap

Standard for reporting acupuncture according to STRICTA

The eight studies were analyzed using STRICTA (online supplemental table S2). 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 one to six weeks, and the retention time varied from 15 to 60 min.

Risk of bias assessment

The eight selected studies were analyzed 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 were identified as having low risk of bias. In terms of the selection of the reported result, studies that reported a pre-specified 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 S1).

Meta-analysis

 A meta-analysis was performed with seven studies [30-36] according to the outcomes, after excluding one study [16] 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).

ROM

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).

NDI

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 S2).

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 diarrhea, 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 S3).

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%).

ROM

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.

NDI

The result of the meta-analysis of NDI changed to the 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 S4).

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 (l^2) was 51%. Thus, the quality of evidence on the pain VAS score was graded as "moderate."

ROM

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."

NDI

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

Publication bias

Publication bias was evaluated using the funnel plot for the pain VAS score (online supplemental figure S3). 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 minimize this effect by utilizing 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 h, 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 favored the control group since it was > 0, affecting the overall effect size and heterogeneity.

A previous study [16] that analyzed 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 analyzed a total of eight RCTs. Accordingly, this study provided more objective and quantitative evidence by synthesizing 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 analyzed using the leave-one-out approach method. 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 minimize 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.

AUTHOR CONTRIBUTIONS

Conceptualization: Sang-Hyun Lee

Formal analysis: Sun-Young Park and In Heo

Funding acquisition: Sun-Young Park and Eui-Hyuoung Hwang

Investigation: Sang-Hyun Lee, In Heo, Byung-Cheul Shin, and Man-Suk Hwang

Methodology: Sun-Young Park, In Heo, Eui-Hyuoung Hwang, and Byung-Cheul Shin

Project administration: Sun-Young Park, In Heo, Eui-Hyuoung Hwang and Man-Suk Hwang

Supervision: Byung-Cheul Shin and Man-Suk Hwang

Writing – original draft: Sang-Hyun Lee

Writing – review & editing: Sang-Hyun Lee, Eui-Hyuoung Hwang, Byung-Cheul Shin and

Man-Suk Hwang

FUNDING

This work was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea [grant number: HF21C0162].

DISCLAIMER

The funding source had no role in the design of the protocol, study search and selection, data extraction and management, data interpretation, report writing, or the decision to submit the report for publication.

COMPETING INTERESTS

None.

PATIENT CONSENT FOR PUBLICATION

Not required.

PROVENANCE AND PEER REVIEW

Not commissioned; extremally peer reviewed.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

AMENDMENT

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.

REFERENCES

- 1. Spitzer WO, Skovron ML, Salmi LR, et al. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. *Spine (Phila Pa 1976)*. 1995;20:1s-73s.
- 2. Eck JC, Hodges SD, Humphreys SC. Whiplash: a review of a commonly misunderstood injury. *Am J Med*. 2001;110:651-6. doi: 10.1016/s0002-9343(01)00680-5.
- 3. Côté P, Hogg-Johnson S, Cassidy JD, et al. Initial patterns of clinical care and recovery from whiplash injuries: a population-based cohort study. *Arch Intern Med.* 2005;165:2257-63. doi: 10.1001/archinte.165.19.2257.
- 4. Kim N, Shin BC, Shin JS, et al. Characteristics and status of Korean medicine use in whiplash-associated disorder patients. *BMC Complement Altern Med.* 2018;18:124. doi: 10.1186/s12906-018-2188-7.
- 5. Curatolo M. Pharmacological and Interventional Management of Pain After Whiplash Injury. *J Orthop Sports Phys Ther.* 2016;46:845-50. doi: 10.2519/jospt.2016.6906.
- 6. Shaked G, Shaked D, Sebbag G, et al. The effect of steroid treatment on whiplash associated syndrome: a controlled randomized prospective trial. *Eur J Trauma Emerg Surg*. 2021;47:1115-22. doi: 10.1007/s00068-019-01282-3.
- 7. Suissa S, Harder S, Veilleux M. The relation between initial symptoms and signs and the prognosis of whiplash. *Eur Spine J.* 2001;10:44-9. doi: 10.1007/s005860000220.
- 8. Côté P, Cassidy JD, Carroll L, et al. A systematic review of the prognosis of acute whiplash and a new conceptual framework to synthesize the literature. *Spine (Phila Pa 1976)*. 2001;26:E445-58. doi: 10.1097/00007632-200110010-00020.
- 9. Hershman DL, Unger JM, Greenlee H, et al. Comparison of Acupuncture vs Sham Acupuncture or Waiting List Control in the Treatment of Aromatase Inhibitor-Related Joint Pain: A Randomized Clinical Trial. *JAMA Netw Open.* 2022;5:e2241720. doi:

- 10.1001/jamanetworkopen.2022.41720.
- 10. Büyükşireci DE, Demirsoy N, Mit S, et al. Comparison of the Effects of Myofascial Meridian Stretching Exercises and Acupuncture in Patients with Low Back Pain. *J Acupunct Meridian Stud.* 2022;15:347-55. doi: 10.51507/j.jams.2022.15.6.347.
- 11. Woo SH, Lee HJ, Park YK, et al. Efficacy and safety of thread embedding acupuncture for knee osteoarthritis: A randomized controlled pilot trial. *Medicine (Baltimore)*. 2022;101:e29306. doi: 10.1097/MD.0000000000029306.
- 12. Pan S, Wang S, Xue X, et al. Multidimensional Pain Modulation by Acupuncture Analgesia: The Reward Effect of Acupuncture on Pain Relief. *Evid Based Complement Alternat Med*. 2022;2022:3759181. doi: 10.1155/2022/3759181.
- 13. Chon TY, Lee MC. Acupuncture. *Mayo Clin Proc.* 2013;88:1141-6. doi: https://doi.org/10.1016/j.mayocp.2013.06.009.
- 14. Bussières AE, Stewart G, Al-Zoubi F, et al. The Treatment of Neck Pain-Associated Disorders and Whiplash-Associated Disorders: A Clinical Practice Guideline. *J Manipulative Physiol Ther*. 2016;39:523-64.e27. doi: 10.1016/j.jmpt.2016.08.007.
- 15. State Insurance Regulatory Authority. Guidelines for the management of acute whiplash associated disorders for health professionals. Syndney: third edition. 2014.
- 16. Moon TW, Posadzki P, Choi TY, et al. Acupuncture for treating whiplash associated disorder: a systematic review of randomised clinical trials. *Evid Based Complement Alternat Med.* 2014;2014:870271. doi: 10.1155/2014/870271.
- 17. Lee S, Jo DH, Kim KH. Acupuncture for treating whiplash-associated disorder: A systematic review and meta-analysis protocol. *Medicine (Baltimore)*. 2018;97:e12654. doi: 10.1097/MD.0000000000012654.
- 18. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLoS Med.* 2021;18:e1003583. doi:

10.1371/journal.pmed.1003583.

- 19. Cumpston M, Li T, Page MJ, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev.* 2019;10:Ed000142. doi: 10.1002/14651858.ED000142.
- 20. Lee SH, Park HJ, Kim HT, et al. Efficacy of acupuncture for whiplash injury: A protocol for systematic review and meta-analysis. *Medicine (Baltimore)*. 2021;100:e27767. doi: 10.1097/MD.0000000000027767.
- 21. Saric L, Vucic K, Dragicevic K, et al. Comparison of conference abstracts and full-text publications of randomized controlled trials presented at four consecutive World Congresses of Pain: Reporting quality and agreement of results. *Eur J Pain*. 2019;23:107-16. doi: 10.1002/ejp.1289.
- 22. TRACsa: Trauma and Injury Recovery. Clinical guidelines for best practice management of acute and chronic whiplash-associated disorders. Adelaide, Australia: South Australian Centre for Trauma and Injury Recovery (TRACsa); 2008.
- 23. Shrestha D, Shrestha R, Grotle M, et al. Validation of the Nepali versions of the Neck Disability Index and the Numerical Rating Scale for Neck Pain. *Spine (Phila Pa 1976)*. 2021;46:E325-e32. doi: 10.1097/BRS.0000000000003810.
- 24. MacPherson H, Altman DG, Hammerschlag R, et al. Revised STandards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA): Extending the CONSORT statement. *J Evid Based Med*. 2010;3:140-55. doi: 10.1111/j.1756-5391.2010.01086.x.
- 25. Hammerschlag R, Milley R, Colbert A, et al. Randomized Controlled Trials of Acupuncture (1997-2007): An Assessment of Reporting Quality with a CONSORT- and STRICTA-Based Instrument. *Evid Based Complement Alternat Med.* 2011;2011. doi: 10.1155/2011/183910.
- 26. Abrams KR, Gillies CL, Lambert PC. Meta-analysis of heterogeneously reported trials assessing change from baseline. *Stat Med.* 2005; 24: 3823–44. doi:

https://doi.org/10.1002/sim.2423.

- 27. Follmann D, Elliott P, Suh I, et al. Variance imputation for overviews of clinical trials with continuous response. *J Clin Epidemiol*. 1992; 45: 769–73. doi: https://doi.org/10.1016/0895-4356(92)90054-q.
- 28. Caplan AM, Caplan L. The GRADE Method. *Rheum Dis Clin North Am*. 2022;48:589-99. doi: https://doi.org/10.1016/j.rdc.2022.04.002.
- 29. Patsopoulos NA, Evangelou E, Ioannidis JP. Sensitivity of between-study heterogeneity in meta-analysis: proposed metrics and empirical evaluation. *Int J Epidemiol*. 2008;37:1148-57. doi: 10.1093/ije/dyn065.
- 30. Sterling M, Vicenzino B, Souvlis T, et al. Dry-needling and exercise for chronic whiplash-associated disorders: a randomized single-blind placebo-controlled trial. *Pain*. 2015;156:635-43. doi: 10.1097/01.j.pain.0000460359.40116.c1.
- 31. Tobbackx Y, Meeus M, Wauters L, et al. Does acupuncture activate endogenous analgesia in chronic whiplash-associated disorders? A randomized crossover trial. *Eur J Pain*. 2013;17:279-89. doi: 10.1002/j.1532-2149.2012.00215.x.
- 32. Kwak H-Y, Kim J-I, Park J-M, et al. Acupuncture for Whiplash-associated disorder: A randomized, waiting-list controlled, pilot trial. *European Journal of Integrative Medicine*. 2012;4:e151-e8. doi: 10.1016/j.eujim.2011.12.008.
- 33. Tough EA, White AR, Richards SH, et al. Myofascial trigger point needling for whiplash associated pain--a feasibility study. *Man Ther*. 2010;15:529-35. doi: 10.1016/j.math.2010.05.010.
- 34. Han S-Y, Lee J-Y, Park S-H, et al. A Clinical Study on Effect of Electro-acupuncture Treatment for Whiplash Injury Patients Caused by Traffic Accident. *J Kor Acup Mox Soc.* 2011;28:107-15.
- 35. Cameron ID, Wang E, Sindhusake D. A randomized trial comparing acupuncture and

simulated acupuncture for subacute and chronic whiplash. *Spine (Phila Pa 1976)*. 2011;36:E1659-65. doi: 10.1097/BRS.0b013e31821bf674.

- 36. Kim D, Park KS, Lee JH, et al. Intensive Motion Style Acupuncture Treatment (MSAT) Is Effective for Patients with Acute Whiplash Injury: A Randomized Controlled Trial. *J Clin Med*. 2020;9. doi: 10.3390/jcm9072079.
- 37. Kim TH, Lee MS, Birch S, et al. Plausible Mechanism of Sham Acupuncture Based on Biomarkers: A Systematic Review of Randomized Controlled Trials. *Front Neurosci*. 2022;16:834112. doi: 10.3389/fnins.2022.834112.

FIGURE LEGENDS

Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses

flowchart of the included studies

Figure 2. Summary in risk of bias 2

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

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

BMJ Open

2

3

5

6

8

10

11

12

13

14

19

24

25 26

27 28

29

30

31

32

33

34 35 36

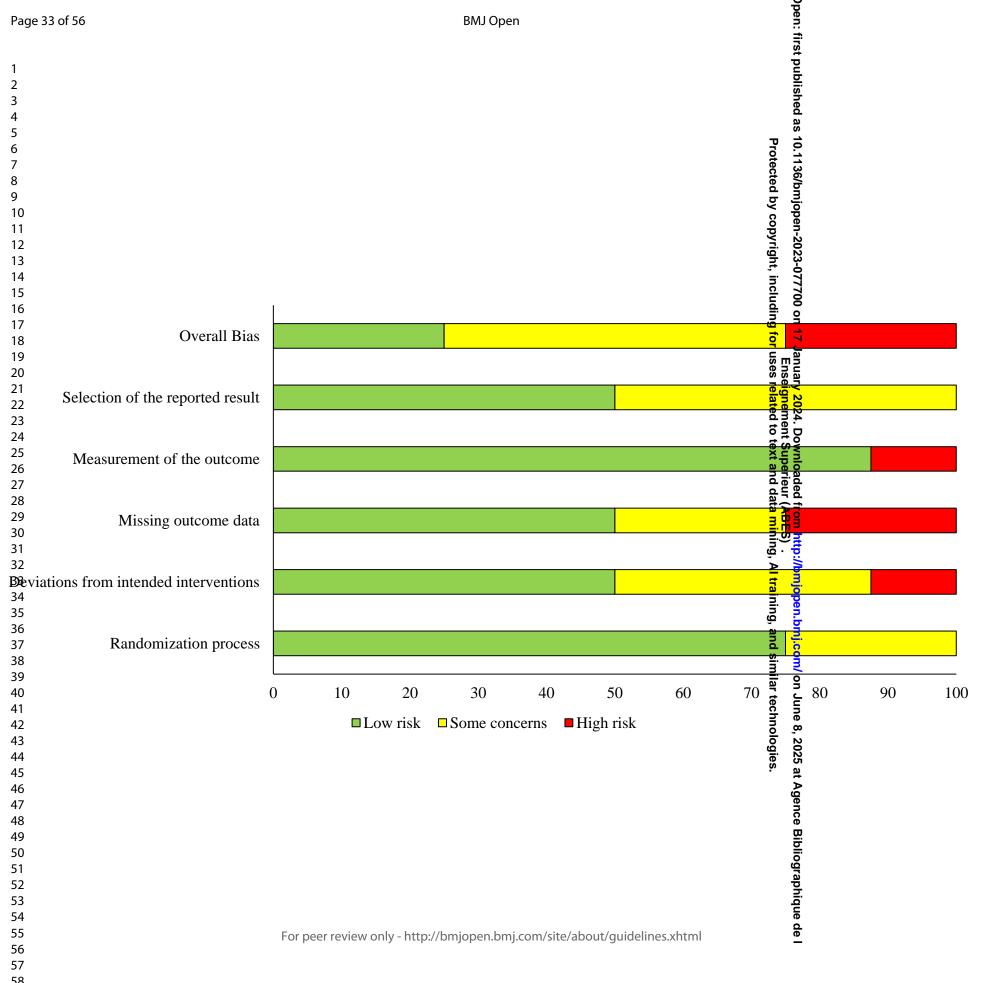
37

38

39 40

42 43

44 45 Page 32 of 56



Page 34 of 56

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

14

15

16

17

18

19

20

21

22

23

24

25

26

27

28

29

30 31

32

33

34

35

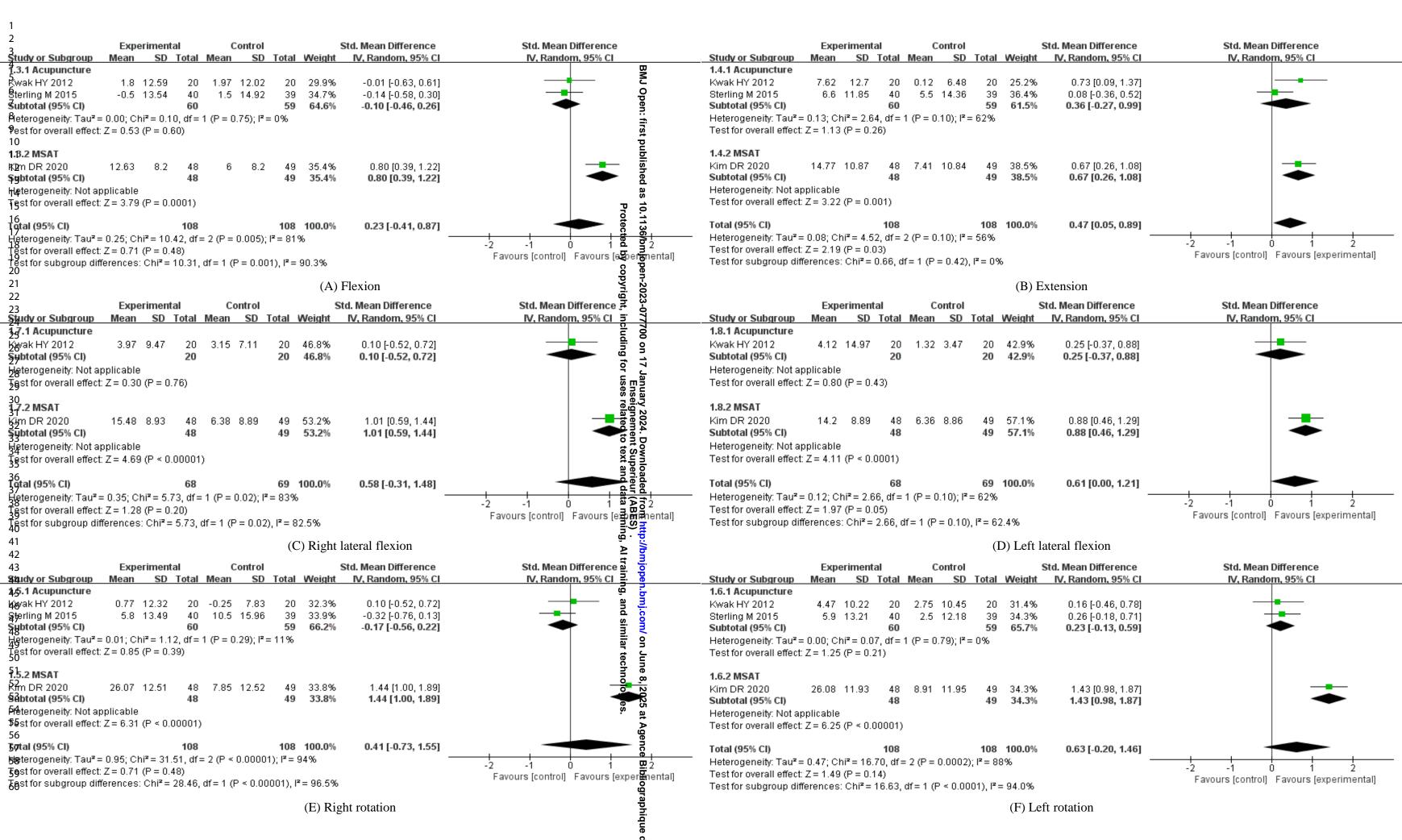
36 37

38

39

40

41 42 43



BMJ Open

For peer review only - hten in the period of the peer review only - hten in the peer review on the peer review of the peer review on the peer review of the peer rev

4 5

6 7

8 9

10 11

12

13 14

15 16

17

18

19

20 21

22 23

24

25 26

27 28

29 30

31 32

33

34 35

36 37

38

39 40

41 42

43 44

45

46 47

48 49

50 51

52 53

54

55 56

57 58

59 60

Database: PubMed (pubmed.ncbi.nlm.nih.gov; 1946-2023) No. Results Search strategy whiplash OR acute whiplash injury* OR acute whiplash associated disorder* OR acute WAD OR acute whiplash associated disorder* II OR acute WAD II OR whiplash associated disorder* OR WAD OR whiplash associated disorder* II OR WAD II, OR whiplash OR whiplash injury* OR whiplash patient* OR whiplash syndrome* OR cervical spine disorder* OR cervical spine injury* OR "Accidents, Traffic" [Mesh] OR (("Motor Vehicles"[Mesh:NoExp] OR "Automobiles"[Mesh] OR #1 24,250 "Motorcycles" [Mesh] OR traffic[tiab] OR vehicle[tiab] OR vehicular[tiab] OR car[tiab] OR cars[tiab] OR automobile[tiab] OR automobiles[tiab] OR motorcycle[tiab] OR motorcycles[tiab] OR taxi[tiab] OR cab[tiab] OR road[tiab] OR pedestrian[tiab] OR pedestrians[tiab]) AND (accident[tiab] OR accidents[tiab] OR injury[tiab] OR injuries[tiab] OR crash[tiab] OR crashes[tiab] OR "Wounds and Injuries"[Mesh] OR "injuries"[Subheading])) AND (cervic* OR thoracic* OR lumba*) #2 42,653 acupuncture 7,448 #3 electroacupuncture #4 1.832 acupressure OR acupuncture Therapy [mh]) OR acupuncture points [mh]) OR acupuncture, ear [mh]) OR acupuncture [Text Word]) OR acupressure [Text Word]) OR electroacupuncture) OR electro acupuncture) OR electro-acupuncture) OR meridian* [Text Word]) OR needling [Text Word]) OR acu-#5 51,277 point*) OR acu point* [Text Word]) OR acupoint* [Text Word]) OR Acupuncture [mh]) OR electroacupuncture [mh]) OR acupuncture* [Text Word]) OR eletroacupuncture* [Text Word]) OR (acupuncture AND th[sh])) OR acupuncture[tiab]) OR acupuncture[mh]) OR acupuncture/th[mh] #6 #2 or #3 or #4 or #5 54,150 #7 #1 and #6 89 Database: Ovid Medline (ovidsp.ovid.com; 1946-2023) 1 exp Whiplash Injuries/ 3,423 2 3,292 whiplash.tw. 3 75 acute whiplash injury*.tw. 71 4 acute whiplash associated disorder*.tw. 5 acute WAD.tw. 66 6 WAD.tw. 1,038

7	1:11 2:44	201
7	whiplash patient*.tw.	201
8	whiplash syndrome*.tw.	183
9	cervical spine disorder*.tw.	228
10	cervical spine injury*.tw.	1,571
11	exp Accidents, Traffic/	48,509
12	exp Motor Vehicles/	24,289
13	exp Automobiles/	7,798
14	exp Motorcycles/	2,900
15	traffic.tw.	58,851
16	vehicle.tw.	134,582
17	vehicular.tw.	4,046
18	car.tw.	36,938
19	cars.tw.	9,562
20	automobile.tw.	6,526
21	automobiles.tw.	1,392
22	motorcycle.tw.	3,814
23	motorcycles.tw.	931
24	taxi.tw.	1,261
25	cab.tw.	3,755
26	road.tw.	48,507
27	pedestrian.tw.	5,278
28	pedestrians.tw.	3,859
29	accident.tw.	53,887
30	accidents.tw.	48,861
31	injury.tw.	801,932
32	injuries.tw.	254,612
33	crash.tw.	11,757
34	crashes.tw.	9,905
35	exp "Wounds and Injuries"/	1,014,422
36	or/29-35	1,675,831
37	or/11-28	298,607
38	or/1-10	6,385

	T	1
39	36 and 37	79,754
40	38 or 39	84,652
41	acupuncture.mp.	34,547
42	electroacupuncture.mp.	7,050
43	acupressure.mp.	1,813
44	meridian.mp.	4,833
45	acupoint.mp.	4,164
46	exp acupuncture/	2,043
47	acupuncture.tw.	27,126
48	acupressure.tw.	1,523
49	electro acupuncture.mp.	951
50	meridian*.tw.	6,456
51	needling.tw.	3,936
52	acu-point*.mp.	33
53	acu point*.tw.	33
54	acupoint*.tw.	7,040
55	elctroacupuncture*.tw.	1
56	(acupuncture and th).mp.	79
57	or/41-56	44,775
58	40 and 57	120
Data	abase: Embase (embase.com; 1947-2023)	
1	'automobiles'/exp	11,661
2	'motor vehicle'/exp	28,069
3	'accident, traffic'/exp	75,665
4	'motorcycle'/exp	3,664
5	vehicle:ta,ab,de	203,388
6	traffic:ta,ab,de	153,433
7	vehicular:ta,ab,de	4,909
8	car:ta,ab,de	77,435
9	cars:ta,ab,de	12,857
		1
10	automobile:ta,ab,de	7,368

12	motorcycle:ta,ab,de	5,934
13	motorcycles:ta,ab,de	1,104
14	taxi:ta,ab,de	1,535
15	cab:ta,ab,de	5,070
16	road:ta,ab,de	48,308
17	pedestrian:ta,ab,de	7,726
18	pedestrians:ta,ab,de	4,183
19	accident:ta,ab,de	593,740
20	accidents:ta,ab,de	56,438
21	injury:ta,ab,de	1,928,938
22	injuries:ta,ab,de	280,812
23	crash:ta,ab,de	12,698
24	crashes:ta,ab,de	10,253
25	'wounds and injuries'/exp	2,824,750
26	#19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25	3,658,250
27	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18	427,543
28	#26 AND #27	136,545
29	acupuncture	65,725
30	electroacupuncture	10,710
31	acupressure	3,180
32	acupoint	6,816
33	acupoint:ta,ab,de	6,154
34	'acupuncture analgesia'	2,374
35	'acupuncture therapy'	2,500
36	'acupuncture points'	2,351
37	'acupuncture, ear'	42
38	acupuncture:ta,ab,de	56,629
39	acupressure:ta,ab,de	3,077
40	electroacupuncture	10,710
41	'electro acupuncture'	1,442
	1	

4

5

6

7 8

9 10

11 12

13

14

15

16 17

18 19

20

21 22

23 24

25 26

27 28

29

30 31

32 33

34 35

36

37

38

39 40

41 42

43

44 45

46 47

48 49

50 51

52

53 54

55 56

57 58

		I
#20	vehicle:ti,ab,kw	8,257
#21	vehicular:ti,ab,kw	56
#22	car:ti,ab,kw	4,202
#23	cars:ti,ab,kw	463
#24	automobile:ti,ab,kw	1,157
#25	automobiles:ti,ab,kw	95
#26	motor cycle*:ti,ab,kw	1,169
#27	taxi*:ti,ab,kw	260
#28	cab*:ti,ab,kw	11,113
#29	road*:ti,ab,kw	2,087
#30	pedestrian*:ti,ab,kw	231
#31	accident*:ti,ab,kw	25,630
#32	injur*:ti,ab,kw	76,691
#33	crash*:ti,ab,kw	773
#34	MeSH descriptor: [Wounds and Injuries] explode all trees	35,004
#35	Any MeSH descriptor in all MeSH products and with qualifier(s): [injuries - IN]	3,961
#36	cervie\$ or thoracie\$ or lumba\$	33,603
#37	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14	1,770
	#15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29	
#38		28,521
#38	or #30	28,521
#38		28,521 112,456
	or #30	
#39	or #30 #31 or #32 or #33 or #34 or #35	112,456
#39	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39	112,456 4,739
#39 #40 #41	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40	112,456 4,739 6,352
#39 #40 #41 #42	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36	112,456 4,739 6,352 429
#39 #40 #41 #42 #43	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture	112,456 4,739 6,352 429 21,079
#39 #40 #41 #42 #43	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture electroacupuncture	112,456 4,739 6,352 429 21,079 3,539
#39 #40 #41 #42 #43 #44 #45	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture electroacupuncture acupressure	112,456 4,739 6,352 429 21,079 3,539 2,174
#39 #40 #41 #42 #43 #44 #45	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture electroacupuncture acupressure meridian	112,456 4,739 6,352 429 21,079 3,539 2,174 1,465
#39 #40 #41 #42 #43 #44 #45 #46	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture electroacupuncture acupressure meridian acupoint	112,456 4,739 6,352 429 21,079 3,539 2,174 1,465 3,749

#51	MeSH descriptor: [acupuncture points] explode all trees	2,520
#52	MeSH descriptor: [acupuncture, ear] explode all trees	244
#53	acupuncture:ti,ab,kw	19,015
#54	acupressure:ti,ab,kw	2,062
#55	electro acupuncture	1,023
#56	electro-acupuncture	783
#57	meridian*:ti,ab,kw	1,399
#58	needling:ti,ab,kw	3,062
#59	acu-point*	43
#60	acu point*:ti,ab,kw	257
#61	acupoint*:ti,ab,kw	5,508
#62	MeSH descriptor: [electroacupuncture] explode all trees	1,161
#63	elctroacupuncture*:ti,ab,kw	4
#64	acupuncture AND th	1,248
#65	#43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64	26,713
#66	#42 and #65	40
Data	base: China National Knowledge Infrastructure (CNKI) (cnki.net; 1993-2023)	
	(SU='traffic accident' OR SU='交通事故' OR SU='whiplash injury' OR SU='颈椎屈伸损伤' OR SU='whiplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR	
1	SU='颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR	54
	SU='針' or SU='electro acupuncture' OR SU='电針' OR SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针')	
	or so-acupuncture-car OK so-477)	
Data	base: ScienceOn (scienceon.kisti.re.kr; 2001-2023)	
1	전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈	61
	이침)	
Data	base: KMBASE (kmbase.medric.or.kr; 1985-2023)	
Data 1	base: KMBASE (kmbase.medric.or.kr; 1985-2023) [ALL=교통사고]	864

2	[ALL=편타성 손상]	25
3	[ALL=채찍질 손상]	0
4	[ALL=경항통]	89
5	[ALL=경추부 염좌]	4
6	[ALL=침]	14,195
7	[ALL=전침]	377
8	[ALL=이침]	80
9	[ALL=경혈]	326
10	(((([ALL=교통사고] OR [ALL=편타성 손상]) OR [ALL=채찍질 손상]) OR [ALL=경항통]) OR [ALL=경추부 염좌])	946
11	((([ALL=침] OR [ALL=전침]) OR [ALL=이침]) OR [ALL=경혈])	14,801
12	((((([ALL=교통사고] OR [ALL=편타성 손상]) OR [ALL=채찍질 손상]) OR [ALL=경항통]) OR [ALL=경항통]) AND ((([ALL=침] OR [ALL=전침]) OR [ALL=이침]) OR [ALL=경혈]))	48
Data	base: Korean Studies Information Service System (KISS) (kiss.kstudy.com; 1993-2023)	
1	교통사고 and 침	126
2	교통사고 and 전침	4
3	교통사고 and 이침	0
4	교통사고 and 경혈	0
Data	base: Korea Med (koreamed.org; 1992-2023)	
1	(((((("traffic"[ALL])) OR ("automobile"[ALL])) OR ("whiplash injury"[ALL])) OR ("whiplash associated disorder"[ALL])) OR ("cervical spine disorder"[ALL])) OR ("cervical spine injury"[ALL])	1,706
2	(((("acupuncture"[ALL])) OR ("electroacupuncture"[ALL])) OR ("meridian"[ALL])) OR ("acupoint"[ALL])	553
3	#1 AND #2	22

First author	TD		Depth of	Stimulation	023 ⁻¹ ight	Total sessions	Frequency and
(year)	Type of acupuncture	Acupoints	needling	response	023 ⁻ 077700 right, includ	otal sessions	Retention
Sterling et al		Posterior muscles of the					Frequency: 2
(2015)	General acupuncture	cervical spine and upper	NR	Pecking, Twirling	Janu En		times/week X 3 weeks
` '		thoracic spine			ary 2 seign s rela		Retention: 30 minute
		Choose from GV14,			024. I emei ted t		
		C1-C7, GB20, SI11,			Down nt Su o text		
		GB21, TE15, SI14,			lloade peried and		Б
Tobbackx et al		BL17, SP10, SI3,		Deqi sensation	ed fro ur (At data		Frequency: 1
(2012)	General acupuncture	BL64, TE5, GB41,	NR		minin		time/week X 1 week
		Shiqizhuixia, Ear Zero			on 17 January 2024. Downloaded from http://bmjopen.bmj.c Enseignement Superieur (ABES) . Ing for uses related to text and data mining, AI training, and ing, Twirling sensation		Retention: 20 minute
		point, Ear Jerome point,			jope rainir		
		Ear C0.			n.bmj.o ng, anc		
		SI2, SI3, SI5, SI7, SI14,			sim/		Emaguamayu 2
Kwak et al		SI15, LI11, BL10,		Deqi sensation,	on Ju		Frequency: 3
(2012)	General acupuncture	BL12, BL13, BL14,	1.0-2.0 cm	Rotating	une 8	•	times/week X 2 weeks
		BL60, BL62, BL66,			om/ on June 8, 2025 a similar technologies		Retention: 15 minute
					at Agence		
					(D		
					bliogr		
					Bibliographique de I		
		eer review only - http://bmjoper			ank		

Supplemental table S2. Appraisal of acupuncture procedure based on the revised SRICTA criteria (2000)

Page 45 of 56

		GB20, GB21, GB40, GB41, TE5, TE15		.t, including fo	
Tough et al		Myofascial trigger		Janu Er r use	Frequency: 1
	General acupuncture	points in muscles in and	NR	Pecking (6-7 times 2-6	time/week X 2-6 times
(2010)		around the neck		Pecking (6-7 times related to text and date of the second	Retention: NR
Aigner et al	General acupuncture	TB5, SI6 bilaterally	NR	text :	NR
(1998)	General acupuncture	1135, Sio bilaterally	TVIC	and di	
Han et al		ST25, GB20, GB21,		at (ABB	Frequency: 2
	Electroacupuncture	SI11, SI14, SI15, Ashi	1.0-2.0 cm	Electrical frequency, 19	times/week X 4 weeks
(2011)		points		300 HZ , Al tra	Retention: 15 minute
			1/0	Electrical frequence:	Frequency: 2
Cameron et al	Electronomytem	GB39, GB20, LI14, SI6	1.0-1.5 cm	2-5 Hz and 3.12	times/week X 6 weeks
(2011)	Electroacupuncture	bilaterally		Electrical intensity	Retention: 20 – 60
				Electrical frequence in the state of from http://bmjopen.bmj.com/ on June 8, 2025 at NR NR Electrical intensity milar technologies.	minutes
Kim et al		3 points at trapezius		hnolo	Frequency: 2
	MSAT	muscle	0.5-1.0 cm	NR logies.	times/day X 3 days
(2020)		muscie		at Age	Retention: 15 minute

Supplemental table S3. The "leave-one-out" approach for sensitivity analysis of whiplash-associated disorder

Study omitted	Pooled	95% Confidence i	nterval	p-value	$I^{2}(\%)$
Study offitted	estimate	Lower Upper		p-varue	1 (70)
Pain VAS score					
Kwak HY 2012	-0.54	-0.87	-0.21	0.001	59
Tobbackx Y 2012	-0.65	-0.96	-0.35	< 0.0001	44
Tough EA 2010	-0.55	-0.87	-0.22	0.001	59
Cameron ID 2011	-0.65	-1.01	-0.29	0.0005	53
Han SY 2011	-0.47	-0.84	-0.11	0.01	61
Kim DR 2020	-0.45	-0.81	-0.10	0.01	53
ROM – flexion					
Kwak HY 2012	0.33	-0.59	1.26	0.48	89
Sterling M 2015	0.43	-0.37	1.22	0.29	78
Kim DR 2020	-0.10	-0.46	0.26	0.60	0
ROM – extension					
Kwak HY 2012	0.38	-0.19	0.96	0.19	73
Sterling M 2015	0.69	0.34	1.03	< 0.0001	0
Kim DR 2020	0.36	-0.27	0.99	0.26	62
ROM – right rotation	on				
Kwak HY 2012	0.56	-1.16	2.29	0.52	97
Sterling M 2015	0.79	-0.53	2.11	0.24	92
Kim DR 2020	-0.17	-0.56	0.22	0.39	11
ROM – left rotation	1				
Kwak HY 2012	0.85	-0.29	1.98	0.15	92
Sterling M 2015	0.81	-0.42	2.05	0.20	90
Kim DR 2020	0.23	-0.13	0.59	0.21	0
NDI					
Sterling M 2015	-0.19	-0.61	0.23	0.37	75

Tobbackx Y 2012	-0.18	-0.59	0.24	0.40	75
Tough EA 2010	-0.11	-0.46	0.25	0.56	71
Cameron ID 2011	-0.29	-0.51	-0.08	0.007	0
Han SY 2011	-0.09	-0.45	0.26	0.61	68
Kim DR 2020	-0.15	-0.56	0.26	0.48	73

VAS: Visual analog scale; ROM: Range of motion; NDI: Neck disability index



			Certainty	assessment			No. of pat	ients	Deptries 2023	
No. of	Study	Risk of	т .,	т 11 .	т	Other	Б : 41	C . 1	Absolute (95%	Certain
studies	design	bias	Inconsistency	Indirectness	Imprecision	considerations	Experimental	Control	Absolute (95% ncluding	
Pain VAS s	score								7 Jar	
6	RCT	Not	Serious*	Not serious	Not serious	None	217	206	SMAN 0.57 lower relative to 0.28 ded to to text	ФФФ(
		serious							d to te	Modera
ROM-flexi	on			0)	^				loa eri	
3	RCT	Not	Very serious§	Not serious	Very serious [†]	None	108	108	Solution 1.23 higher 1.23 higher 1.25 high	Ф00
		serious							s) the higher)	Very lo
ROM-exter	nsion						· ·		98MD 0.47 higher	
3	RCT	Not	Serious*	Not serious	Serious [‡]	None	108	108	98Mb 0.47 higher and (0.95 higher to similar 1	ФФО
		serious							imilar 0989 higher)	Low
ROM-right	lateral flex	xion							June 8,	
									2025 logie:	
									7-	
									nce B	
									ibliog	
									Agence Bibliographique de l	
				_		,, ,	n/site/about/guic		ue d	

						BMJ Open			njopen-2023 by copyrigl	
2	RCT	Not serious	Very serious [§]	Not serious	Very serious [†]	None	68	69	mjopen-2023-077200 0.58 higher Moopen-2023-077200 opinion opi	⊕○○○
		Serious							T uses	Very low
ROM-left	lateral flexi	ion							ary 20 eigne relat	
2	RCT	Not	Serious*	Not serious	Very serious [†]	None	68	69	6 20 0.61 higher	⊕○○○
		serious			<u> </u>				Auto 1.21 higher)	Very low
ROM-righ	t rotation			4	$\nu_{\rm R}$				d fro ır (At	
3	RCT	Not	Very serious§	Not serious	Very serious [†]	None	108	108	0.41 higher	Ф000
		serious							S).73 lower to 1.55 Al training.	Very low
ROM-left	rotation						01/		n.bmj ng, an	
3	RCT	Not	Very serious§	Not serious	Very serious [†]	None	108	108	8 M 0.63 higher 8 M 0.63 higher 8 0.29 ower to 1.46	⊕○○○
		serious	J		very serious				r technologies	Very low
NDI									, 2025 blogies	
6	RCT	Not	Serious*	Not serious	Serious [¶]	None	237	225	SM 0.17 lower (0.5 blower to 0.17	⊕⊕○○
		serious				-	ö Denigher) E	Low		
									ographique de l	
									ique c	

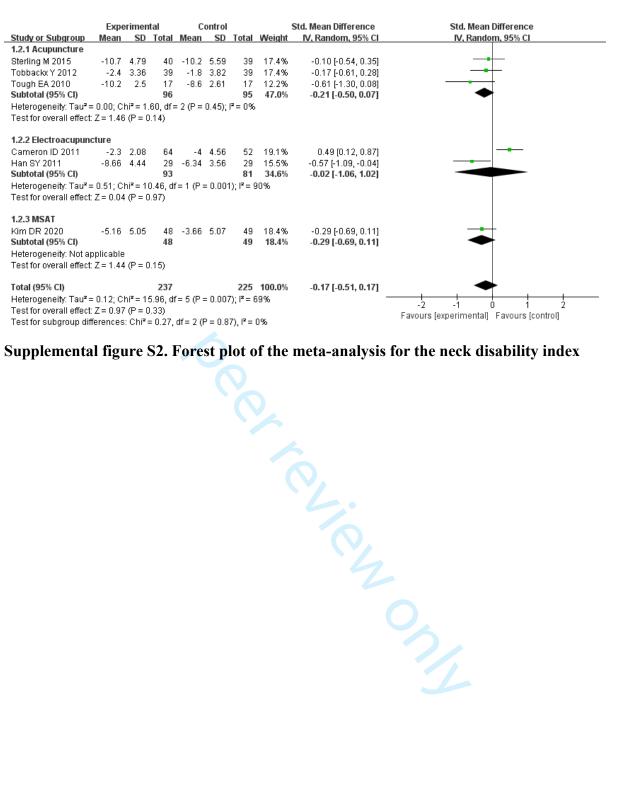
	<u>D1</u>	<u>D2</u>	<u>D3</u>	<u>D4</u>	<u>D5</u>	<u>Overall</u>
Aigner 1998	!				!	-
Cameron 2011	+	+	-	+	!	-
Han 2011	!	!	+	+	!	!
Kim 2020	+	+	+	+	+	+
Kwak 2012	+	+	+	+	+	+
Sterling 2015	+	+	!	+	+	!
Tobbackx 2012	+	!	+	+	+	!
Tough 2010	+	!	!	+	!	!

+	Low risk	
!	Some concerns	
	High risk	

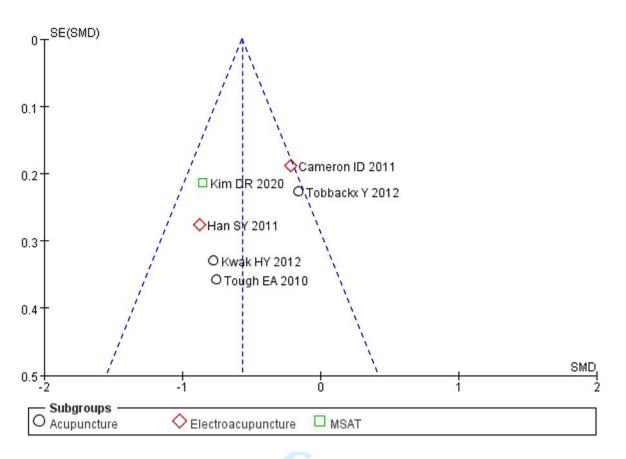
D3

- D1 Randomisation process
- D2 Deviations from the intended interventions
 - Missing outcome data
- D4 Measurement of the outcome
- D5 Selection of the reported result

Supplemental figure S1. Individual data of RoB 2



Supplemental figure S2. Forest plot of the meta-analysis for the neck disability index



Supplemental figure S3. Funnel plot for the pain visual analog scale score



PRISMA 2020 Checklist

age 55 of 56		BMJ Open	
PRIS	MA 2	by copyrigh	
Section and Topic	Item #	Checklist item	Location where item is reported
TITLE	π	ud 00	item is reported
Title	1	Identify the report as a systematic review.	1
ABSTRACT		<u> </u>	
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2-3
INTRODUCTION		8 S S	
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	4
2 Objectives	4	Describe the rationale for the review in the context of existing knowledge. Provide an explicit statement of the objective(s) or question(s) the review addresses.	4-5
METHODS	<u> </u>	5 # D	
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6-7
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted specify studies. Specify the date when each source was last searched or consulted.	6 Supple table 1
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6 Supple table 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each sport, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of actionation tools used in the process.	7-8
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each successful description of the compatible with each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide whether the compatible with each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide whether the compatible with each successful decide whether all results that were compatible with each successful decide whether all results that were compatible with each successful decide whether all results that were compatible with each successful decide whether all results that were compatible with each successful decide whether all results that were compatible with each successful decide whether all results that were compatible with each successful decide whether all results that were compatible with each successful decide whether all results that were compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decide whether all results the compatible with each successful decided whether all results the compatible with each successful decided whether all results the	6-7
} 	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, fundamental sources). Describe any assumptions made about any missing or unclear information.	6-7
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how matey reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or preservation of results.	8
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study ter tention characteristics and comparing against the planned groups for each synthesis (item #5)).	7-8
; ;	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summery statistics, or data conversions.	7-8
,	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7-8
3))	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was per med, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	8-9
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analys, meta-regression).	8-9
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	8-9
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases. For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	8-9



47

PRISMA 2020 Checklist

		vrigh	
Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	8-9
RESULTS		for the second s	
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to said methods included in the review, ideally using a flow diagram.	10 Figure 1.
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	10 Figure 1.
Study characteristics	17	Cite each included study and present its characteristics.	10 Table 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study. and or iou of the property of th	14-15 Figure 2. Supple figure 1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an extension (e.g. confidence/credible interval), ideally using structured tables or plots.	15-16 Figure 3,4. Supple figure 2
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	15-17 Figure 2,3,4. Supple figure 1,2
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary stingate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the discrete of the effect.	15-16 Figure 3,4. Supple figure 2
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	16-17 Supple table 3
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	16-17 Supple table 3
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	19 Supple figure 3
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	17-19 Supple table 4
DISCUSSION		<u>5.</u> 	
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	20-21
	23b	Discuss any limitations of the evidence included in the review.	21-22
	23c	Discuss any limitations of the review processes used.	21-22
ļ		Discuss implications of the resolution of the re	20-22



PRISMA 2020 Checklist

۷.				gh	23.		
4	Section and Topic	Item #	Checklist item	t, incl	0777	Location where item is reported	
5	OTHER INFORMAT	ER INFORMATION E S					
7	Registration and	24a	Provide registration information for the review, including register name and registration number, or state that the	ne∄revi	w was not registered.	3	
r R	protocol	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	for	7 J	3	
9		24c	Describe and explain any amendments to information provided at registration or in the protocol.	En use	anu	23	
10	Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in	theene	view.	22-23	
11 12	Competing interests	26	Declare any competing interests of review authors.	igneme elated	2024.	23	
12 14 15	Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection form included studies; data used for all analyses; analytic code; any other materials used in the review.	भ्रम्हें Super to⊱text ar	extracted from	23	
16 17 18	o 7 <i>From:</i> Page MJ, M 3 10.1136/bmj.n71	cKenzie	included studies; data used for all analyses; analytic code; any other materials used in the review. JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for For more information, visit: http://www.prisma-statement.org/	ieur∄AB nd d⊛ta n	ng systematic reviews. BN	1J 2021;372:n71. doi:	
19 20) 1		For more information, visit: http://www.prisma-statement.org/	nini NES	3		
21	, I			ng,			
22	<u>)</u>			≥			
23	3			trai	<u>o</u>		
24	1 -		For more information, visit: http://www.prisma-statement.org/	Al training, and similar technologies	oen.		
25 26	5			g a	b		
27	7			pu ,	.		
28	3			mi.	Ž		
29	9			ar	9		
30)			tec			
31				Ĭ	∞		
32 33	2) jo	20		
34	,			jies	2025		
35				•	<u>a</u>		
36	5			(Age		
37	7				nce		
38					<u>B.</u>		
39					_		
40				(o G		
41 41				-	iographique		
42 43					io.		
42 44							
45 45			For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml		<u>o.</u> e		
+- 46			, , , , , , , , , , , , , , , , , , , ,		_		
47							
٠,							

cted by copyrig 36/bm jopen-202

BMJ Open

Efficacy of acupuncture for whiplash injury: A systematic review and meta-analysis

Journal:	BMJ Open
Manuscript ID	bmjopen-2023-077700.R3
Article Type:	Original research
Date Submitted by the Author:	18-Dec-2023
Complete List of Authors:	Lee, Sang-Hyun; Pusan National University, Graduate School, Department of Korean Medicine Park, Sun-Young; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine Heo, In; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Hwang, Eui-Hyoung; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation Shin, Byung-Cheul; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Rehabilitation Hwang, Man-Suk; Pusan National University School of Korean Medicine, 3rd Division of Clinical Medicine; Pusan National University Korean Medicine Hospital, Spine and Joint Center, Department of Korean Medicine Rehabilitation
Primary Subject Heading :	Complementary medicine
Secondary Subject Heading:	Complementary medicine
Keywords:	Systematic Review, Randomized Controlled Trial, COMPLEMENTARY MEDICINE, PAIN MANAGEMENT

SCHOLARONE™ Manuscripts

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Sang-Hyun Lee¹, Sun-Young Park², In Heo^{2,3}, Eui-Hyoung Hwang^{2,3}, Byung-Cheul Shin^{2,3}, Man-Suk Hwang^{2,3,*}

¹ Department of Korean Medicine, Graduate School, Pusan National University, Yangsan,

Gyeongnam, Republic of Korea

² 3rd Division of Clinical Medicine, School of Korean Medicine, Pusan National University,

Yangsan, Gyeongnam, Republic of Korea

³ Department of Korean Medicine Rehabilitation, Spine and Joint Center, Pusan National

University Korean Medicine Hospital, Yangsan, Gyeongnam, Republic of Korea

* Corresponding author:

Man-Suk Hwang

Department of Korean Medicine Rehabilitation, Spine and Joint Center, Pusan National

University Korean Medicine Hospital, Yangsan, Gyeongnam, Republic of Korea

Tel: +82-55-360-5970

Fax: +82-51-510-8437

Email: hwangmansuk@pusan.ac.kr

ABSTRACT

Objectives: This study aimed to establish clinical evidence for acupuncture by analyzing 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 to 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 October 1, 2023. Eligibility criteria: We included randomized controlled trials (RCTs) using acupuncture on patients with WAD. The outcomes were the pain visual analog 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 analyzed 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.

Keywords: Acupuncture; Whiplash injuries; Whiplash-associated disorder; Systematic review; Meta-analysis; Randomized controlled trial

Word Count: 3836

Article Summary

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.

INTRODUCTION

Whiplash injury or whiplash-associated disorder (WAD) is caused by rapid 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 recognized despite its usefulness in clinical practice [13]. The Canadian and Australian WAD clinical practice guidelines (CPGs) do not recommend acupuncture for treating WAD [14]; 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 analyzing 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 to 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

SR [16] 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 July 18, 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 October 1, 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 S1). 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 as reported as 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. Randomized 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 pre- and post-clinical 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 analog 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 (SHL and MSH) 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 (SHL and MSH) analyzed 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 summarized 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 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 (SHL and MSH) 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,

Statistical analysis

The meta-analysis was performed using the Review Manager version 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% confidence interval (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 intervention, 6 articles without full text, 3 articles without a valid control group, and 2 articles for other reasons. In addition, we included 1 study through reference tracking [16]. Thus, 8 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 study [36] 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], UK [33], and Austria [16]. The recruitment period was less than one year in five studies [31-34, 36], more than four years in two studies [30, 35], and not reported in one study [16]. Among the eight studies, one [31] 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. was described based on its reference in the SR by Moon et al. [16], as the original text could not be accessed (Table 1).

alia – RCT	Total: 80 Exp.: 40 Con.: 40	WAD II	Atx. + exercise	Sham atx. +	en-2023-677700 on 17 January 2024. Downsbaded from Enseignement Superieur (1) Out R R Hed to text and data Out C R R R R R R R R R R R R R R R R R R	(Effect size, P-value) 1) 0.10, P=0.67 2) (1) -0.14, P=0.54
– RCT	Exp.: 40	WAD II	Atx. + exercise	Sham atx. +	1) Norus 20 Res relation (1) F	2)
– RCT	Exp.: 40	WAD II	Atx. + exercise	Sham atx. +	2) Ros in lary 20 (1) Face 22 (2)	
		WAD II	Atx. + exercise	Sham atx. +	(1) F整定 2	(1) -0.14 P=0.54
)24 led	(1) -0.14, 1 -0.34
	Committee			exercise		(2) 0.08, P=0.71
					(3) Ration.	(3) -0.32, P=0.16
					de en	(4) 0.26, P=0.24
		WAD I or II or			om http: \BES) . mining,	
um Crossover		ш			ng, Atl 1) NATI	1) 0.17, P=0.47
011 – RCT	Total: 39	(chronic WAD	Atx.	Relaxation	2) pa li n V A S	2) 0.16, P=0.47
11)		persisting more			n.bmj າg, ar	, ,
		than 3 months)			.com/ nd sim	
n RCT	Total: 40	WAD	Atx. + UC	UC	1) pa VAS	1) 0.78, P=0.02
009 –	Exp.: 20	(persisting more		(PTx. +		2)
10)	Con.: 20	than 3 months)		exercise)	(1) Fuex. 22	(1) -0.01, P=0.97
	Crossover 011 – RCT 111) RCT 009 –	Crossover 011 – Total: 39 RCT 111) RCT Total: 40 009 – Exp.: 20	Crossover RCT Total: 39 (chronic WAD persisting more than 3 months) RCT Total: 40 WAD Exp.: 20 (persisting more	Crossover RCT Total: 39 (chronic WAD persisting more than 3 months) RCT RCT Total: 40 WAD Atx. + UC Exp.: 20 (persisting more	Crossover RCT Total: 39 (chronic WAD Atx. Relaxation persisting more than 3 months) RCT Total: 40 WAD Atx. + UC UC	Crossover O11 - RCT Total: 39 (chronic WAD Atx. Relaxation Total: 39 (persisting more than 3 months) RCT RCT RCT RCT Total: 40 WAD Atx. + UC UC Total: 40 WAD Atx. + UC Exp.: 20 (persisting more (PTx. + 2) Rem exp. 20) RCT Total: 40 WAD Atx. + UC Relaxation O09 - Exp.: 20 (persisting more (PTx. + 2) Rem exp. 20)

Table 1. Data of clinical studies on acupuncture for whiplash-associated disorder BMJ Open

mjopen-2023-(

	Korea		Total: 97			IKM	1) padding for gases as (1) Fig. (2) No. (2) No. (3) Roses as (1) Fig. (3) Roses as (1) Fig. (3) Roses as (2) Fig. (3) Roses as (3) Fig. (4) Fig. (4) Fig. (5) Fig. (6) Fig. (1) 0.85, P<0.0001 2) 0.29, P=0.15 3) (1) 0.80, P=0.0001
Kim et al (2020) [36]	(07/2019 – 09/2019)	RCT	Exp.: 48 Con.: 49	WAD (within 7 days)	MSAT + IKM	(Atx. + pharm. +	7 January 2024. Downloaded from Ses Pelated to text and date (1) Responding to text and date (2) B (3) Ret and date (4) Le (5) Responding to text and date (5) Responding to text and date	(2) 0.67, P=0.001 (3) 1.01, P<0.001
	,					CMT + HM)	nloader (4) Leaded Flex (4) Leaded fg. (5) Ref. (5) Ref.	(4) 0.88, P<0.001 (5) 1.44, P<0.001
treatment; IKM NDI: Neck disa	1: Integrative Koability index; Ro	orean med OM: Rang	icine treatment; Plee of motion; Flex.	narm.: Pharmacopund	cture; CMT: Chuna	manual therapy; I	HM: Herral and medicine of the control of the contr	e; VAS: Visual analog s
treatment; IKM NDI: Neck disa	1: Integrative Koability index; Ro	orean med OM: Rang	icine treatment; Plee of motion; Flex.	narm.: Pharmacopund	cture; CMT: Chuna	manual therapy; I	g, Attraining, and similar technologies.	(6) 1.43, P<0.001 SAT: Motion-style acup e; VAS: Visual analog s tx.: Acupuncture therap
treatment; IKM NDI: Neck disa	1: Integrative Koability index; Ro	orean med OM: Rang	icine treatment; Plee of motion; Flex.	narm.: Pharmacopund	cture; CMT: Chuna	manual therapy; I	g, Attraining, and similar technologie:	SAT: Motion-style acupe; VAS: Visual analog s

Standard for reporting acupuncture according to STRICTA

The eight studies were analyzed using STRICTA (online supplemental table S2). 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 one to six weeks, and the retention time varied from 15 to 60 min.

Risk of bias assessment

The eight selected studies were analyzed 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 were identified as having low risk of bias. In terms of the selection of the reported result, studies that reported a pre-specified 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 S1).

Meta-analysis

 A meta-analysis was performed with seven studies [30-36] according to the outcomes, after excluding one study [16] 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).

ROM

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).

NDI

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 S2).

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 diarrhea, 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 S3).

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%).

ROM

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.

NDI

The result of the meta-analysis of NDI changed to the 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 S4).

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 (l^2) was 51%. Thus, the quality of evidence on the pain VAS score was graded as "moderate."

ROM

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."

NDI

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

Publication bias

Publication bias was evaluated using the funnel plot for the pain VAS score (online supplemental figure S3). 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 minimize this effect by utilizing 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 h, 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 favored the control group since it was > 0, affecting the overall effect size and heterogeneity.

A previous study [16] that analyzed 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 analyzed a total of eight RCTs. Accordingly, this study provided more objective and quantitative evidence by synthesizing 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 analyzed using the leave-one-out approach method. 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 minimize 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.

AUTHOR CONTRIBUTIONS

Conceptualization: Sang-Hyun Lee

Formal analysis: Sun-Young Park and In Heo

Funding acquisition: Sun-Young Park and Eui-Hyuoung Hwang

Investigation: Sang-Hyun Lee, In Heo, Byung-Cheul Shin, and Man-Suk Hwang

Methodology: Sun-Young Park, In Heo, Eui-Hyuoung Hwang, and Byung-Cheul Shin

Project administration: Sun-Young Park, In Heo, Eui-Hyuoung Hwang and Man-Suk Hwang

Supervision: Byung-Cheul Shin and Man-Suk Hwang

Writing – original draft: Sang-Hyun Lee

Writing – review & editing: Sang-Hyun Lee, Eui-Hyuoung Hwang, Byung-Cheul Shin and

Man-Suk Hwang

FUNDING

This work was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea [grant number: HF21C0162].

DISCLAIMER

The funding source had no role in the design of the protocol, study search and selection, data extraction and management, data interpretation, report writing, or the decision to submit the report for publication.

COMPETING INTERESTS

None.

PATIENT CONSENT FOR PUBLICATION

Not required.

PROVENANCE AND PEER REVIEW

Not commissioned; extremally peer reviewed.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

AMENDMENT

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.

REFERENCES

- 1. Spitzer WO, Skovron ML, Salmi LR, et al. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. *Spine (Phila Pa 1976)*. 1995;20:1s-73s.
- 2. Eck JC, Hodges SD, Humphreys SC. Whiplash: a review of a commonly misunderstood injury. *Am J Med*. 2001;110:651-6. doi: 10.1016/s0002-9343(01)00680-5.
- 3. Côté P, Hogg-Johnson S, Cassidy JD, et al. Initial patterns of clinical care and recovery from whiplash injuries: a population-based cohort study. *Arch Intern Med.* 2005;165:2257-63. doi: 10.1001/archinte.165.19.2257.
- 4. Kim N, Shin BC, Shin JS, et al. Characteristics and status of Korean medicine use in whiplash-associated disorder patients. *BMC Complement Altern Med.* 2018;18:124. doi: 10.1186/s12906-018-2188-7.
- 5. Curatolo M. Pharmacological and Interventional Management of Pain After Whiplash Injury. *J Orthop Sports Phys Ther*. 2016;46:845-50. doi: 10.2519/jospt.2016.6906.
- 6. Shaked G, Shaked D, Sebbag G, et al. The effect of steroid treatment on whiplash associated syndrome: a controlled randomized prospective trial. *Eur J Trauma Emerg Surg*. 2021;47:1115-22. doi: 10.1007/s00068-019-01282-3.
- 7. Suissa S, Harder S, Veilleux M. The relation between initial symptoms and signs and the prognosis of whiplash. *Eur Spine J.* 2001;10:44-9. doi: 10.1007/s005860000220.
- 8. Côté P, Cassidy JD, Carroll L, et al. A systematic review of the prognosis of acute whiplash and a new conceptual framework to synthesize the literature. *Spine (Phila Pa 1976)*. 2001;26:E445-58. doi: 10.1097/00007632-200110010-00020.
- 9. Hershman DL, Unger JM, Greenlee H, et al. Comparison of Acupuncture vs Sham Acupuncture or Waiting List Control in the Treatment of Aromatase Inhibitor-Related Joint Pain: A Randomized Clinical Trial. *JAMA Netw Open.* 2022;5:e2241720. doi:

- 10.1001/jamanetworkopen.2022.41720.
- 10. Büyükşireci DE, Demirsoy N, Mit S, et al. Comparison of the Effects of Myofascial Meridian Stretching Exercises and Acupuncture in Patients with Low Back Pain. *J Acupunct Meridian Stud.* 2022;15:347-55. doi: 10.51507/j.jams.2022.15.6.347.
- 11. Woo SH, Lee HJ, Park YK, et al. Efficacy and safety of thread embedding acupuncture for knee osteoarthritis: A randomized controlled pilot trial. *Medicine (Baltimore)*. 2022;101:e29306. doi: 10.1097/MD.0000000000029306.
- 12. Pan S, Wang S, Xue X, et al. Multidimensional Pain Modulation by Acupuncture Analgesia: The Reward Effect of Acupuncture on Pain Relief. *Evid Based Complement Alternat Med*. 2022;2022:3759181. doi: 10.1155/2022/3759181.
- 13. Chon TY, Lee MC. Acupuncture. *Mayo Clin Proc.* 2013;88:1141-6. doi: https://doi.org/10.1016/j.mayocp.2013.06.009.
- 14. Bussières AE, Stewart G, Al-Zoubi F, et al. The Treatment of Neck Pain-Associated Disorders and Whiplash-Associated Disorders: A Clinical Practice Guideline. *J Manipulative Physiol Ther*. 2016;39:523-64.e27. doi: 10.1016/j.jmpt.2016.08.007.
- 15. State Insurance Regulatory Authority. Guidelines for the management of acute whiplash associated disorders for health professionals. Syndney: third edition. 2014.
- 16. Moon TW, Posadzki P, Choi TY, et al. Acupuncture for treating whiplash associated disorder: a systematic review of randomised clinical trials. *Evid Based Complement Alternat Med.* 2014;2014:870271. doi: 10.1155/2014/870271.
- 17. Lee S, Jo DH, Kim KH. Acupuncture for treating whiplash-associated disorder: A systematic review and meta-analysis protocol. *Medicine (Baltimore)*. 2018;97:e12654. doi: 10.1097/MD.0000000000012654.
- 18. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLoS Med.* 2021;18:e1003583. doi:

10.1371/journal.pmed.1003583.

- 19. Cumpston M, Li T, Page MJ, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev.* 2019;10:Ed000142. doi: 10.1002/14651858.ED000142.
- 20. Lee SH, Park HJ, Kim HT, et al. Efficacy of acupuncture for whiplash injury: A protocol for systematic review and meta-analysis. *Medicine (Baltimore)*. 2021;100:e27767. doi: 10.1097/MD.0000000000027767.
- 21. Saric L, Vucic K, Dragicevic K, et al. Comparison of conference abstracts and full-text publications of randomized controlled trials presented at four consecutive World Congresses of Pain: Reporting quality and agreement of results. *Eur J Pain*. 2019;23:107-16. doi: 10.1002/ejp.1289.
- 22. TRACsa: Trauma and Injury Recovery. Clinical guidelines for best practice management of acute and chronic whiplash-associated disorders. Adelaide, Australia: South Australian Centre for Trauma and Injury Recovery (TRACsa); 2008.
- 23. Shrestha D, Shrestha R, Grotle M, et al. Validation of the Nepali versions of the Neck Disability Index and the Numerical Rating Scale for Neck Pain. *Spine (Phila Pa 1976)*. 2021;46:E325-e32. doi: 10.1097/BRS.0000000000003810.
- 24. MacPherson H, Altman DG, Hammerschlag R, et al. Revised STandards for Reporting Interventions in Clinical Trials of Acupuncture (STRICTA): Extending the CONSORT statement. *J Evid Based Med*. 2010;3:140-55. doi: 10.1111/j.1756-5391.2010.01086.x.
- 25. Hammerschlag R, Milley R, Colbert A, et al. Randomized Controlled Trials of Acupuncture (1997-2007): An Assessment of Reporting Quality with a CONSORT- and STRICTA-Based Instrument. *Evid Based Complement Alternat Med.* 2011;2011. doi: 10.1155/2011/183910.
- 26. Abrams KR, Gillies CL, Lambert PC. Meta-analysis of heterogeneously reported trials assessing change from baseline. *Stat Med.* 2005; 24: 3823–44. doi:

https://doi.org/10.1002/sim.2423.

- 27. Follmann D, Elliott P, Suh I, et al. Variance imputation for overviews of clinical trials with continuous response. *J Clin Epidemiol*. 1992; 45: 769–73. doi: https://doi.org/10.1016/0895-4356(92)90054-q.
- 28. Caplan AM, Caplan L. The GRADE Method. *Rheum Dis Clin North Am*. 2022;48:589-99. doi: https://doi.org/10.1016/j.rdc.2022.04.002.
- 29. Patsopoulos NA, Evangelou E, Ioannidis JP. Sensitivity of between-study heterogeneity in meta-analysis: proposed metrics and empirical evaluation. *Int J Epidemiol*. 2008;37:1148-57. doi: 10.1093/ije/dyn065.
- 30. Sterling M, Vicenzino B, Souvlis T, et al. Dry-needling and exercise for chronic whiplash-associated disorders: a randomized single-blind placebo-controlled trial. *Pain*. 2015;156:635-43. doi: 10.1097/01.j.pain.0000460359.40116.c1.
- 31. Tobbackx Y, Meeus M, Wauters L, et al. Does acupuncture activate endogenous analgesia in chronic whiplash-associated disorders? A randomized crossover trial. *Eur J Pain*. 2013;17:279-89. doi: 10.1002/j.1532-2149.2012.00215.x.
- 32. Kwak H-Y, Kim J-I, Park J-M, et al. Acupuncture for Whiplash-associated disorder: A randomized, waiting-list controlled, pilot trial. *European Journal of Integrative Medicine*. 2012;4:e151-e8. doi: 10.1016/j.eujim.2011.12.008.
- 33. Tough EA, White AR, Richards SH, et al. Myofascial trigger point needling for whiplash associated pain--a feasibility study. *Man Ther*. 2010;15:529-35. doi: 10.1016/j.math.2010.05.010.
- 34. Han S-Y, Lee J-Y, Park S-H, et al. A Clinical Study on Effect of Electro-acupuncture Treatment for Whiplash Injury Patients Caused by Traffic Accident. *J Kor Acup Mox Soc.* 2011;28:107-15.
- 35. Cameron ID, Wang E, Sindhusake D. A randomized trial comparing acupuncture and

simulated acupuncture for subacute and chronic whiplash. *Spine (Phila Pa 1976)*. 2011;36:E1659-65. doi: 10.1097/BRS.0b013e31821bf674.

- 36. Kim D, Park KS, Lee JH, et al. Intensive Motion Style Acupuncture Treatment (MSAT) Is Effective for Patients with Acute Whiplash Injury: A Randomized Controlled Trial. *J Clin Med*. 2020;9. doi: 10.3390/jcm9072079.
- 37. Kim TH, Lee MS, Birch S, et al. Plausible Mechanism of Sham Acupuncture Based on Biomarkers: A Systematic Review of Randomized Controlled Trials. *Front Neurosci*. 2022;16:834112. doi: 10.3389/fnins.2022.834112.

FIGURE LEGENDS

Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses

flowchart of the included studies

Figure 2. Summary in risk of bias 2

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

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

BMJ Open

2

3

5

6

8

10

11

12

13

14

19

24

25 26

27 28

29

30

31

32

33

34 35 36

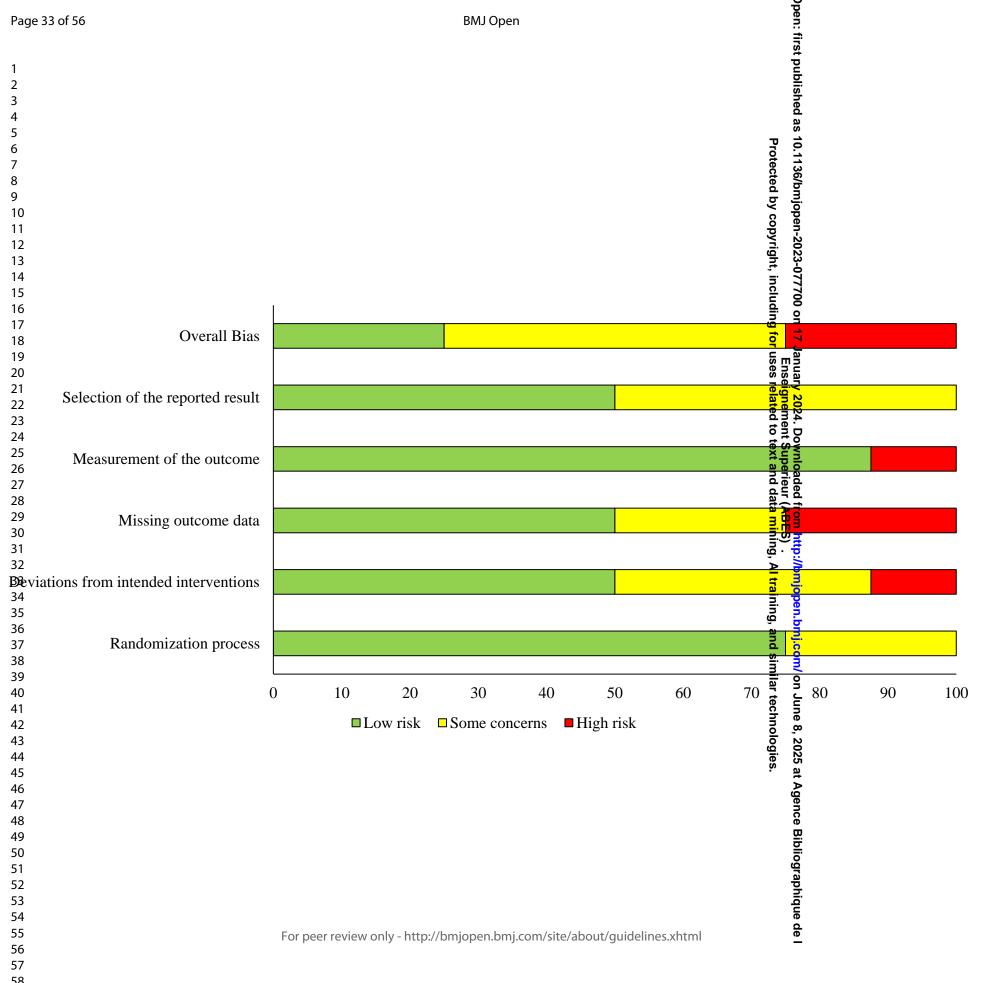
37

38

39 40

42 43

44 45 Page 32 of 56



Page 34 of 56

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

14

15

16

17

18

19

20

21

22

23

24

25

26

27

28

29

30 31

32

33

34

35

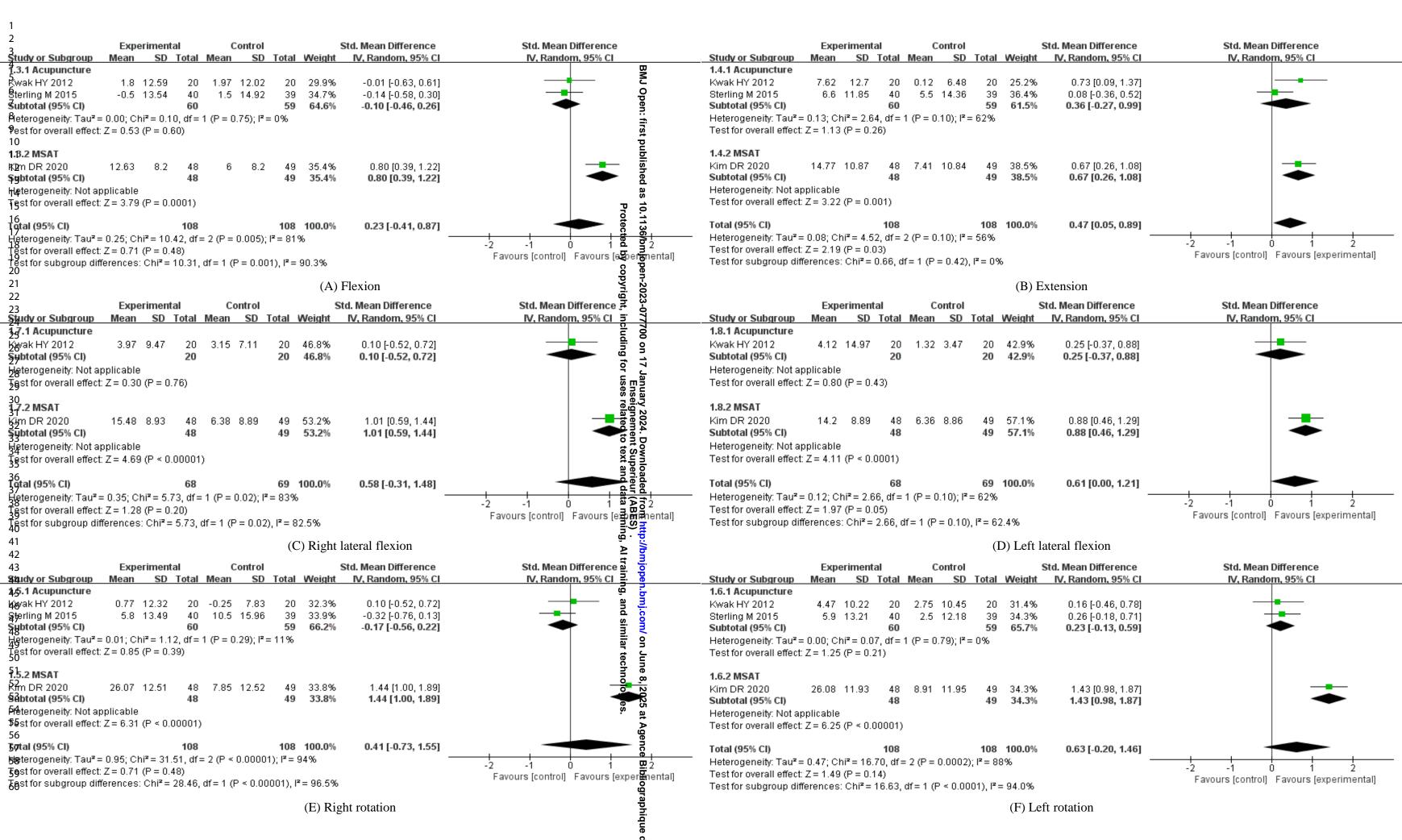
36 37

38

39

40

41 42 43



BMJ Open

For peer review only - hten in the period of the peer review only - hten in the peer review on the peer review of the peer review of the peer review on the peer review of the peer r

4 5

6 7

8 9

10 11

12

13 14

15 16

17

18

19

20 21

22 23

24

25 26

27 28

29 30

31 32

33

34 35

36 37

38

39 40

41 42

43 44

45

46 47

48 49

50 51

52 53

54

55 56

57 58

59 60

Database: PubMed (pubmed.ncbi.nlm.nih.gov; 1946-2023) No. Results Search strategy whiplash OR acute whiplash injury* OR acute whiplash associated disorder* OR acute WAD OR acute whiplash associated disorder* II OR acute WAD II OR whiplash associated disorder* OR WAD OR whiplash associated disorder* II OR WAD II, OR whiplash OR whiplash injury* OR whiplash patient* OR whiplash syndrome* OR cervical spine disorder* OR cervical spine injury* OR "Accidents, Traffic" [Mesh] OR (("Motor Vehicles"[Mesh:NoExp] OR "Automobiles"[Mesh] OR #1 24,250 "Motorcycles" [Mesh] OR traffic[tiab] OR vehicle[tiab] OR vehicular[tiab] OR car[tiab] OR cars[tiab] OR automobile[tiab] OR automobiles[tiab] OR motorcycle[tiab] OR motorcycles[tiab] OR taxi[tiab] OR cab[tiab] OR road[tiab] OR pedestrian[tiab] OR pedestrians[tiab]) AND (accident[tiab] OR accidents[tiab] OR injury[tiab] OR injuries[tiab] OR crash[tiab] OR crashes[tiab] OR "Wounds and Injuries"[Mesh] OR "injuries"[Subheading])) AND (cervic* OR thoracic* OR lumba*) #2 42,653 acupuncture 7,448 #3 electroacupuncture #4 1.832 acupressure OR acupuncture Therapy [mh]) OR acupuncture points [mh]) OR acupuncture, ear [mh]) OR acupuncture [Text Word]) OR acupressure [Text Word]) OR electroacupuncture) OR electro acupuncture) OR electro-acupuncture) OR meridian* [Text Word]) OR needling [Text Word]) OR acu-#5 51,277 point*) OR acu point* [Text Word]) OR acupoint* [Text Word]) OR Acupuncture [mh]) OR electroacupuncture [mh]) OR acupuncture* [Text Word]) OR eletroacupuncture* [Text Word]) OR (acupuncture AND th[sh])) OR acupuncture[tiab]) OR acupuncture[mh]) OR acupuncture/th[mh] #6 #2 or #3 or #4 or #5 54,150 #7 #1 and #6 89 Database: Ovid Medline (ovidsp.ovid.com; 1946-2023) 1 exp Whiplash Injuries/ 3,423 2 3,292 whiplash.tw. 3 75 acute whiplash injury*.tw. 71 4 acute whiplash associated disorder*.tw. 5 acute WAD.tw. 66 6 WAD.tw. 1,038

7	T 1: 1 1 2: 2*2	201
7	whiplash patient*.tw.	201
8	whiplash syndrome*.tw.	183
9	cervical spine disorder*.tw.	228
10	cervical spine injury*.tw.	1,571
11	exp Accidents, Traffic/	48,509
12	exp Motor Vehicles/	24,289
13	exp Automobiles/	7,798
14	exp Motorcycles/	2,900
15	traffic.tw.	58,851
16	vehicle.tw.	134,582
17	vehicular.tw.	4,046
18	car.tw.	36,938
19	cars.tw.	9,562
20	automobile.tw.	6,526
21	automobiles.tw.	1,392
22	motorcycle.tw.	3,814
23	motorcycles.tw.	931
24	taxi.tw.	1,261
25	cab.tw.	3,755
26	road.tw.	48,507
27	pedestrian.tw.	5,278
28	pedestrians.tw.	3,859
29	accident.tw.	53,887
30	accidents.tw.	48,861
31	injury.tw.	801,932
32	injuries.tw.	254,612
33	crash.tw.	11,757
34	crashes.tw.	9,905
35	exp "Wounds and Injuries"/	1,014,422
36	or/29-35	1,675,831
37	or/11-28	298,607
38	or/1-10	6,385

39	36 and 37	79,754
40	38 or 39	84,652
41	acupuncture.mp.	34,547
42	electroacupuncture.mp.	7,050
43	acupressure.mp.	1,813
44	meridian.mp.	4,833
45	acupoint.mp.	4,164
46	exp acupuncture/	2,043
47	acupuncture.tw.	27,126
48	acupressure.tw.	1,523
49	electro acupuncture.mp.	951
50	meridian*.tw.	6,456
51	needling.tw.	3,936
52	acu-point*.mp.	33
53	acu point*.tw.	33
54	acupoint*.tw.	7,040
		·
55	elctroacupuncture*.tw.	1
56	(acupuncture and th).mp.	79
57	or/41-56	44,775
58	40 and 57	120
Data	abase: Embase (embase.com; 1947-2023)	
1	'automobiles'/exp	11,661
2	'motor vehicle'/exp	28,069
3	'accident, traffic'/exp	75,665
	'accident, traffic'/exp 'motorcycle'/exp	75,665 3,664
4		·
5	'motorcycle'/exp	3,664
5	'motorcycle'/exp vehicle:ta,ab,de	3,664
4 5 6 7	'motorcycle'/exp vehicle:ta,ab,de traffic:ta,ab,de	3,664 203,388 153,433
4 5 6 7 8	'motorcycle'/exp vehicle:ta,ab,de traffic:ta,ab,de vehicular:ta,ab,de	3,664 203,388 153,433 4,909
3 4 5 6 7 8 9	'motorcycle'/exp vehicle:ta,ab,de traffic:ta,ab,de vehicular:ta,ab,de car:ta,ab,de	3,664 203,388 153,433 4,909 77,435

		7.004
12	motorcycle:ta,ab,de	5,934
13	motorcycles:ta,ab,de	1,104
14	taxi:ta,ab,de	1,535
15	cab:ta,ab,de	5,070
16	road:ta,ab,de	48,308
17	pedestrian:ta,ab,de	7,726
18	pedestrians:ta,ab,de	4,183
19	accident:ta,ab,de	593,740
20	accidents:ta,ab,de	56,438
21	injury:ta,ab,de	1,928,938
22	injuries:ta,ab,de	280,812
23	crash:ta,ab,de	12,698
24	crashes:ta,ab,de	10,253
25	'wounds and injuries'/exp	2,824,750
26	#19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25	3,658,250
27	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18	427,543
28	#26 AND #27	136,545
29	acupuncture	65,725
30	electroacupuncture	10,710
31	acupressure	3,180
32	acupoint	6,816
33	acupoint:ta,ab,de	6,154
34	'acupuncture analgesia'	2,374
35	'acupuncture therapy'	2,500
36	'acupuncture points'	2,351
37	'acupuncture, ear'	42
38	acupuncture:ta,ab,de	56,629
39	acupressure:ta,ab,de	3,077
40	electroacupuncture	10,710
41	'electro acupuncture'	1,442
		9,056

4

5

6

7 8

9 10

11 12

13

14

15

16 17

18 19

20

21 22

23 24

25 26

27 28

29

30 31

32 33

34 35

36

37

38

39 40

41 42

43

44 45

46 47

48 49

50 51

52

53 54

55 56

57 58

#20	vehicle:ti,ab,kw	8,257
#21	vehicular:ti,ab,kw	56
#22	car:ti,ab,kw	4,202
#23	cars:ti,ab,kw	463
#24	automobile:ti,ab,kw	1,157
#25	automobiles:ti,ab,kw	95
#26	motor cycle*:ti,ab,kw	1,169
#27	taxi*:ti,ab,kw	260
#28	cab*:ti,ab,kw	11,113
#29	road*:ti,ab,kw	2,087
#30	pedestrian*:ti,ab,kw	231
#31	accident*:ti,ab,kw	25,630
#32	injur*:ti,ab,kw	76,691
#33	crash*:ti,ab,kw	773
#34	MeSH descriptor: [Wounds and Injuries] explode all trees	35,004
#35	Any MeSH descriptor in all MeSH products and with qualifier(s): [injuries - IN]	3,961
#36	cervie\$ or thoracic\$ or lumba\$	33,603
#37	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14	1,770
	#15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29	
#38		28,521
#38	or #30	28,521
#39		28,521 112,456
	or #30	
#39	or #30 #31 or #32 or #33 or #34 or #35	112,456
#39	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39	112,456 4,739
#39 #40 #41	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40	112,456 4,739 6,352
#39 #40 #41 #42	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36	112,456 4,739 6,352 429
#39 #40 #41 #42 #43	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture	112,456 4,739 6,352 429 21,079
#39 #40 #41 #42 #43	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture electroacupuncture	112,456 4,739 6,352 429 21,079 3,539
#39 #40 #41 #42 #43 #44 #45	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture electroacupuncture acupressure	112,456 4,739 6,352 429 21,079 3,539 2,174
#39 #40 #41 #42 #43 #44 #45	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture electroacupuncture acupressure meridian	112,456 4,739 6,352 429 21,079 3,539 2,174 1,465
#39 #40 #41 #42 #43 #44 #45 #46	or #30 #31 or #32 or #33 or #34 or #35 #38 and #39 #37 or #40 #41 and #36 acupuncture electroacupuncture acupressure meridian acupoint	112,456 4,739 6,352 429 21,079 3,539 2,174 1,465 3,749

### MeSH descriptor: [acupuncture, ear] explode all trees	#51	MeSH descriptor: [acupuncture points] explode all trees	2,520
#55 electro acupuncture	#52	MeSH descriptor: [acupuncture, ear] explode all trees	244
#55 electro-acupuncture	#53	acupuncture:ti,ab,kw	19,015
#56 electro-acupuncture	#54	acupressure:ti,ab,kw	2,062
#57 meridian*:ti,ab,kw	#55	electro acupuncture	1,023
#58 needling:ti;ab,kw 3,062 #59 acu-point* 43 #60 acu point*:ti;ab,kw 257 #61 acupoint*:ti;ab,kw 5,508 #62 MeSH descriptor: [electroacupuncture] explode all trees 1,161 #63 eletroacupuncture*:ti,ab,kw 4 #64 acupuncture AND th 1,248 #65 or #58 or #59 or #60 or #61 or #62 or #63 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 #66 #42 and #65 40 Database: China National Knowledge Infrastructure (CNKI) (cnki.net; 1993-2023) (SU='traffic accident' OR SU='交通事故' OR SU='whiplash injury' OR SU='须椎屈伸损伤' OR SU='whiplash associated disorder' OR SU='排鞭样损伤' OR SU='eervical spine disorder' OR SU='缀椎功能紊乱' OR SU='全型中的时代' OR SU='会型中的时代' OR SU='全型中的时代' OR SU='全型	#56	electro-acupuncture	783
#59 acu-point*	#57	meridian*:ti,ab,kw	1,399
#60 acu point*:ti,ab,kw	#58	needling:ti,ab,kw	3,062
#61 acupoint*:ti,ab,kw 5,508 #62 MeSH descriptor: [electroacupuncture] explode all trees 1,161 #63 eletroacupuncture*:ti,ab,kw 4 #64 acupuncture AND th 1,248 #65 #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 #66 #42 and #65 40 Database: China National Knowledge Infrastructure (CNKI) (cnki.net; 1993-2023) (SU='traffic accident' OR SU='交通事故' OR SU='whiplash injury' OR SU='颈椎屈伸损伤' OR SU='whiplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR SU='對性功能紊乱' OR SU='eervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='對' or SU='electro acupuncture' OR SU='电針' OR SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-car' OR SU='再针') Database: ScienceOn (scienceon.kisti.re.kr; 2001-2023) **Dăl=(교통사고 型타성 손상 채찍질 손상 경항통 경추부 영좌) AND 전체=(침 전침 경혈 61 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)	#59	acu-point*	43
#62 MeSH descriptor: [electroacupuncture] explode all trees	#60	acu point*:ti,ab,kw	257
#63 electroacupuncture*:ti,ab,kw 4 #64 acupuncture AND th 1,248 #65 #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 #66 #42 and #65 #0 Database: China National Knowledge Infrastructure (CNKI) (cnki.net; 1993-2023) (SU='traffic accident' OR SU='交通事故' OR SU='按\(\pm\) whiplash injury' OR SU='\(\frac{\text{3}}{\text{4}}\) kmplash associated disorder' OR SU='\(\frac{\text{3}}{\text{4}}\) kmplash associated disorder' OR SU='\(\frac{\text{3}}{\text{4}}\) kmplash associated disorder' OR SU='\(\frac{\text{3}}{\text{4}}\) kmplash or SU='\(\text{3}\) kmplash associated disorder' OR SU='\(\frac{\text{3}}{\text{4}}\) kmplash or SU='\(\frac{\text{4}}{\text{5}}\) kmplash or SU='\(#61	acupoint*:ti,ab,kw	5,508
#64 acupuncture AND th 1,248 #65 #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 #66 #42 and #65 #66 #42 and #65 #66 #67 And #65 #67 And #67 And #67 And #67 And #68 A	#62	MeSH descriptor: [electroacupuncture] explode all trees	1,161
#43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62 or #63 or #64 #66 #42 and #65 40 Database: China National Knowledge Infrastructure (CNKI) (cnki.net; 1993-2023) (SU='traffic accident' OR SU='交通事故' OR SU='whiplash injury' OR SU='颈椎屈伸损伤' OR SU='whiplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR SU='如椎功能紊乱' OR SU='cervical spine disorder' OR SU='acupuncture' OR SU='acupuncture' OR SU='acupuncture' OR SU='acupuncture' OR SU='acupuncture-ear' OR SU='耳针') Database: ScienceOn (scienceon.kisti.re.kr; 2001-2023) ② 전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)	#63	elctroacupuncture*:ti,ab,kw	4
26,713 or #58 or #59 or #60 or #61 or #62 or #63 or #64 26,713 26,713 40 40 40 40 40 40 40 4	#64	acupuncture AND th	1,248
Database: China National Knowledge Infrastructure (CNKI) (cnki.net; 1993-2023) (SU='traffic accident' OR SU='交通事故' OR SU='whiplash injury' OR SU='颈椎屈伸损伤' OR SU='颈椎屈伸损伤' OR SU='细hiplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR SU='颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' OR SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针') Database: ScienceOn (scienceon.kisti.re.kr; 2001-2023) 전체=(교통사고 편타성 손상 채찍질 손상 경향통 경추부 염좌) AND 전체=(침 전침 경혈 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)	#65		26,713
(SU='traffic accident' OR SU='交通事故' OR SU='whiplash injury' OR SU='颈椎屈伸损伤' OR SU='y种iplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR SU='颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='acupuncture' OR SU='电針' OR SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='耳针') Database: ScienceOn (scienceon.kisti.re.kr; 2001-2023) 전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)	#66	#42 and #65	40
SU='whiplash associated disorder' OR SU='挥鞭样损伤' OR SU='cervical spine disorder' OR SU='颈椎功能紊乱' OR SU='cervical spine injury' OR SU='颈椎损伤') AND (SU='acupuncture' OR SU='針' or SU='electro acupuncture' OR SU='电針' OR SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='再针') Database: ScienceOn (scienceon.kisti.re.kr; 2001-2023) 전체=(교통사고 편타성 손상 채찍질 손상 경향통 경추부 염좌) AND 전체=(침 전침 경혈 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)	Data	base: China National Knowledge Infrastructure (CNKI) (cnki.net; 1993-2023)	
SU='針' or SU='electro acupuncture' OR SU='电針' OR SU='meridian' OR SU='经穴' or SU='acupoint' or SU='acupuncture-ear' OR SU='再针') Database: ScienceOn (scienceon.kisti.re.kr; 2001-2023) 전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)			
or SU='acupuncture-ear' OR SU='再针') Database: ScienceOn (scienceon.kisti.re.kr; 2001-2023) 전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)	1		54
전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)			
1 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)	Data	base: ScienceOn (scienceon.kisti.re.kr; 2001-2023)	
1 이침) Database: KMBASE (kmbase.medric.or.kr; 1985-2023)		전체=(교통사고 편타성 손상 채찍질 손상 경항통 경추부 염좌) AND 전체=(침 전침 경혈	
, , , , , , , , , , , , , , , , , , ,	1		61
1 [ALL=교통사고] 964	Data	base: KMBASE (kmbase.medric.or.kr; 1985-2023)	
	1	[ALL=교통사고]	864

2	[ALL=편타성 손상]	25
3	[ALL=채찍질 손상]	0
4	[ALL=경항통]	89
5	[ALL=경추부 염좌]	4
6	[ALL=침]	14,195
7	[ALL=전침]	377
8	[ALL=이침]	80
9	[ALL=경혈]	326
10	(((([ALL=교통사고] OR [ALL=편타성 손상]) OR [ALL=채찍질 손상]) OR [ALL=경항통]) OR [ALL=경추부 염좌])	946
11	((([ALL=침] OR [ALL=전침]) OR [ALL=이침]) OR [ALL=경혈])	14,801
12	((((([ALL=교통사고] OR [ALL=편타성 손상]) OR [ALL=채찍질 손상]) OR [ALL=경항통]) OR [ALL=경항통]) AND ((([ALL=침] OR [ALL=전침]) OR [ALL=이침]) OR [ALL=경혈]))	48
Data	base: Korean Studies Information Service System (KISS) (kiss.kstudy.com; 1993-2023)	
1	교통사고 and 침	126
2	교통사고 and 전침	4
3	교통사고 and 이침	0
4	교통사고 and 경혈	0
Data	base: Korea Med (koreamed.org; 1992-2023)	
1	(((((("traffic"[ALL])) OR ("automobile"[ALL])) OR ("whiplash injury"[ALL])) OR ("whiplash associated disorder"[ALL])) OR ("cervical spine disorder"[ALL])) OR ("cervical spine injury"[ALL])	1,706
2	(((("acupuncture"[ALL])) OR ("electroacupuncture"[ALL])) OR ("meridian"[ALL])) OR ("acupoint"[ALL])	553
3	#1 AND #2	22

D :	1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	.(2, 2022)
Data	base: Oriental Medicine Advanced Searching Integrated System (OASIS) (oasis.kiom.re.kr; 19	063-2023)
1	교통사고 침	1
2	교통사고 전침	4
3	교통사고 이침	0
4	교통사고 경혈	0
Data	base: Research Information Sharing Service (RISS) (riss.kr; 1988-2023)	
1	전체 : 교통사고 <and> 전체 : 침</and>	92
2	전체 : 교통사고 <and> 전체 : 전침</and>	4
3	전체 : 교통사고 <and> 전체 : 이침</and>	0
4	전체 : 교통사고 <and> 전체 : 경혈</and>	1

First author	T		Depth of	Stimulation	023- ight	Total sessions	Frequency and
(year)	Type of acupuncture	Acupoints	needling	response	023-077700 right, includ	lotal sessions	Retention
Sterling et al		Posterior muscles of the			on 17 January 2024. Downloaded from http://bmjopen.bmj.c Enseignement Superieur (ABES) . Ing for uses related to text and data mining, AI training, and		Frequency: 2
(2015)	General acupuncture	cervical spine and upper	NR	Pecking, Twirling	Janu En use	Ó	times/week X 3 weeks
` '		thoracic spine			ary 2 seign s rela		Retention: 30 minute
		Choose from GV14,			024. I emel ted to		
		C1-C7, GB20, SI11,			Dowr nt Su o text		
		GB21, TE15, SI14,			lloade peried and		Б
Tobbackx et al		BL17, SP10, SI3,	NR		ad from Jr (AE data		Frequency: 1
(2012)	General acupuncture	BL64, TE5, GB41,		Deqi sensation	BES)		time/week X 1 week
		Shiqizhuixia, Ear Zero			ig, Al t		Retention: 20 minute
		point, Ear Jerome point,			jope rainir		
		Ear C0.			n.bmj.o ng, anc		
		SI2, SI3, SI5, SI7, SI14,			sim/		Emaguamayu 2
Kwak et al		SI15, LI11, BL10,	1.0-2.0 cm	Deqi sensation,	on Ju		Frequency: 3
(2012)	General acupuncture	BL12, BL13, BL14,		Rotating	ine 8)	times/week X 2 weeks
		BL60, BL62, BL66,			om/ on June 8, 2025 a similar technologies.		Retention: 15 minute
					at Agence s.		
					(D		
					bliogr		
					Bibliographique de I		
		eer review only - http://bmjoper			ane c		

Supplemental table S2. Appraisal of acupuncture procedure based on the revised SRICTA criteria (2000)

Page 45 of 56

time/week X 2-6 times

2 3

5

6

8

10

11 12

13

14

15 16

17

18

19

20

21 22

23 24

25

26

27 28

29 30

31

32

33

34

35 36

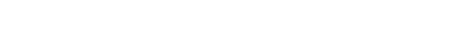
37

Supplemental table S3. The "leave-one-out" approach for sensitivity analysis of whiplash-associated disorder

Study omitted	Pooled	95% Confidence i	nterval	p-value	$I^{2}(\%)$	
Study offitted	estimate	Lower	Upper	p-varue	1 (70)	
Pain VAS score						
Kwak HY 2012	-0.54	-0.87	-0.21	0.001	59	
Tobbackx Y 2012	-0.65	-0.96	-0.35	< 0.0001	44	
Tough EA 2010	-0.55	-0.87	-0.22	0.001	59	
Cameron ID 2011	-0.65	-1.01	-0.29	0.0005	53	
Han SY 2011	-0.47	-0.84	-0.11	0.01	61	
Kim DR 2020	-0.45	-0.81	-0.10	0.01	53	
ROM – flexion						
Kwak HY 2012	0.33	-0.59	1.26	0.48	89	
Sterling M 2015	0.43	-0.37	1.22	0.29	78	
Kim DR 2020	-0.10	-0.46	0.26	0.60	0	
ROM – extension						
Kwak HY 2012	0.38	-0.19	0.96	0.19	73	
Sterling M 2015	0.69	0.34	1.03	< 0.0001	0	
Kim DR 2020	0.36	-0.27	0.99	0.26	62	
ROM – right rotation	on					
Kwak HY 2012	0.56	-1.16	2.29	0.52	97	
Sterling M 2015	0.79	-0.53	2.11	0.24	92	
Kim DR 2020	-0.17	-0.56	0.22	0.39	11	
ROM – left rotation	1					
Kwak HY 2012	0.85	-0.29	1.98	0.15	92	
Sterling M 2015	0.81	-0.42	2.05	0.20	90	
Kim DR 2020	0.23	-0.13	0.59	0.21	0	
NDI						
Sterling M 2015	-0.19	-0.61	0.23	0.37	75	

Tobbackx Y 2012	-0.18	-0.59	0.24	0.40	75
Tough EA 2010	-0.11	-0.46	0.25	0.56	71
Cameron ID 2011	-0.29	-0.51	-0.08	0.007	0
Han SY 2011	-0.09	-0.45	0.26	0.61	68
Kim DR 2020	-0.15	-0.56	0.26	0.48	73

VAS: Visual analog scale; ROM: Range of motion; NDI: Neck disability index



			Certainty	assessment			No. of pat	ients	Dyrigh 2023	
No. of	Study	Risk of	T	т 1	т	Other	T ' / 1	C . 1	Absolute (95%	Certain
studies	design	bias	Inconsistency	Indirectness	Imprecision	considerations	Experimental	Control	Absolute (95% ncluding	
Pain VAS s	core								7 Jar	
6	RCT	Not	Serious*	Not serious	Not serious	None	217	206	Simple 0.57 lower of 0.28 companies of the companies of t	ФФФ(
		serious							d to te	Modera
ROM-flexi	on			9/	^				loa eri	
3	RCT	Not	Very serious§	Not serious	Very serious [†]	None	108	108	Solution 10.23 higher 10.23 higher 10.25 higher 10.27	ФОО
		serious							ing, the higher)	Very lo
ROM-exter	nsion						· ·		98MD 0.47 higher	
3	RCT	Not	Serious*	Not serious	Serious [‡]	None	108	108	95MD 0.47 higher and (0.95 higher to similar 1	ФФО
		serious							imilar 1 0989 higher)	Low
ROM-right	lateral flex	xion							June 8,	
									2025 logie:	
									7	
									ince B	
									ibliogr	
									Agence Bibliographique de l	
				Fan 200 2 2	ovious only between	/bmjopen.bmj.cor		ا مانام می برام ا	ue de	

						BMJ Open			mjopen-2023 d by copyrigi	
2	RCT	Not serious	Very serious§	Not serious	Very serious [†]	None	68	69	mjopen-2023-077700 0.58 higher MM0 0.58 higher MM0 0.58 higher MM1 0.58 higher MM2 0.58 higher MM2 0.58 higher MM2 0.58 higher MM3 0.58 higher MM3 0.58 higher Lated to 1.48 Enseignement Suberieur (ABMS) O.41 higher O.41 higher O.41 higher	⊕○○○ Very low
ROM-lef	t lateral flex	ion							Sahigher) Enseig	very low
2	RCT	Not serious	Serious*	Not serious	Very serious [†]	None	68	69	a 20 a 20	⊕○○○ Very low
ROM-rig	tht rotation				00				aded from the rieur (A	
3	RCT	Not serious	Very serious§	Not serious	Very serious [†]	None	108	108	0.41 higher	⊕○○○ Very low
ROM-lef	t rotation						9/		ng(0.73) lower to 1.55 Al training, an	very low
3	RCT	Not serious	Very serious§	Not serious	Very serious [†]	None	108	108	SMD 0.63 higher SMD 0.63 higher MD 0.29 ower to 1.46 This phigher)	⊕○○○ Very low
NDI									2025 ogie	
6	RCT	Not	Serious*	Not serious	Serious¶	None	237	225	SM 0.17 lower (0.5 blower to 0.17	⊕⊕○○
		serious							Hanigher) E	Low
					eview only - http://bn				ographique de l	

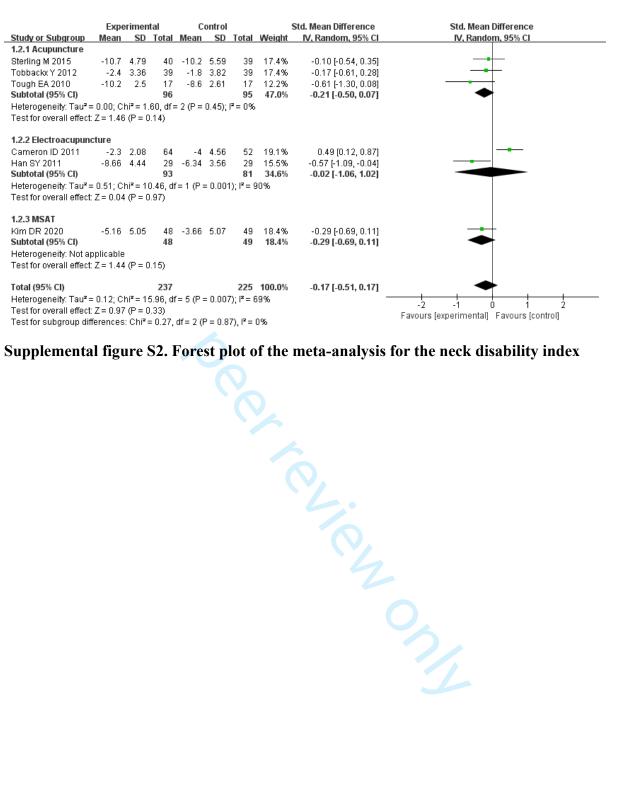
	<u>D1</u>	<u>D2</u>	<u>D3</u>	<u>D4</u>	<u>D5</u>	<u>Overall</u>
Aigner 1998	!	-	-		!	-
Cameron 2011	+	+	•	+	!	-
Han 2011	!	!	+	+	!	!
Kim 2020	+	+	+	+	+	+
Kwak 2012	+	+	+	+	+	+
Sterling 2015	+	+	!	+	+	!
Tobbackx 2012	+	!	+	+	+	!
Tough 2010	+	!	-	+	!	!

+	Low risk
!	Some concerns
	High risk

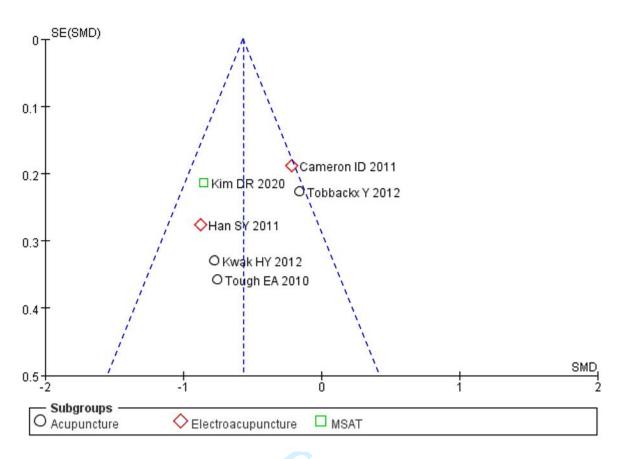
D3

- D1 Randomisation process
- D2 Deviations from the intended interventions
 - Missing outcome data
- D4 Measurement of the outcome
- D5 Selection of the reported result

Supplemental figure S1. Individual data of RoB 2



Supplemental figure S2. Forest plot of the meta-analysis for the neck disability index



Supplemental figure S3. Funnel plot for the pain visual analog scale score



PRISMA 2020 Checklist

Page 55 of 56		BMJ Open BMJ Open	
PRIS	MA 2	by copyrigh	
Section and Topic	Item #	Checklist item Checklist item	Location where item is reported
TITLE	#	ud 00	item is reported
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2-3
INTRODUCTION		S S S S S S S S S S S S S S S S S S S	
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	4
2 Objectives	4	Describe the rationale for the review in the context of existing knowledge. Provide an explicit statement of the objective(s) or question(s) the review addresses.	4-5
METHODS		5 nt D	
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6-7
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consultations. Specify the date when each source was last searched or consulted.	6 Supple table 1
8 Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6 Supple table 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many were screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each sport whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	7-8
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each succome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	6-7
8	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, fighting sources). Describe any assumptions made about any missing or unclear information.	6-7
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how matery reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
2 Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or preservation of results.	8
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study the study and comparing against the planned groups for each synthesis (item #5)).	7-8
5 6	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summery statistics, or data conversions.	7-8
7	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7-8
:8 :9 :0	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was per med, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	8-9
.1	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analys, meta-regression).	8-9
2	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	8-9
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biase.	8-9



47

PRISMA 2020 Checklist

		righ	
Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	8-9
RESULTS		for the state of t	
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to from the search to from the included in the review, ideally using a flow diagram.	10 Figure 1.
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	10 Figure 1.
Study characteristics	17	Cite each included study and present its characteristics.	10 Table 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	14-15 Figure 2. Supple figure 1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an at the precision (e.g. confidence/credible interval), ideally using structured tables or plots.	15-16 Figure 3,4. Supple figure 2
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	15-17 Figure 2,3,4. Supple figure 1,2
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary stingate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	15-16 Figure 3,4. Supple figure 2
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	16-17 Supple table 3
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	16-17 Supple table 3
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	19 Supple figure 3
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	17-19 Supple table 4
DISCUSSION		OC C	1
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	20-21
	23b	Discuss any limitations of the evidence included in the review.	21-22
	23c	Discuss any limitations of the review processes used.	21-22
	23d	Discuss implications of the resource roll productive interpretations and the resource roll productive interpretations are resourced in the resource roll productive interpretations and the resource roll productive interpretations are resourced in the resource roll productive interpretation in the resource roll productive roll producti	20-22



PRISMA 2020 Checklist

۷.				gh	2 3	
4	Section and Topic	Item #	Checklist item	t, incl	0777	Location where item is reported
5	OTHER INFORMAT	ΓΙΟΝ			0	
7	Registration and	24a	Provide registration information for the review, including register name and registration number, or state that the	n ∉∄ revi	www.was.not.registered.	3
r R	protocol	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	for	17 J	3
9		24c	Describe and explain any amendments to information provided at registration or in the protocol.	En	anu	23
10	Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in	theese	view.	22-23
11 12	Competing interests	26	Declare any competing interests of review authors.	igneme elated	2024.	23
12 14 15	Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection form included studies; data used for all analyses; analytic code; any other materials used in the review.	ந் Super to text ar	extracted from	23
16 17 18	o 7 <i>From:</i> Page MJ, M 3 10.1136/bmj.n71	cKenzie	included studies; data used for all analyses; analytic code; any other materials used in the review. JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for For more information, visit: http://www.prisma-statement.org/	ieur∄AB nd data n	g ng systematic reviews. BM	1J 2021;372:n71. doi:
19 20) 1		For more information, visit: http://www.prisma-statement.org/	nini NES	<u>ਤ</u>	
21	, I			ng,		
22	<u>)</u>			≥	//bn	
23	3			trai	<u>3</u> . <u>0</u>	
24	1 -		For more information, visit: http://www.prisma-statement.org/	Al training, and similar technologies	oen.	
25 26	5			g, a	. b B	
27	7			bu.		
28	3			<u> </u>	Ž	
29	9			ar	9	
30)			tec	ב ב	
31				μ		
32 33	2) Joc	20	
34	,			jies	2025	
35				•	at /	
36	5			(Age	
37	7				nce	
38					Bib	
39					_	
40				(o <u>q</u>	
41 41					iographique	
42 43					<u> </u>	
42 44						
45 45			For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml		<u>a</u>	
+- 46			, , , , , , , , , , , , , , , , , , , ,		_	
47						
٠,						

cted by copyrig 36/bm jopen-202