Effects of matched vs. unmatched physical therapy interventions on pain or disability in patients with neck pain - a systematic review and meta-analysis.

MASTROMARCHI, Paolo, MCLEAN, Sionnadh <http://orcid.org/0000-0002-9307-8565>, ALI, Nancy and MAY, Stephen

Physiotherapy Theory and Practice
An International Journal of Physical Therapy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/iptp20

Effects of matched vs. unmatched physical therapy interventions on pain or disability in patients with neck pain – a systematic review and meta-analysis

Paolo Mastromarchi, Sionnadh McLean, Nancy Ali & Stephen May

To cite this article: Paolo Mastromarchi, Sionnadh McLean, Nancy Ali & Stephen May (01 Dec 2023): Effects of matched vs. unmatched physical therapy interventions on pain or disability in patients with neck pain – a systematic review and meta-analysis, Physiotherapy Theory and Practice, DOI: 10.1080/09593985.2023.2285892

To link to this article: https://doi.org/10.1080/09593985.2023.2285892

PHYSIOTHERAPY THEORY AND PRACTICE
https://doi.org/10.1080/09593985.2023.2285892

Taylor & Francis
Taylor & Francis Group

SYSTEMATIC REVIEW

Effects of matched vs. unmatched physical therapy interventions on pain or disability in patients with neck pain – a systematic review and meta-analysis

Paolo Mastromarchi MSc, PT[a,b], Sionnadh McLean PhD, MSc, PT[b], Nancy Ali PhD, MSc PT[b], and Stephen May PhD, MSc, PT[c]

[a]Scuola Universitaria per la Svizzera Italiana, DEASS, via Violino 11, Manno, Switzerland; [b]Department of Allied Health Professions, College of Health, Wellbeing and Life Sciences, Sheffield Hallam University, Sheffield, UK; [c]Centre for Applied Health and Social Care Research (CARe), College of Health, Wellbeing and Life Sciences, Sheffield Hallam University, Sheffield, UK

ABSTRACT

Background: The interventions performed in most randomized controlled trials (RCTs) on neck pain patients are standardized, irrespective of the high heterogeneity of patients. However, clinicians tend to choose an intervention based on the patients' clinical characteristics, and thus match the treatment to the patient.

Objectives: To investigate the effectiveness of interventions matched to the clinical characteristics of patients with neck pain versus the same, but unmatched treatment for improving pain or disability.

Design: A systematic review and meta-analysis conducted following Cochrane guidelines

Methods: Databases searches were performed from inception to September 2023. RCTs were included if the patients in the experimental group received a treatment matched to clinical presentation or to clinicians' assessment, if the patients in the control group received a similar but unmatched treatment, and if pain or disability were reported as outcome measures.

Results: The literature search produced 9516 records of which 27 met the inclusion criteria. Matched exercise therapy was superior to unmatched exercise for pain (SMD −0.57; 95% CI −0.95, −0.18) and for disability (SMD −0.69; 95% CI −1.14, −0.23) at short term, but not at intermediate-term follow-up. Matched manual treatment was not superior to unmatched manual therapy for pain or for disability at short or intermediate-term follow-up.

Conclusions: Results suggest that matching exercise to movement limitation, trapezius myalgia, or forward head position may lead to better outcomes in the short term, but not in the intermediate-term. Matched manual therapy was not superior to unmatched treatment either short or intermediate-term. Further research is warranted to verify if those criteria are potentially useful matching criteria.

ARTICLE HISTORY
Received 24 February 2023
Revised 9 November 2023
Accepted 9 November 2023

KEYWORDS
Neck pain; matched treatment; assessment; clinical decision making; clinical reasoning

Introduction

Neck pain is the ninth and eleventh most common cause of disability among females and males worldwide, respectively (Vos et al., 2016). Its global annual incidence is higher in females; prevalence peaks at the 50–54 age group for females and at the 45–49 age group for males (Safiri et al., 2020). Although neck pain is generally considered to be a benign condition, 50% to 80% of people having neck pain will develop chronic or recurrent pain (Carroll et al., 2009).

Non-specific neck pain (NSNP) is defined as pain originating from the cervical spine, not related to trauma, without underlying serious pathologies or cervical radiculopathies, and constitutes the majority (90%) of those with neck pain (Verhagen, 2021). Existing European guidelines on NSNP management recommend reassurance, advice and education, non-steroidal anti-inflammatory drugs (NSAIDs), paracetamol, topical medications, and exercise interventions alone or in combination with manual therapy (Corp et al., 2021). Exercise and manual therapy are the most commonly used physical therapy interventions (Verhagen, 2021); however, specific criteria for selecting a particular intervention are not given. Guidelines are based on systematic reviews of existing RCTs; however, some have criticized the value of such reviews derived as they are from trials of poor quality and clinical relevance (Jull and Moore, 2020). Furthermore, a recent Delphi study investigating the research agenda for neck pain, prioritized the need for the assessment of effectiveness of available treatments and the identification of clinical features that can be used to direct treatment decisions (Silva et al., 2019). Given the

CONTACT Paolo Mastromarchi MSc, PT pmastromarchi@yahoo.it Scuola Universitaria per la Svizzera Italiana, via Violino 11, Manno 6928, Switzerland

high heterogeneity of NSNP patients and the homogeneity of the application of interventions in most randomized controlled trials (RCTs), it could be important, in the overall judgment of trial quality, to examine whether there is a match between the intervention investigated and the patients' presentations. A recent systematic review assessed the quality and the effectiveness of 13 treatment-based classification systems that attempted any such matching (Maissan et al., 2020). They concluded that clinical implementation should not be recommended given the overall low quality and clinical relevance of such systems and the low quality of the clinical comparison trials. Therefore, it could be speculated whether any matching or assessment strategy is in vain, or if sets of clinical criteria could aid clinicians in the identification of the most effective treatment for the individual patient. However, Maissan et al. (2020) investigated mainly statistically or theoretically derived classification systems but the use of high quality RCTs is recommended when the aim is to identify clinical features able to predict the effectiveness of a specific intervention (Kelly, Ritchie, and Sterling, 2017). Consequently, the aim of this systematic review is to investigate the effectiveness of interventions matched with any form of clinical assessment compared with similar but unmatched interventions for improving pain and disability for people with NSNP.

Methods

A systematic review was conducted following the Cochrane guidelines (Higgins et al., 2019) and reported according to the PRISMA guidelines (Page et al., 2021). The protocol was registered with PROSPERO (CRD42021297163).

Information sources and search strategy

A comprehensive systematic literature search was performed using international databases including PubMED, MEDLINE, EMBASE, CINAHL, COCHRANE CENTRAL, psycINFO and SPORTDiscus from their inception to September 2023. For the full search strings see Appendix 1.

Eligibility criteria

Studies were included if they: 1) were RCTs; 2) investigated patients with NSNP; 3) the patients in the experimental group received a treatment or a set of treatments matched to their clinical presentations, to healthcare professionals' evidence-based assessment or to patient preference; 4) patients in the control group received similar, but unmatched treatment; and 5) reported pain or disability as outcome measures.

Studies were excluded if 1) they investigated patients with serious pathology or radicular signs, headache as a primary complaint or history of trauma (whiplash); 2) patients were simply randomized to intervention without regard for matching or suitability; 3) patients in the control group received inactive/different treatment; and 4) full text articles were not available or were not written in English.

Selection process

The studies identified during the searches were screened to remove duplicates. Following this, a three-stage screening strategy of titles, abstracts, and full-texts was then conducted against inclusion and exclusion criteria with findings recorded using Rayyan software comments section. Studies were first screened based on the title by a single reviewer (PM) to remove irrelevant studies. Abstracts and subsequently potentially relevant full-text studies were then assessed independently by two reviewers (PM, SM). Differences during the screening process were discussed between the two reviewers until consensus was reached. If no consensus was obtained a third researcher (SMc) was consulted to make a final decision.

Data items and collection process

Data extracted from each paper included date, country, sample size, duration of symptoms, eligibility criteria, matched and unmatched interventions, number of sessions and frequency, means and standard deviations for pain and disability, short term (0–3 months), intermediate term (4–6 months), and long term (>6 months) follow-ups, and integrity of intervention in case of exercises. Data were recorded on a purposefully developed electronic sheet by one reviewer (PM) and checked by the second reviewer (SM).

Risk of bias assessment

The risk of bias (RoB) of the included papers was rated by two independent assessors (PM, SM) using the Revised Cochrane Risk of Bias tool (RoB2) (Sterne et al., 2019). This tool rates each paper according to potential bias arising from five main domains: randomization process, deviation from intended intervention, missing outcome data, measurement of the outcome and selection of the reported results. Judgements of each domain and of overall risk of bias were based on an algorithm aimed to assign to each item a quality rating of low RoB, some concern or high RoB (Sterne et al., 2019).

Disagreements were discussed between the two reviewers and any remaining disagreements were resolved through further discussion with a third researcher (SMc).

Synthesis methods and data analysis

Meta-analysis was performed using the RevMan 5.4.1 (Cochrane software) for pain and disability at similar follow-up periods. We used the standardized mean difference (SMD) and 95% confidence interval (95% CI) of the change score from baseline because it has been shown to be more generalizable than the mean difference with continuous variable in meta-analyses (Takeshima et al., 2014). Forest plots of "matched" versus "unmatched" interventions were used to graphically represent the findings. The SMDs with standard deviations of the change rate for each outcome and for each paper were grouped according to the timing of the follow-ups. Where the standard deviation of the change rate was not presented it was imputed through the correlation coefficient calculated from the data of the other studies assessing the same intervention (Higgins et al., 2019). Cohen's d was used to calculate the magnitude of the effect size for each intervention, where 0.2 represents a small effect size, 0.5 a moderate effect size, and 0.8 a large effect size (Sullivan and Feinn, 2012). Effect sizes for matched and unmatched interventions were calculated with the SMD standardized with the pooled standard deviation. As considerable heterogeneity was expected around issues such as, the interventions used and study settings, random-effects meta-analyses were used throughout. The p-value and I^2 statistics were used to assess heterogeneity between trials (Guyatt et al., 2011). Higgins, Thompson, Deeks, and Altman (2003) suggested rating heterogeneity as follows: low if $I^2 = 25\%$; moderate if $I^2 = 50\%$; and high if $I^2 = 75\%$.

Quality of evidence

The Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) framework was used to assess the levels of certainty of evidence for matched intervention for pain and disability, among the selected papers. This framework suggests rating levels of certainty as high, moderate, low or very low (Guyatt et al., 2011). Quality was rated down according to the: risks of bias (1–2 levels); inconsistency (1–2 levels); indirectness (1–2 levels); imprecision (1–2 levels); and publication bias (1–2 levels). Quality was upgraded according to large effect size (1–2 levels); dose response gradient (1 level); and in case of the effect of a plausible confounder (1 level).

Results

Study selection

The literature search produced 9516 records. After removing 9489 based on the title, abstract and full text, 27 studies were considered to have a matching treatment against a similar unmatched treatment. Figure 1 shows the PRISMA flow-chart of the search results and reasoning for exclusion. Of 27 studies identified, 12 were included in the manual therapy meta-analysis, 13 in the exercise meta-analysis and three could not be included in the meta-analysis because one described mixed interventions (Paoloni et al., 2012), and two described different interventions other than exercise and manual therapy (Gu, Yan, Zhang, and Li, 2019; Martín-Rodríguez, Sáez-Olmo, Pecos-Martín, and Calvo-Lobo, 2019). One study was included in both sets of the meta-analysis because it considered both exercise and manual therapy (Cleland et al., 2010). Two studies that could have been included in the meta-analyses displayed incomplete data (Kotteeswaran and Nayak, 2021; Puntumetakul et al., 2015) and the authors were contacted for additional information but no response was received.

Studies characteristics, outcome measures and follow-up

The 27 studies identified in the review included 1613 patients and the 24 studies included in the meta-analysis had a total of 1119 patients. See Table 1 for study details. Twenty-two studies used the Visual Analogic Scale (VAS) or Numeric Pain Rating Scale (NPRS) to quantify pain perceived. Neck Disability Index was the disability questionnaire used in 15 studies. All studies assessed outcomes at short term, four studies at intermediate term, and only one at long-term follow-up.

Matching criteria

For manual therapy, the eligibility criteria chosen to match patient clinical presentation with specific manual therapy treatment were as follows: manually assessed symptomatic level (Aquino et al., 2009; Schomacher, 2009); movement restriction (Joshi, Balthillaya, and Neelapala, 2020; Karas and Olson Hunt, 2014; Karas et al., 2018; Martínez-Segura et al., 2006; Puntumetakul et al., 2015); clinical prediction rule for thoracic manipulation (Cleland et al., 2010); clinical prediction rule for thoracic manipulation and movement restriction (Puentedura et al., 2011); central or unilateral neck pain (Kanlayanaphotporn,

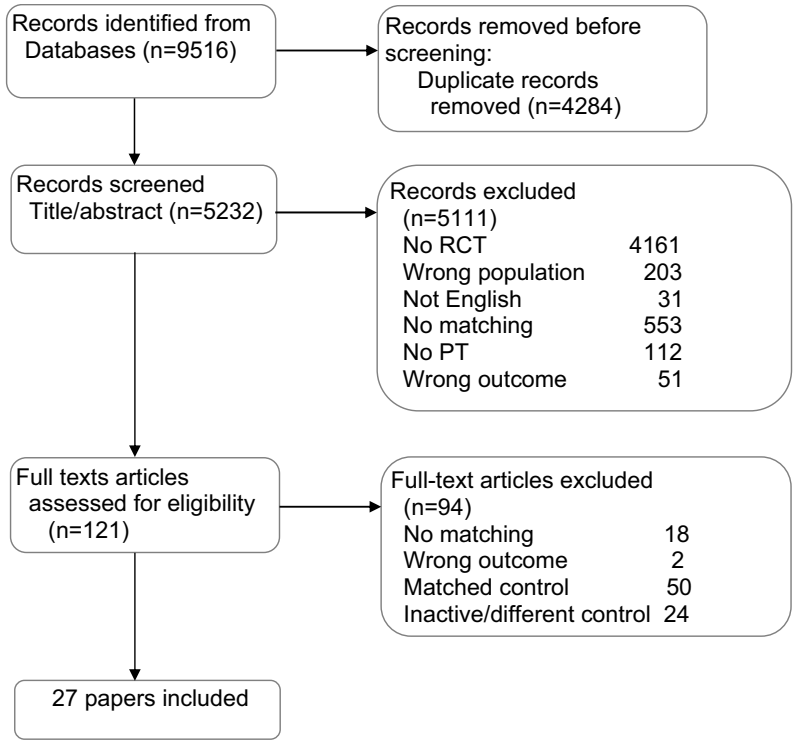

Figure 1. Study flow diagram.

Chiradejnant, and Vachalathiti, 2009, 2010); and a pragmatic clinical assessment (Lagoutaris, Sullivan, Hancock, and Leaver, 2020).

For exercise therapy the eligibility criteria chosen to match patient clinical presentation with specific exercise treatment were diagnostic criteria for trapezius myalgia (Andersen et al., 2008); movement restriction (Lee and Kim, 2016; Petersen et al., 2015); clinical prediction rule for thoracic manipulation (Cleland et al., 2010); cranio-vertebral angle >50° (CVA) (Abd El-Azeim, Mahmoud, Mohamed, and El-Khateeb, 2022; Arif, Rehman, and Ikram, 2022; Im, Kim, Chung, and Hwang, 2016; Kang, Im, and Kim, 2021); abnormal joint position sense (Jull et al., 2007); mechanical diagnosis and therapy criteria (Kjellman and Öberg, 2002; Takasaki and Yamasaki, 2023); and muscle weakness (Giménez-Costa et al., 2022; Kotteeswaran and Nayak, 2021).

Other than manual therapy and exercise the eligibility criteria chosen to match patient clinical presentation with specific treatment were as follows: Chinese medicine criteria for acupuncture (Gu, Yan, Zhang, and Li, 2019); physiotherapist preference (Paoloni et al., 2012); and active trigger point criteria (Martín-Rodríguez, Sáez-Olmo, Pecos-Martín, and Calvo-Lobo, 2019). None of which could have been included in a meta-analysis.

Risk of bias assessment

Overall, 10 papers were rated as having low risk of bias and 17 as having some concerns of risk of bias (Figure 2). There was some concern about RoB in four studies regarding randomization concealment of group allocation (Andersen et al., 2008; Im, Kim, Chung, and Hwang, 2016; Kotteeswaran and Nayak, 2021; Lee and Kim, 2016); and in 17 studies regarding potential selection of reported results because a published protocol was not available (Andersen et al., 2008; Aquino et al., 2009; Gu, Yan, Zhang, and Li, 2019; Im, Kim, Chung, and Hwang, 2016; Joshi, Balthillaya, and Neelapala, 2020; Jull et al., 2007; Kang, Im, and Kim, 2021; Kanlayanaphotporn, Chiradejnant, and Vachalathiti, 2009, 2010; Kjellman and Öberg, 2002; Kotteeswaran and Nayak, 2021; Lee and Kim, 2016; Martínez-Segura et al., 2006; Puentedura et al., 2011; Puntumetakul et al., 2015; Schomacher, 2009); or incomplete (Abd El-Azeim, Mahmoud, Mohamed, and El-Khateeb, 2022).

Manual therapy matched vs unmatched – pain and disability short term

Twelve studies compared matched with unmatched manual therapy for pain and four for disability at short-term follow-up. Matched manual treatment was not

Table 1. Studies characteristics.

	Participants	Interventions	# of sessions	Follow-ups	Outcome	Std Mean difference (95%CI)
MANUAL THERAPY STUDIES						
MATCHING CRITERIA: MANUALLY ASSESSED SYMPTOMATIC LEVEL						
Aquino et al. (2009)	48, age 18-65 years, chronic NSNP	Matched group: manual mobilization of symptomatic level ($n = 24$) Unmatched group: manual mobilization of random level ($n = 24$)	1 session	Immediately post-intervention	Pain (NRS)	No statistically significant difference in pain intensity between groups.
Schomacher (2009)	126, neck pain, symptoms changing with selective neck movements	Matched group: manual mobilization of symptomatic level ($n = 59$) Unmatched group: manual mobilization of random level ($n = 67$)	1 session	Immediately post-intervention	Pain (NRS)	No statistically significant difference in pain intensity between groups.
MATCHING CRITERIA: MANUALLY ASSESSED MOVEMENT LIMITATION						
Joshi, Balthillaya, and Neelapala (2020)	42, neck pain, 18–60 years, cervico-thoracic movement dysfunction	Matched group: manual mobilization of C7-T1 ($n = 21$) Unmatched group: manipulation T3-T6 ($n = 21$)	1 session	Immediately post-intervention	Pain (NRS)	No statistically significant difference in pain intensity between groups.
Karas and Olson Hunt (2014)	39, neck pain, 18–60 years	Matched group: supine thoracic manipulation at limited segment ($n = 19$) Unmatched group: seated thoracic global manipulation ($n = 20$)	1 session	Immediately post-intervention	Pain (NRS)	Difference in pain intensity between groups in favor of matched group: −1.2, $p < .05$
Martínez-Segura et al. (2006)	70, mechanical neck pain for more than 1 month, positive lateral gliding test (limitation C3-C5)	Matched group: cervical manipulation at limited segment ($n = 34$) Unmatched group: cervical mobilization held for 30″ similar to the manipulation without thrust ($n = 37$)	1 session	Immediately post-intervention	Pain (VAS)	Difference in pain intensity between groups in favor of matched group: −3.1, $p < .01$
Puentedura et al. (2011)	24, 18–60 years, NDI > 20%, CPR for thoracic manipulation[+]	Matched group: cervical manipulation at limited segment plus exercise ($n = 14$) Unmatched group: thoracic global manipulation plus exercise ($n = 10$)	5 sessions over 2 weeks	4 weeks, 6 months	Pain (NRS)	Difference in pain intensity between groups in favor of matched group: −1.83, $p < .001$ at short term, −2.2 $p < .001$ at intermediate-term
Puntumetakul et al. (2015)	48, chronic neck pain, NDI > 10%	Matched group: multiple level thoracic manipulation at limited segments ($n = 16$) Unmatched group: T6–7 spinal manipulation ($n = 16$) Sham manipulation group ($n = 16$)	1 session	1 week after intervention	Pain (VAS) Disability (NDI)	Incomplete data Incomplete data
MATCHING CRITERIA: MANUALLY ASSESSED DIRECTION OF MOVEMENT LIMITATION						
Karas et al. (2018)	69, mechanical neck pain, 18–60 years	Matched group: supine thoracic manipulation at limited segment in the direction of the movement limitation ($n = 34$) Unmatched group: supine thoracic manipulation at limited segment in the opposite direction of the movement limitation ($n = 35$)	1 session	Immediately post-intervention	Pain (NRS) Disability (NDI)	No statistically significant difference in pain intensity between groups. No statistically significant difference in disability between groups.

(*Continued*)

Table 1. (Continued).

	Participants	Interventions	# of sessions	Follow-ups	Outcome	Std Mean difference (95%CI)
MATCHING CRITERIA: CLINICAL PREDICTION RULE FOR THORACIC MANIPULATION						
Cleland et al. (2010)	140, neck pain, 18–60 years, NDI > 20%, CPR for thoracic manipulation^{+}	Matched group: 3 manipulations to mid-thoracic spine plus specific exercise, CPR+ ($n = 33$) Unmatched group: 3 manipulations to mid-thoracic spine plus specific exercise, CPR- ($n = 27$)	5 sessions over 4 weeks	4 weeks, 6 months	Pain (NRS)	No statistically significant difference in pain intensity between groups at short and intermediate-term
					Disability (NDI)	No statistically significant difference in disability between groups at short and intermediate-term
MATCHING CRITERIA: PAIN LOCATION						
Kanlayanaphotporn, Chiradejnant, and Vachalathiti (2009)	60, unilateral neck pain, VAS at rest > 2	Matched group: cervical unilateral postero-anterior cervical mobilization ($n = 30$) Unmatched group: cervical random mobilization ($n = 30$)	1 session	Immediately post-intervention	Pain (VAS)	No statistically significant difference in disability between groups
Kanlayanaphotporn, Chiradejnant, and Vachalathiti (2010)	60, central or bilateral neck pain, VAS at rest > 2	Matched group: cervical central postero-anterior cervical mobilization ($n = 30$) Unmatched group: cervical random mobilization ($n = 30$)	1 session	Immediately post-intervention	Pain (VAS)	No statistically significant difference in disability between groups
MATCHING CRITERIA: UNDEFINED CLINICAL ASSESSMENT						
Lagoutaris, Sullivan, Hancock, and Leaver (2020)	20, acute neck pain, 18–60 years, 2<VAS <7	Matched group: pragmatic cervical mobilization ($n = 10$) Unmatched group: C1–2 and T1–2 unilateral mobilization ($n = 10$)	1 session	48 hours after intervention	Pain (VAS)	No statistically significant difference in pain intensity between groups.
					Disability (NDI)	No statistically significant difference in disability between groups.
EXERCISE THERAPY STUDIES						
MATCHING CRITERIA: TRAPEZIUS MYALGIA						
Andersen et al. (2008)	48, chronic neck pain, women, repetitive work task, tightness and tenderness of upper trapezius	Matched group: Specific neck/shoulder strength training neck/shoulder ($n = 18$) Unmatched group: general aerobic training ($n = 16$) Other group:no treatment ($n = 14$)	3 sessions per week over 10 weeks	10 weeks, 5 months	Pain (VAS)	Difference in pain intensity between groups in favor of matched group: −2.5, $p < .001$ on short term, −1.3 $p < .001$ on intermediate-term
MATCHING CRITERIA: CLINICAL PREDICTION RULE FOR THORACIC MANIPULATION						
Cleland et al. (2010)	140, neck pain, 18–60 years, NDI > 20%, CPR for thoracic manipulation^{+}	Matched group: Stretching and strengthening CPR+ ($n = 29$) Unmatched group: Stretching and strengthening, CPR- ($n = 25$)	5 sessions over 4 weeks	4 weeks, 6 months	Pain (NRS)	No statistically significant difference in pain intensity between groups at short and intermediate-term
					Disability (NDI)	No statistically significant difference in disability between groups at short and intermediate-term

(*Continued*)

Table 1. (Continued).

	Participants	Interventions	# of sessions	Follow-ups	Outcome	Std Mean difference (95%CI)
MATCHING CRITERIA: CRANIO-VERTEBRAL ANGLE						
Im, Kim, Chung, and Hwang (2016)	15, chronic neck pain, shoulder flexion > 130°, CVA < 44°	Matched group: scapular stabilization exercises ($n = 8$) Unmatched group: relaxation exercises ($n = 7$)	12 sessions over 4 weeks	4 weeks	Pain (NRS)	Difference in pain intensity between groups in favor of matched group: −1.3, $p < .001$
					Disability (NDI)	Difference in disability between groups in favor of matched group: −5.6 $p < .001$
Kang, Im, and Kim (2021)	32, neck pain, 20–60 years, VAS > 4, CVA < 53°	Matched group: scapular stabilization and thoracic extension exercise ($n = 16$) Unmatched group: cervical stabilization and stretching exercises ($n = 16$)	18 sessions over 6 weeks	6 weeks	Pain (NRS)	Difference in pain intensity between groups in favor of matched group: −1.1, $p < .013$
					Disability (NDI)	No statistically significant difference in disability between groups at short and intermediate-term
Abd El-Azeim, Mahmoud, Mohamed, and El-Khateeb (2022)	60, chronic neck pain, 20–60 years, CVA < 50°	Matched group: Scapular stabilization exercises and postural correction exercises ($n = 30$) Unmatched group: postural correction exercises ($n = 30$)	30 sessions over 10 weeks	10 weeks	Disability (NDI)	Difference in disability between groups in favor of matched group: −4.9, $p < .001$
Arif, Rehman, and Ikram (2022)	40, chronic neck pain, NDI 5–15, CVA < 50°	Matched group: cervical stabilization, heating pad, TENS, cervical isometric exercises ($n = 20$) Unmatched group: heating pad, TENS, cervical isometric exercises ($n = 20$)	12 sessions over 4 weeks	4 weeks	Pain (NPRS)	Difference in pain between groups in favor of matched group: −1.05, $p < .001$
					Disability (NDI)	Difference in disability between groups in favor of matched group: −3.3, $p < .001$
MATCHING CRITERIA: MANUALLY ASSESSED MOVEMENT LIMITATION						
Lee and Kim (2016)	46, chronic neck pain, 18–60 years, NDI > 20, limited upper cervical and thoracic spine in flexion/extension	Matched group: deep neck flexors strengthening and stretching exercises ($n = 15$) Unmatched group: active mobility exercises ($n = 15$) Other group: manual therapy, deep neck flexors strengthening and stretching exercises ($n = 16$)	30 sessions over 10 weeks	10 weeks	Pain (NRS)	Difference in pain intensity between groups in favor of matched group: −1.3, $p < .001$
					Disability (NDI)	Difference in disability between groups in favor of matched group: −9.7 $p < .001$
Petersen et al. (2015)	72, neck pain	Matched group: pragmatic manual therapy plus movement direction specific exercise ($n = 36$) Unmatched group: pragmatic manual therapy plus general exercises ($n = 36$)	1 session	4 days after intervention	Pain (NRS)	No statistically significant difference in pain intensity between groups
					Disability (NDI)	No statistically significant difference in disability between groups

(*Continued*)

Table 1. (Continued).

	Participants	Interventions	# of sessions	Follow-ups	Outcome	Std Mean difference (95%CI)
MATCHING CRITERIA: ABNORMAL JOINT POSITION SENSE						
Jull et al. (2007)	58, chronic neck pain, abnormal joint position sense	Matched group: proprioceptive training exercise ($n = 28$) Unmatched group: deep neck flexors strengthening exercises ($n = 30$)	6 sessions over 6 weeks	7 weeks	Pain (NRS)	No statistically significant difference in pain intensity between groups
					Disability (NDI)	No statistically significant difference in disability between groups
MATCHING CRITERIA: MECHANICAL DIAGNOSIS AND THERAPY CRITERIA						
Kjellman and Öberg (2002)	77, neck pain provoked by active/sustained movement, foraminal test, upper limb tension test	Matched group: mechanical diagnosis and therapy criteria ($n = 28$) Unmatched group: general exercises ($n = 23$) Other group: ultrasound ($n = 26$)	16 sessions over 8 weeks	8 weeks, 6 months, 12 months	Pain (NRS)	No statistically significant difference in pain intensity between groups at short and intermediate-term
					Disability (NDI)	No statistically significant difference in disability between groups at short and intermediate-term
Takasaki and Yamasaki (2023)	19, neck pain, direction preference for cervical retraction or extension	Matched group: seated repeated retraction exercise ($n = 9$) Unmatched group: Supine repeated cranio-cervical flexion exercise ($n = 10$)	1 session	Immediately post-intervention	Pain (NRS)	No statistically significant difference in pain intensity between groups
MATCHING CRITERIA: MUSCLE WEAKNESS						
Kotteeswaran and Nayak (2021)	30, neck pain, 20–60 years	Matched group: weak scapular muscle strengthening exercises plus interferential therapy ($n = 15$) Unmatched group: resisted neck isometric exercises plus interferential therapy ($n = 15$)	12 sessions over 4 weeks	4 weeks	Disability (NDI)	Incomplete data
Giménez-Costa et al. (2022)	46, women, chronic neck pain, VAS 3–5/10, <250s neck extensor resistance test	Matched group: specific neck extensor exercise and home exercise program ($n = 23$) Unmatched group: general neck extensor exercise and home exercise program ($n = 23$)	6 sessions over 6 weeks	6 weeks,	Pain (NPRS)	No statistically significant difference in pain intensity between groups at short term
				6 weeks, 6 months	Disability (NDI)	No statistically significant difference in disability at short term and intermediate term
DIFFERENT TREATMENT STUDIES						
MATCHING CRITERIA: PHYSIOTHERAPIST PREFERENCE						
Paoloni et al. (2012)	220, neck pain, VAS > 4	Matched group: combination of electrotherapy, exercise, manual therapy decided by physiotherapists ($n = 114$) Unmatched group: medical doctor prescribed combination of electrotherapy, exercise, manual therapy ($n = 106$)	10 sessions over 3 weeks	4 weeks	Pain (VAS)	Difference in pain intensity between groups in favor of matched group: −0.42, $p < .05$
					Disability (NPDS-I)	Difference in disability between groups in favor of matched group: −0.30, $p < .05$

(*Continued*)

Table 1. (Continued).

	Participants	Interventions	# of sessions	Follow-ups	Outcome	Std Mean difference (95%CI)
MATCHING CRITERIA: ACTIVE TRIGGER POINTS						
Martín-Rodríguez, Sáez-Olmo, Pecos-Martín, and Calvo-Lobo (2019)	34, neck pain, 20–58 years, sternocleidomastoid active trigger point	Matched group: dry needling on the trigger points ($n = 17$) Unmatched group: dry needling 1.5 cm away from trigger points ($n = 17$)	1 session	1 month	Pain (VAS)	No statistically significant difference in pain intensity between groups
					Disability (NDI)	No statistically significant difference in disability between groups
MATCHING CRITERIA: CHINESE TRADITIONAL ACUPUNCTURE POINTS						
Gu, Yan, Zhang, and Li (2019)	60, 18–70 years, spondilosys on X-rays	Matched group: 7 acupunture points needling plus mechanical traction ($n = 30$) Unmatched group: random acupuncture needling plus mechanical traction ($n = 30$)	10 sessions over 11 days	11 days	Pain (VAS)	Difference in pain between groups in favor of matched group: −0.54, $p < .05$
					Disability (NDI)	Difference in disability between groups in favor of matched group: −1.52, $p < .05$

+ CPR for thoracic manipulation: symptoms <30 days, no symptoms below the shoulder, cervical spine extension does not aggravate FABQPA < 12, cervical spine extension < 30°, decreased thoracic kyphosis.

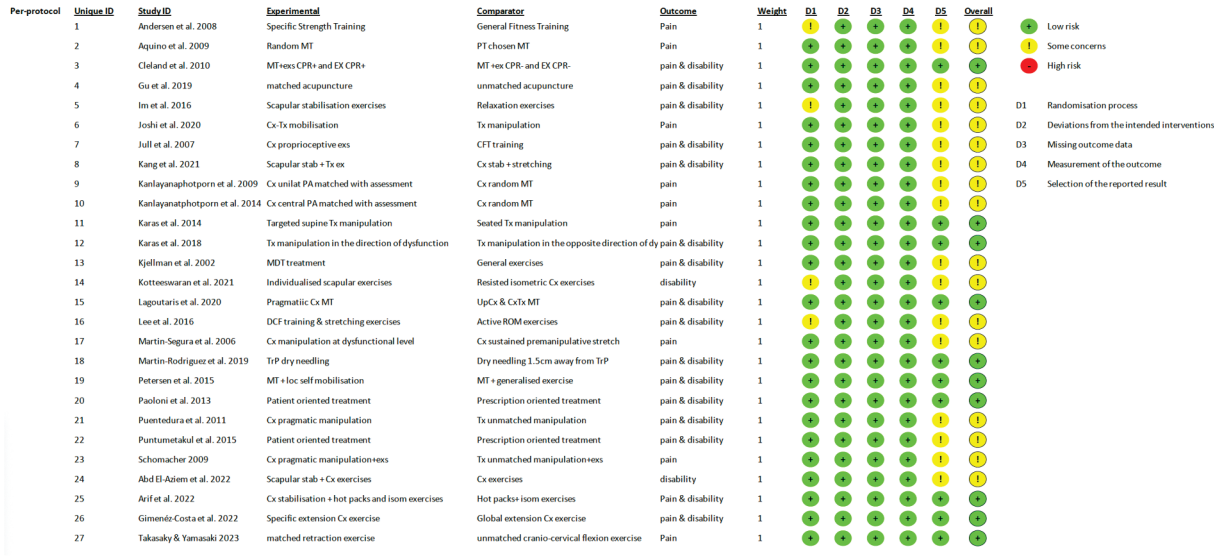

Figure 2. Risk of bias assessment.

more effective than unmatched manual therapy for improving short-term pain (SMD −0.48; 95% CI −1.12, 0.17) (Figure 3) or short-term disability (SMD −0.35; 95% CI −1.35, 0.66) (GRADE: Low) (Fig3 **4**). The Cohen's d was moderate for pain (Figure 3) and small for disability (Figure 4).

Manual therapy matched vs unmatched - pain and disability intermediate-term

Two studies compared matched with unmatched manual therapy for pain and disability at intermediate-term. Matched manual therapy was not more effective than unmatched manual therapy for improving intermediate-

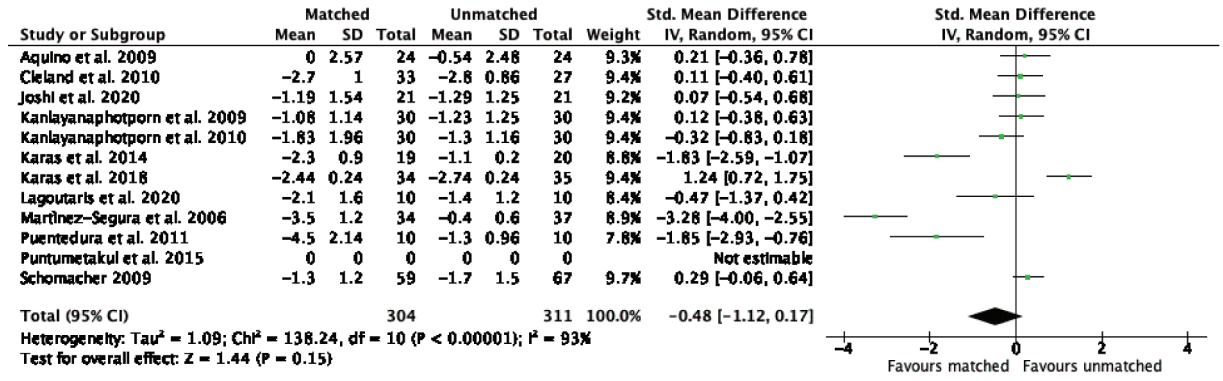

Figure 3. Forest plot of matched manual therapy compared to unmatched on pain at short-term follow-up.

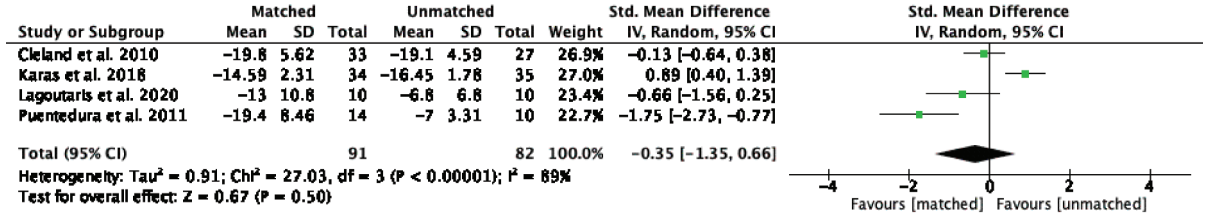

Figure 4. Forest plot of matched manual therapy compared to unmatched on disability at short-term follow up.

term pain (SMD −0.63; 95% CI −2.76,1.50) (Figure 5) or intermediate-term disability (SMD −0.55; 95% CI −2.16, 1.07) (GRADE: Very Low) (Figure 6) The Cohen's d was moderate for both outcomes (Figure 5 and 6).

Exercise matched vs unmatched – pain and disability short-term

Twelve studies compared matched with unmatched exercise for pain and disability at short-term. Matched exercise therapy was significantly more effective compared to unmatched exercise for improving short-term pain (SMD −0.57; 95% CI −0.95, −0.18) (GRADE: Moderate) (Figure 8) or short-term disability (SMD −0.69; 95% CI −1.14, −0.23) (GRADE: Low) (Figure 9). The Cohen's d was large for pain and moderate for disability (Figure 8 and 9).

Exercise matched vs unmatched - pain and disability intermediate-term

Three studies compared matched with unmatched exercise for pain and two studies for disability at intermediate-term. Matched exercise therapy was not more effective than unmatched exercise for pain (SMD −0.37; 95% CI −0.88, 0.15) (GRADE: Moderate) (Figures 7 and 8)(Figure 10), or disability (SMD 0.12; 95% CI −0.21, 0.45) (GRADE: High) (Figure 11). The Cohen's d was small for both outcomes (Figure 10 and 11 and 12).

Other interventions

Gu, Yan, Zhang, and Li (2019) compared acupuncture applied using the Chinese medicine criteria with randomly applied acupuncture and found statistically significant results in favor of the matched group for pain (STD −0.54; 95% CI −1.06, −0.03), and disability (STD −1.52; 95% CI −2.09, −0.94) at short term with moderate and large Cohen's d respectively. Martín-Rodríguez, Sáez-Olmo, Pecos-Martín, and Calvo-Lobo (2019) compared dry needling applied on sternocleidomastoid trigger points with dry needling applied randomly away from trigger points. Randomly applied trigger points were statistically significantly better in terms of pain (STD 0.84; 95% CI 0.13, 1.54) with large Cohen's d, while disability did not differ significantly (STD 0.15.; 95% CI −0.53, 0.82) with small Cohen's d at short term.

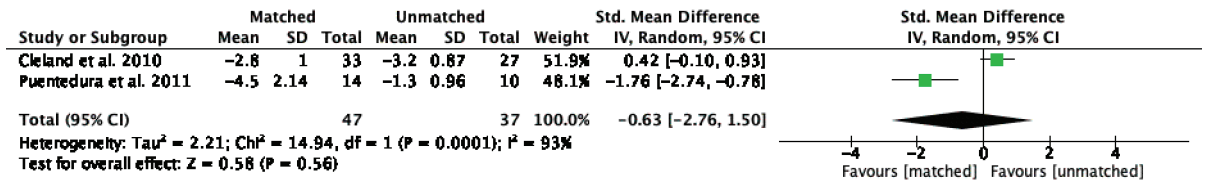

Figure 5. Forest plots of matched manual therapy compared to unmatched on pain at short-term follow-up.

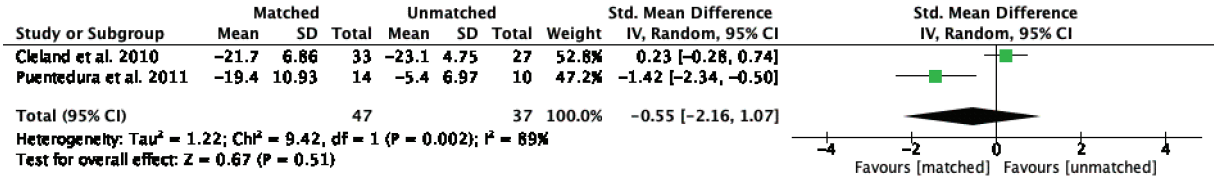

Figure 6. Forest plots of matched manual therapy compared to unmatched on disability at intermediate-term follow-up.

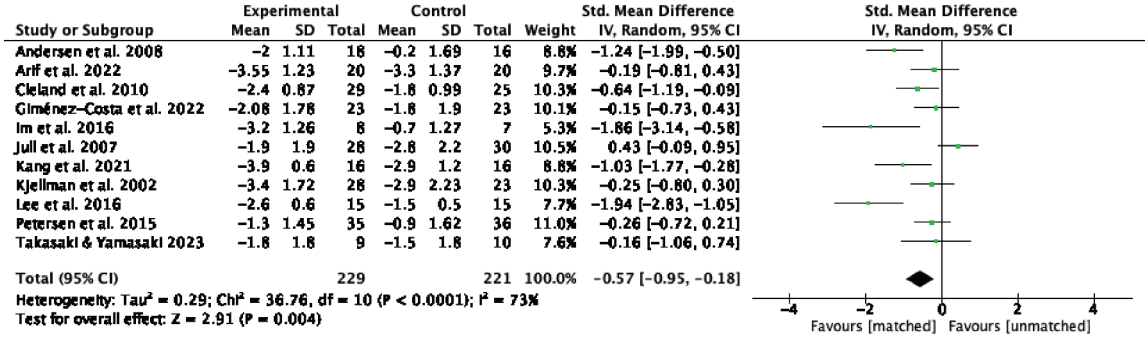

Figure 7. Manual therapy, quality of the evidence (GRADE assessment).

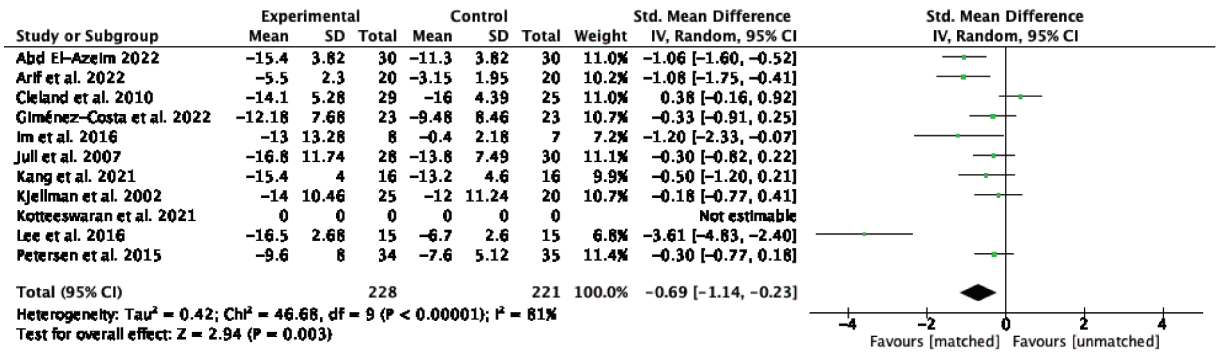

Figure 8. Forest plot of matched exercise compared to unmatched on pain at short-term follow up.

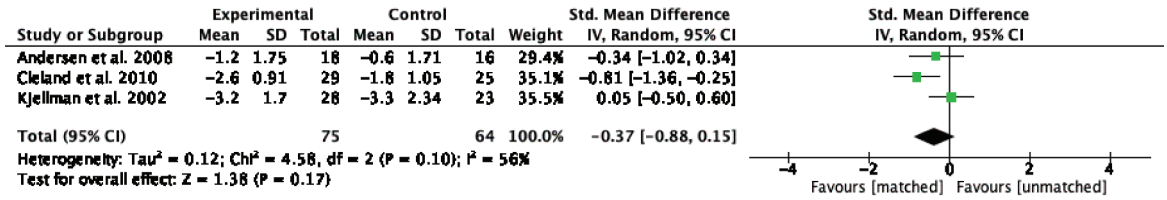

Figure 9. Forest plot of matched exercise compared to unmatched on disability at short-term follow up.

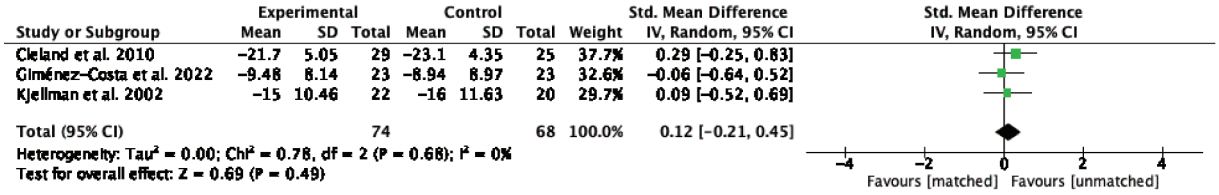

Figure 10. Forest plot of matched exercise compared to unmatched on pain at intermediate-term follow-up.

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	matched manual therapy	unmatched manual therapy	Relative (95% CI)	Absolute (95% CI)		
Pain short-term (assessed with: VAS/NRS; Scale from: 0 to 10)												
12	randomised trials	not serious	very serious[a]	not serious	not serious	none	304	311	-	SMD **0.48 SD lower** (1.12 lower to 0.17 higher)	⨁⨁◯◯ Low	CRITICAL
Disability short-term (assessed with: %NDI; Scale from: 0 to 100)												
4	randomised trials	not serious	very serious[a]	not serious	not serious	none	91	82	-	SMD **0.35 SD lower** (1.35 lower to 0.66 higher)	⨁⨁◯◯ Low	CRITICAL
Pain intermediate-term (follow-up: range 3 months to 6 months; assessed with: VAS/NRS; Scale from: 0 to 10)												
2	randomised trials	not serious	very serious[a]	not serious[a,b]	serious[b]	none	47	37	-	SMD **0.63 SD lower** (2.76 lower to 1.5 higher)	⨁◯◯◯ Very low	IMPORTANT
Disability intermediate-term (follow-up: range 3 months to 6 months; assessed with: %NDI; Scale from: 0 to 100)												
2	randomised trials	not serious	very serious[a]	not serious	serious[b]	none	47	37	-	SMD **0.55 SD lower** (2.16 lower to 1.07 higher)	⨁◯◯◯ Very low	IMPORTANT

Figure 11. Forest plot of matched exercise compared to unmatched on disability at intermediate-term follow up.

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	matched exercise	unmatched exercise	Relative (95% CI)	Absolute (95% CI)		
Pain short-term (assessed with: VAS/NRS; Scale from: 0 to 10)												
11	randomised trials	not serious	serious[a]	not serious	not serious	none	229	221	-	SMD **0.57 SD lower** (0.95 lower to 0.18 lower)	⨁⨁⨁◯ Moderate	CRITICAL
Disability short-term (assessed with: %NDI; Scale from: 0 to 100)												
11	randomised trials	not serious	very serious[a]	not serious	not serious	none	228	221	-	SMD **0.69 SD lower** (1.14 lower to 0.23 higher)	⨁⨁◯◯ Low	CRITICAL
Pain intermediate-term (follow-up: range 3 months to 6 months; assessed with: VAS/NRS; Scale from: 0 to 10)												
3	randomised trials	not serious	serious[b]	not serious	not serious	none	75	64	-	SMD **0.37 SD lower** (0.88 lower to 0.15 lower)	⨁⨁⨁◯ Moderate	IMPORTANT
Disability intermediate-term (follow-up: range 3 months to 6 months; assessed with: %NDI; Scale from: 0 to 100)												
3	randomised trials	not serious	not serious	not serious	not serious	none	74	68	-	SMD **0.12 SD higher** (0.21 lower to 0.45 higher)	⨁⨁⨁⨁ High	IMPORTANT

Figure 12. Exercise, quality of the evidence (GRADE assessment).

Paoloni et al. (2012) found that matching a multimodal treatment to patient assessment was better, but not significantly better, than delivering it according to a standardized prescription by a medical doctor both in terms of pain (STD −0.42; 95% CI −0.68, 0.15), and disability (STD −0.30; 95% CI −0.57, 0.03) at short term with small and moderate Cohen's d respectively.

Discussion

This systematic review investigated whether matched intervention led to better pain and disability outcomes compared to unmatched interventions for people with NSNP. Twenty-seven RCTs met the inclusion criteria, 12 were eligible for a meta-analysis on manual therapy, and 13 for exercise. Matched exercise therapy was significantly more effective than unmatched exercise for pain (GRADE: Moderate) and disability (GRADE: Low) at short term, but not in the intermediate-term. Matched manual therapy was not more effective than unmatched manual therapy for pain and disability either in the short or intermediate term.

Matched vs unmatched exercise intervention

Our review found that matched exercise interventions were more effective than unmatched exercise interventions for improving pain and disability in the short term, but not in the intermediate-term. However, in a recent systematic review, Villanueva-Ruiz, Falla, and Lascurain-Aguirrebeña (2022) found no advantage to tailoring neck specific exercise to patients with motor control dysfunction compared to the same exercise prescribed to patients not tested for motor control dysfunction. However, considering that neck pain patients tend to have reduced capacity to sustain isometric cranio-cervical flexion (O'Leary, Jull, Kim, and Vicenzino, 2007) the studies that did not test patients for motor control dysfunction are likely to have included patients with neck flexors deficits which may have confounded the results. Furthermore, the only muscle function test used was the cranio-cervical flexion test, and a more comprehensive cluster of clinical tests may have better matched the intervention to the patients (Segarra et al., 2015). In their RCT, Svedmark et al. (2016) compared exercise

interventions tailored to individual's functional limitations and symptoms such as cervical movement limitation, neck muscle strength impairments, impaired sensorimotor control, trapezius myalgia, and cervicogenic headache with semi-random unmatched interventions. However, even this attempt led to no difference in pain and disability at short, intermediate, and long term.

The conflicting results within our review could be explained in several ways. Firstly, inadequate matching processes may explain why no exercise modality seems clearly superior to another for musculoskeletal pain lasting more than three months (Gross et al., 2015). Secondly, optimal exercise dosage, in terms of load, volume and frequency of training is unknown, and the failure to increase or adapt some or all the parameters to the patient evolving situation may hinder the efficacy of the management over time (Svedmark et al., 2020; Wilhelm et al., 2020).

Thirdly, the studies reviewed matched exercise according only to patient presentation. It is possible that neglecting patient goals and perceived threats with exercise hindered the effects of matching in the intermediate-term. Fourthly, only three studies had intermediate-term follow-up for pain and for disability (Andersen et al., 2008; Cleland et al., 2010; Giménez-Costa et al., 2022; Kjellman and Öberg, 2002). The low number of studies with longer follow-up, and, the low number of participants, could, in part, explain the non-significant intermediate-term results.

Another possible explanation for these non-significant findings in the intermediate-term could relate to decline of exercise adherence. Maintaining adherence to exercise is a key factor for maintaining benefit over time (Jordan, Holden, Mason, and Foster, 2010). Of the three papers with intermediate-term follow-up only Andersen et al. (2008) reported high adherence in both groups measured through the compilation of logbooks. Thus, a progressive decrease of exercise adherence cannot be excluded.

The greatest difference between matched and unmatched treatments was demonstrated in the: trapezius myalgia (Andersen et al., 2008); CVA (Abd El-Azeim, Mahmoud, Mohamed, and El-Khateeb, 2022; Arif, Rehman, and Ikram, 2022; Im, Kim, Chung, and Hwang, 2016; Kang, Im, and Kim, 2021); and movement limitation sub-groups (Cleland et al., 2010; Lee and Kim, 2016), perhaps this result provides evidence for clinicians to use matched exercise intervention for these three subgroups and may therefore warrant further investigation.

Matched vs unmatched manual therapy intervention

Our findings suggest that matched manual therapy is not more effective than unmatched manual therapy. Similarly, a recent systematic review found that there was no difference between spinal manual therapy applied to clinically relevant segments and manual therapy applied to randomly chosen segments (Nim et al., 2021). However, manual therapy has the capacity to activate peripheral, spinal and supraspinal pain inhibitory responses (Bialosky et al., 2018). For example, it can increase pressure pain threshold in the application site (Voogt et al., 2015), but also has remote pain modulation effects (Lascurain-Aguirrebena, Newham, and Critchley, 2016). Furthermore, a thorough assessment and manual therapy are part of the expectations of patients referred to physical therapy and may influence nociception through modulation of cortical networks and descending inhibitory pathways, in particular in chronic pain patients (Bialosky, Bishop, and Penza, 2017; Subialka et al., 2022). If the remote neurophysiological and psychological effects predominate, then potentially the site of application is less important, as well as any assessment process to decide where to apply it.

Only two studies reviewed (Cleland et al., 2010; Puentedura et al., 2011) used exercises with manual therapy, whereas the majority of international guidelines recommend the use of manual therapy in association with exercise and not as a stand-alone (Corp et al., 2021). A recent systematic review highlighted that combining different forms of manual therapy may augment the effect of manual therapy or exercise therapy performed in isolation because, possibly, manual therapy may increase the activity of deep neck flexors and reduce that of superficial muscles on the short term, or have some other unknown neurophysiological effect, thus increasing the exercises' efficacy (Hidalgo et al., 2017; Sterling, Jull, and Wright, 2001).

The matching criteria used to decide if and where to apply manual therapy were most painful and/or hypomobile segment or side or a set of criteria involving active movement limitation, pain duration, and location and low impact of fear avoidance beliefs. The studies that showed the best results in favor of matched treatment were those looking for movement limitation (Karas and Olson Hunt, 2014; Martínez-Segura et al., 2006; Puentedura et al., 2011) indicating that this could be a promising criterion to predict benefit from manual therapy.

Strengths and limitations of this review

The main strengths of this review are that we conducted a search in seven databases, adopting all recommendations proposed by the Cochrane Handbook for Systematic Reviews (Higgins et al., 2019) and used the RoB 2 and the GRADE framework for evaluating the quality of evidence. Nevertheless, the review also has some limitations. First, two papers selected for the meta-analysis had incomplete data and, despite contacting the authors, it was not possible to include those results. Secondly, the high heterogeneity of the studies led to high variability in results and then to lower levels of certainty for some of the findings. Thirdly, there were few trials with intermediate-term and only one with long-term follow-up. Missing data meant that data extrapolation increased reliance on fewer trials. Again, this reduces the certainty of any advantages offered by a matching process to increase the effectiveness of treatments for patients with the neck pain.

Clinical implications

Our review provides evidence to support the use of exercise that is matched to patient presentation in the short term for improving pain (moderate) and disability (low) for patients with NSNP. For example, neck/shoulder strength training for women with trapezius myalgia, scapular stabilization, and thoracic spine extension exercise in case of CVA, or deep neck flexors strengthening in people with upper cervical spine flexion and thoracic spine extension movement limitation. In the intermediate-term the use of matched exercise is not supported, and it is possible that as treatment is progressed that greater focus can be given toward exercise-based strategies that are tailored to achieving the patients' functional goals.

Implication for future research

The matching of treatment for patients with neck pain to the results of a clinical assessment can be supported only if a clear set of factors for predicting benefit from exercise therapy or manual therapy can be identified. The results of this review did not provide definite answers, and this might be due to the heterogeneity of the matching criteria investigated.

The revision of clinical practice guidelines for NP of the American Physical Therapy Association suggested to categorize patients according to acute or chronic stage and to the presence of movement limitation or movement coordination impairments (Blanpied et al., 2017). However, they suggested both exercise therapy and manual therapy interventions in presence of movement limitations and of movement coordination impairment, again, offering no clear guidance to clinicians. Further research into potentially useful matching criteria used in clinical practice by expert physiotherapists may support new directions for investigation and may also improve the management of neck pain in clinical practice. Qualitative research designs, investigating these criteria may be better suited to derive key clinical features than prospective cohort studies previously used in derivation stage of clinical prediction rules. Subsequently, RCTs with inclusion criteria based on those clinical features may support their usefulness into clinical practice.

Conclusion

The results of this systematic review and meta-analysis suggest that matching exercise therapy to patient clinical features may lead to better results than unmatched treatments in neck pain patients, but only at short-term follow-up. Matched manual therapy was not superior to unmatched manual therapy at short or at intermediate term. The trials included in the meta-analysis used widely different matching criteria and this created a wide level of heterogeneity reducing the overall quality of evidence. Movement limitation, trapezius myalgia and forward head position could be useful criteria, perhaps able to predict a better outcome for patients receiving matched treatments but need further investigation.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

References

Abd El-Azeim AS, Mahmoud AG, Mohamed MT, El-Khateeb YS 2022 Impact of adding scapular stabilization to postural correctional exercises on symptomatic forward head posture: A randomized controlled trial. European Journal of Physical and Rehabilitation Medicine 58: 757–766.

Andersen LL, Andersen CH, Zebis MK, Nielsen PK, Søgaard K, Sjøgaard G 2008 Effect of physical training on function of chronically painful muscles: A randomized controlled trial. Journal of Applied Physiology 105: 1796–1801.

Andersen LL, Kjær M, Søgaard K, Hansen L, Kryger AI, Sjøgaard G 2008 Effect of two contrasting types of physical exercise on chronic neck muscle pain. Arthritis Care and Research 59: 84–91.

Aquino RL, Caires PM, Furtado FC, Louriero AV, Ferreira PH, Ferreira ML 2009 Applying joint mobilization

at different cervical vertebral levels does not influence immediate pain reduction in patients with chronic neck pain: A randomized clinical trial. Journal of Manipulative and Physiological Therapeutics 17: 95–100.

Arif T, Rehman SS, Ikram M 2022 Effects of cervical stabilisation exercises on respiratory strength in chronic neck pain patients with forward head posture. Journal of the Pakistan Medical Association 72: 1635–1638.

Bialosky JE, Beneciuk JM, Bishop MD, Coronado RA, Penza CW, Simon CB, George SZ 2018 Unraveling the mechanisms of manual therapy: Modeling an approach. Journal of Orthopaedic and Sports Physical Therapy 48: 8–18.

Bialosky JE, Bishop MD, Penza CW 2017 Placebo mechanisms of manual therapy: A sheep in Wolf's clothing? Journal of Orthopaedic and Sports Physical Therapy 47: 301–304.

Blanpied PR, Gross AR, Elliott JM, Devaney LL, Clewley D, Walton DM, Sparks C, Robertson EK 2017 Clinical practice guidelines linked to the international classification of functioning, disability and health from the orthopaedic section of the American Physical therapy Association. Journal of Orthopaedic and Sports Physical Therapy 47: A1–A83.

Carroll LJ, Hogg-Johnson S, van der Velde G, Haldeman S, Holm LW, Carragee EJ, Hurwitz EL, Côté P, Nordin M, Peloso PM, et al. 2009 Course and prognostic factors for neck pain in the general population. Results of the bone and joint decade 2000-2010 task force on neck pain and its associated disorders. Journal of Manipulative and Physiological Therapeutics 32: 75–82.

Cleland JA, Mintken PE, Carpenter K, Fritz JM, Glynn P, Whitman J, Childs JD 2010 Examination of a clinical prediction rule to identify patients with neck pain likely to benefit from thoracic spine thrust manipulation and a general cervical range of motion exercise: Multi-center randomized clinical trial. Physical Therapy 90: 1239–1250.

Corp N, Mansell G, Stynes S, Wynne-Jones G, Morsø L, Hill JC, van der Windt DA 2021 Evidence-based treatment recommendations for neck and low back pain across Europe: A systematic review of guidelines. European Journal of Pain 25: 275–295.

Giménez-Costa M, Schomacher J, Murillo C, Sentandreu T, Falla D, Lluch E 2022 Specific versus non-specific exercises for the neck extensor muscles in women with chronic idiopathic neck pain: A randomized controlled trial. Musculoskeletal Science and Practice 60: 102561.

Gross A, Kay TM, Paquin JP, Blanchette S, Lalonde P, Christie T, Dupont G, Graham N, Burnie SJ, Gelley G, et al. 2015 Exercises for mechanical neck disorders. Cochrane Database of Systematic Reviews 1: CD004250.

Gu CL, Yan Y, Zhang D, Li P 2019 An evaluation of the effectiveness of acupuncture with seven acupoint-penetrating needles on cervical spondylosis. Journal of Pain Research 12: 1441–1445.

Guyatt GH, Oxman AD, Kunz R, Woodcock J, Brozek J, Helfand M, Alonso-Coello P, Glasziou P, Jaeschke R, Akl EA, et al. 2011 GRADE guidelines: 7. Rating the quality of evidence - inconsistency. Journal of Clinical Epidemiology 64: 1294–1302.

Guyatt GH, Oxman AD, Sultan S, Glasziou P, Akl EA, Alonso-Coello P, Atkins D, Kunz R, Brozek J, Montori V et al. 2011 GRADE guidelines: 9. Rating up the quality of evidence. Journal of Clinical Epidemiology 64: 1311–1316.

Hidalgo B, Hall T, Bossert J, Dugeny A, Cagnie B, Pitance L 2017 The efficacy of manual therapy and exercise for treating non-specific neck pain: A systematic review. Journal of Back and Musculoskeletal Rehabilitation 30: 1149–1169.

Higgins JP, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Walch VA 2019 Cochrane Handbook for systematic reviews of interventions (2nd ed). Chichester (UK): John Wiley & Sons.

Higgins JP, Thompson SG, Deeks JJ, Altman DG 2003 Measuring inconsistency in meta-analyses. British Medical Journal 327: 557–560.

Im B, Kim Y, Chung Y, Hwang S 2016 Effects of scapular stabilization exercise on neck posture and muscle activation in individuals with neck pain and forward head posture. Journal of Physical Therapy Science 28: 951–955.

Jordan JL, Holden MA, Mason E, Foster NE 2010 Interventions to improve adherence to exercise for chronic musculoskeletal pain in adults. Cochrane Database of Systematic Reviews 2010: CD005956.

Joshi S, Balthillaya G, Neelapala YV 2020 Immediate effects of cervicothoracic junction mobilization versus thoracic manipulation on the range of motion and pain in mechanical neck pain with cervicothoracic junction dysfunction: A pilot randomized controlled trial. Chiropractic and Manual Therapies 28: 38.

Jull G, Falla D, Treleaven J, Hodges PW, Vicenzino B 2007 Retraining cervical joint position sense: The effect of two exercise regimes. Journal of Orthopaedic Research 25: 404–412.

Jull G, Moore A 2020 Systematic reviews in review. Musculoskeletal Science and Practice 46: 102135.

Kang NY, Im SC, Kim K 2021 Effects of a combination of scapular stabilization and thoracic extension exercises for office workers with forward head posture on the craniovertebral angle, respiration, pain, and disability: A randomized-controlled trial. Turkish Journal of Physical Medicine and Rehabilitation 67: 291–299.

Kanlayanaphotporn R, Chiradejnant A, Vachalathiti R 2009 The immediate effects of mobilization technique on pain and range of motion in patients presenting with unilateral neck pain: A randomized controlled trial. Archives of Physical Medicine and Rehabilitation 90: 187–192.

Kanlayanaphotporn R, Chiradejnant A, Vachalathiti R 2010 Immediate effects of the central posteroanterior mobilization technique on pain and range of motion in patients with mechanical neck pain. Disability and Rehabilitation 32: 622–628.

Karas S, Olson Hunt MJ 2014 A randomized clinical trial to compare the immediate effects of seated thoracic manipulation and targeted supine thoracic manipulation on cervical spine flexion range of motion and pain. Journal of Manual and Manipulative Therapy 22: 108–114.

Karas S, Olson Hunt MJ, Temes B, Thiel M, Swoverland T, Windsor B 2018 The effect of direction specific thoracic spine manipulation on the cervical spine: A randomized controlled trial. Journal of Manual and Manipulative Therapy 26: 3–10.

Kelly J, Ritchie C, Sterling M 2017 Clinical prediction rules for prognosis and treatment prescription in neck pain: A systematic review. Musculoskeletal Science and Practice 27: 155–164.

Kjellman G, Öberg B 2002 A randomized clinical trial comparing general exercise, McKenzie treatment and a control group in patients with neck pain. Journal of Rehabilitation Medicine 34: 183–190.

Kotteeswaran K, Nayak CK 2021 A study to find the effectiveness of scapular strengthening exercise in patients with cervical dysfunction. Research Journal of Pharmacy and Technology 14: 3591–3594.

Lagoutaris C, Sullivan J, Hancock M, Leaver AM 2020 Approaches to cervical spine mobilization for neck pain: A pilot randomized controlled trial. Chiropractic and Manual Therapies 28: 61.

Lascurain-Aguirrebena I, Newham D, Critchley DJ 2016 Mechanism of action of spinal mobilizations: A systematic review. Spine 41: 159–172.

Lee KW, Kim WH 2016 Effect of thoracic manipulation and deep craniocervical flexor training on pain, mobility, strength, and disability of the neck of patients with chronic nonspecific neck pain: A randomized clinical trial. Journal of Physical Therapy Science 28: 175–180.

Maissan F, Pool J, de Raaij E, Wittink H, Ostelo R 2020 Treatment based classification systems for patients with non-specific neck pain. A systematic review. Musculoskeletal Science and Practice 47: 102133.

Martínez-Segura R, Fernández-de-Las-Peñas C, Ruiz-Sáez M, López-Jiménez C, Rodríguez-Blanco C 2006 Immediate effects on neck pain and active range of motion after a single cervical high-velocity low-amplitude manipulation in subjects presenting with mechanical neck pain: A randomized controlled trial. Journal of Manipulative and Physiological Therapeutics 29: 511–517.

Martín-Rodríguez A, Sáez-Olmo E, Pecos-Martín D, Calvo-Lobo C 2019 Effects of dry needling in the sternocleidomastoid muscle on cervical motor control in patients with neck pain: A randomised clinical trial. Acupuncture in Medicine 37: 151–163.

Nim CG, Downie A, O'Neill S, Kawchuk GN, Perle SM, Leboeuf-Yde C 2021 The importance of selecting the correct site to apply spinal manipulation when treating spinal pain: Myth or reality? A systematic review. Scientific Reports 11: 23415.

O'Leary S, Jull G, Kim M, Vicenzino B 2007 Cranio-cervical flexor muscle impairment at maximal, moderate, and low loads is a feature of neck pain. Manual Therapy 12: 34–39.

Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, et al. 2021 The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 372: n71.

Paoloni M, Tavernese E, Cacchio A, Tattoli A, Melis L, Ronconi R, Santilli V 2012 Patient-oriented rehabilitation in the management of chronic mechanical neck pain: A randomized controlled trial. European Journal of Physical and Rehabilitation Medicine 48: 273–281.

Petersen SB, Cook C, Donaldson M, Hassen A, Ellis A, Learman K 2015 The effect of manual therapy with augmentative exercises for neck pain: A randomised clinical trial. Journal of Manual and Manipulative Therapy 23: 264–274.

Puentedura EJ, Landers MR, Cleland JA, Mintken P, Huijbregts P, Fernandez-De-Las-Peñas C 2011 Thoracic spine thrust manipulation versus cervical spine thrust manipulation in patients with acute neck pain: A randomized clinical trial. Journal of Orthopaedic & Sports Physical Therapy 41: 208–220.

Puntumetakul R, Suvarnnato T, Werasirirat P, Uthaikhup S, Yamauchi J, Boucaut R 2015 Acute effects of single and multiple level thoracic manipulations on chronic mechanical neck pain: A randomized controlled trial. Neuropsychiatric Disease and Treatment 11: 137–144.

Safiri S, Kolahi AA, Hoy D, Buchbinder R, Mansournia MA, Bettampadi D, Ashrafi-Asgarabad A, Almasi-Hashiani A, Smith E, Sepidarkish M, et al. 2020 Global, regional, and national burden of neck pain in the general population, 1990-2017: Systematic analysis of the global burden of disease study 2017. BMJ 368: m791.

Schomacher J 2009 The effect of an analgesic mobilization technique when applied at symptomatic or asymptomatic levels of the cervical spine in subjects with neck pain: A randomized controlled trial. Journal of Manual and Manipulative Therapy 17: 101–108.

Segarra V, Dueñas L, Torres R, Falla D, Jull G, Lluch E 2015 Inter-and intra-tester reliability of a battery of cervical movement control dysfunction tests. Manual Therapy 20: 570–579.

Silva PV, Costa LO, Maher CG, Kamper SJ, Costa LD 2019 The new agenda for neck pain research: A modified delphi study. Journal of Orthopaedic and Sports Physical Therapy 49: 666–674.

Sterling M, Jull G, Wright A 2001 Cervical mobilisation: Concurrent effects on pain, sympathetic nervous system activity and motor activity. Manual Therapy 6: 72–81.

Sterne JA, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, Cates CJ, Cheng HY, Corbett MS, Eldridge SM, et al. 2019 RoB 2: A revised tool for assessing risk of bias in randomised trials. BMJ 366: l4898.

Subialka JA, Smith K, Signorino JA, Young JL, Rhon DI, Rentmeester C 2022 What do patients referred to physical therapy for a musculoskeletal condition expect? A qualitative assessment. Musculoskeletal Science and Practice 59: 102543.

Sullivan GM, Feinn R 2012 Using effect size - or why the P value is not enough. Journal of Graduate Medical Education 4: 279–282.

Svedmark Å, Djupsjöbacka M, Hager C, Jull G, Bjorklund M 2016 Is tailored treatment superior to non-tailored treatment for pain and disability in women with non-specific neck pain? A randomized controlled trial. BMC Musculoskeletal Disorders 17: 408.

Svedmark Å, Djupsjöbacka M, Hager C, Jull G, Bjorklund M, Falla D, Hodges PW, O'Riordan C, Clifford A, Van De Ven P, et al. 2020 Chronic neck pain and exercise interventions: Frequency, intensity, time, and type principle. Musculoskeletal Science and Practice 15: 105–115.

Takasaki H, Yamasaki C 2023 Immediate neck hypoalgesic effects of craniocervical flexion exercises and cervical retraction exercises among individuals with non-acute neck pain and a directional preference for retraction or extension: Preliminary pretest-posttest randomized experimen. Journal of Manual and Manipulative Therapy 31: 368–375.

Takeshima N, Sozu T, Tajika A, Ogawa Y, Hayasaka Y, Furukawa TA 2014 Which is more generalizable, powerful and interpretable in meta-analyses, mean difference or standardized mean difference? BMC Medical Research Methodology 14: 30.

Verhagen AP 2021 Physiotherapy management of neck pain. Journal of Physiotherapy 67: 5–11.

Villanueva-Ruiz I, Falla D, Lascurain-Aguirrebeña I 2022 Effectiveness of specific neck exercise for nonspecific neck pain; usefulness of strategies for patient selection and tailored exercise - a systematic review with meta-analysis. Physical Therapy 102: zab259.

Voogt L, de Vries J, Meeus M, Struyf F, Meuffels D, Nijs J 2015 Analgesic effects of manual therapy in patients with musculoskeletal pain: A systematic review. Manual Therapy 20: 250–256.

Vos T, Allen C, Arora M, Barber RM, Brown A, Carter A, Casey DC, Charlson FJ, Chen AZ 2016 Coggeshall M et al 2016 global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: A systematic analysis for the global burden of disease study 2015. Lancet 388: 1545–1602.

Wilhelm MP, Donaldson M, Griswold D, Learman KE, Garcia AN, Learman SM, Cleland JA 2020 The effects of exercise dosage on neck-related pain and disability: A systematic review with meta-analysis. Journal of Orthopaedic and Sports Physical Therapy 50: 607–621.

Appendix 1 - Search strategies

EMBASE

"neck pain" OR (chronic AND neck AND pain) OR (mechanical AND neck AND pain) OR (cervical AND spine)

AND

rehabil* OR (manual AND therapy) OR manipul* OR mobili* OR exerc* OR education OR train* OR (endurance training) OR (motor control training) OR (neuromuscular training) OR (stabilization training) OR (deep cervical flexor training) OR (craniocervical flexor training)

neck AND pain NOT insulin NOT thyroid NOT arterial NOT nutrit* NOT eating NOT tmd NOT temporomandibular NOT injur* NOT dental NOT nerve NOT fusion NOT back NOT lumbar NOT trauma* NOT crash NOT rheum* NOT neur* NOT palsy NOT diabetes NOT burn NOT fibromyalgia NOT hip NOT hand NOT knee NOT card* NOT osteoporosis NOT arthritis NOT occlus* NOT sedation NOT fracture NOT cord NOT surg* NOT spondylitis NOT pulmonary NOT dizziness NOT radicul* NOT headache NOT whiplash NOT stroke NOT discectomy NOT cancer NOT surgery NOT tumor

PUBMED

((chronic neck pain) OR (trapezius myalgia) OR (neck pain) OR (cervical spine) OR (mechanical neck pain))

AND

((rehabil*) OR (manual therapy) OR (manipul*) OR (mobil*) OR (exerc*) OR (train*) OR (endurance training) OR (motor control training) OR (neuromuscular training) OR (stabilization training) OR (deep cervical flexor training) OR (craniocervical flexor training) OR (education)))

NOT

((insulin) OR (thyroid) OR (arterial) OR (nutrit*) OR (eating) OR (TMD) OR (temporomandibular) OR (injur*) OR (dental) OR (dogs) OR (nerve) OR (fusion) OR (back) OR (lumbar) OR (trauma*) OR (rat) OR (crash) OR (rheum*) OR (neur*) OR (palsy) OR (diabetes) OR (burn) OR (fibromyalgia) OR (osteoporosis) OR (hip) OR (hand) OR (knee) OR (card*) OR (osteoporosis) OR (arthritis) OR (occlus*) OR (sedation) OR (fracture) OR (cord) OR (surg*) OR (spondylitis) OR (pulmonary) OR (dizziness) OR (radicul*) OR (headache) OR (whiplash) OR (stroke) OR (discectomy) OR (cancer) OR (needl*) OR (taping) OR (tape) OR (surgery) OR (tumor))

Filters: English

MEDLINE

((chronic neck pain) OR (trapezius myalgia) OR (neck pain) OR (cervical spine) OR (mechanical neck pain))

AND

((rehabil*) OR (manual therapy) OR (manipul*) OR (mobil*) OR (exerc*) OR (train*) OR (endurance training) OR (motor control training) OR (neuromuscular training) OR (stabilization training) OR (deep cervical flexor training) OR (craniocervical flexor training) OR (education))

NOT

((insulin) OR (thyroid) OR (arterial) OR (nutrit*) OR (eating) OR (TMD) OR (temporomandibular) OR (injur*) OR (dental) OR (dogs) OR (nerve) OR (fusion) OR (back) OR (lumbar) OR (trauma*) OR (rat) OR (crash) OR (rheum*) OR (neur*) OR (palsy) OR (diabetes) OR (burn) OR (fibromyalgia) OR (osteoporosis) OR (hip) OR (hand) OR (knee) OR (card*) OR (osteoporosis) OR (arthritis) OR (occlus*) OR (sedation) OR (fracture) OR (cord) OR (surg*) OR (spondylitis) OR (pulmonary) OR (dizziness) OR (radicul*) OR (headache) OR (whiplash) OR (stroke) OR (discectomy) OR (cancer) OR (needl*) OR (taping) OR (tape) OR (surgery) OR (tumor))

Filters: human, English

COCHRANE

(chronic neck pain) OR (trapezius myalgia) OR (neck pain) OR (cervical spine) OR (mechanical neck pain)

AND

(rehabil*) OR (manual therapy) OR (manipul*) OR (mobil*) OR (exerc*) OR (train*) OR (endurance training) OR (motor control training) OR (neuromuscular training) OR (stabilization training) OR (deep cervical flexor training) OR (craniocervical flexor training) OR (education)

AND a NOT

(insulin) NOT (thyroid) NOT (arterial) NOT (nutrit*) NOT (eating) NOT (tmd) NOT (temporomandibular) NOT (injur*) NOT (dental) NOT (nerve) NOT (fusion) NOT (back) NOT (lumbar) NOT (trauma*) NOT (crash) NOT (rheum*) NOT (neur*) NOT (palsy) NOT (diabetes) NOT (burn) NOT (fibromyalgia) NOT (hip) NOT (hand) NOT (knee) NOT (card*) NOT (osteoporosis) NOT (arthritis) NOT (occlus*) NOT (sedation) NOT (fracture) NOT (cord) NOT (surg*) NOT (spondylitis) NOT (pulmonary) NOT (dizziness) NOT (radicul*) NOT (headache) NOT (whiplash) NOT (stroke) NOT (discectomy) NOT (cancer) NOT (surgery) NOT (tumor)

CINAHL

(chronic neck pain) OR (neck pain) OR (cervical spine) OR (mechanical neck pain)

AND

(rehabil*) OR (manual therapy) OR (manipul*) OR (mobil*) OR (exerc*) OR (train*) OR (endurance training) OR (motor control training) OR (neuromuscular training) OR (stabilization training) OR (deep cervical flexor training) OR (craniocervical flexor training) OR (education)

NOT

(insulin) OR (thyroid) OR (arterial) OR (nutrit*) OR (eating) OR (TMD) OR (temporomandibular) OR (injur*) OR (dental) OR (dogs) OR (nerve) OR (fusion) OR (back) OR (lumbar) OR (trauma*) OR (rat) OR (crash) OR (rheum*) OR (neur*) OR (palsy) OR (diabetes) OR (burn) OR (fibromyalgia) OR (osteoporosis) OR (hip) OR (hand) OR (knee) OR (card*) OR (osteoporosis) OR (arthritis) OR (occlus*) OR (sedation) OR (fracture) OR (cord) OR (surg*) OR (spondylitis) OR (pulmonary) OR (dizziness) OR (radicul*) OR (headache) OR (whiplash) OR (stroke) OR (discectomy) OR (cancer) OR (needl*) OR (taping) OR (tape) OR (surgery) OR (tumor)

psycINFO

(chronic neck pain) OR (neck pain) OR (cervical spine) OR (mechanical neck pain)

AND

(rehabil*) OR (manual therapy) OR (manipul*) OR (mobil*) OR (exerc*) OR (train*) OR (endurance training) OR (motor control training) OR (neuromuscular training)

OR (stabilization training) OR (deep cervical flexor training) OR (craniocervical flexor training) OR (education)

NOT

(insulin) OR (thyroid) OR (arterial) OR (nutrit*) OR (eating) OR (TMD) OR (temporomandibular) OR (injur*) OR (dental) OR (dogs) OR (nerve) OR (fusion) OR (back) OR (lumbar) OR (trauma*) OR (rat) OR (crash) OR (rheum*) OR (neur*) OR (palsy) OR (diabetes) OR (burn) OR (fibromyalgia) OR (osteoporosis) OR (hip) OR (hand) OR (knee) OR (card*) OR (osteoporosis) OR (arthritis) OR (occlus*) OR (sedation) OR (fracture) OR (cord) OR (surg*) OR (spondylitis) OR (pulmonary) OR (dizziness) OR (radicul*) OR (headache) OR (whiplash) OR (stroke) OR (discectomy) OR (cancer) OR (needl*) OR (taping) OR (tape) OR (surgery) OR (tumor)

Filters: Human, English

SPORTDiscus

(chronic neck pain) OR (neck pain) OR (cervical spine) OR (mechanical neck pain)

AND

(rehabil*) OR (manual therapy) OR (manipul*) OR (mobil*) OR (exerc*) OR (train*) OR (endurance training) OR (motor control training) OR (neuromuscular training) OR (stabilization training) OR (deep cervical flexor training) OR (craniocervical flexor training) OR (education)

NOT

(insulin) OR (thyroid) OR (arterial) OR (nutrit*) OR (eating) OR (TMD) OR (temporomandibular) OR (injur*) OR (dental) OR (dogs) OR (nerve) OR (fusion) OR (back) OR (lumbar) OR (trauma*) OR (rat) OR (crash) OR (rheum*) OR (neur*) OR (palsy) OR (diabetes) OR (burn) OR (fibromyalgia) OR (osteoporosis) OR (hip) OR (hand) OR (knee) OR (card*) OR (osteoporosis) OR (arthritis) OR (occlus*) OR (sedation) OR (fracture) OR (cord) OR (surg*) OR (spondylitis) OR (pulmonary) OR (dizziness) OR (radicul*) OR (headache) OR (whiplash) OR (stroke) OR (discectomy) OR (cancer) OR (needl*) OR (taping) OR (tape) OR (surgery) OR (tumor)

Filters: English