Physiotherapy rehabilitation for whiplash associated disorder II: a systematic review and meta-analysis of randomised controlled trials

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ABSTRACT

Objective: To evaluate effectiveness of physiotherapy management in patients experiencing whiplash associated disorder II, on clinically relevant outcomes in the short and longer term.

Design: Systematic review and meta-analysis. Two reviewers independently searched information sources, assessed studies for inclusion, evaluated risk of bias and extracted data. A third reviewer mediated disagreement. Assessment of risk of bias was tabulated across included trials. Quantitative synthesis was conducted on comparable outcomes across trials with similar interventions. Meta-analyses compared effect sizes, with random effects as primary analyses.

Data sources: Predefined terms were employed to search electronic databases. Additional studies were identified from key journals, reference lists, authors and experts.

Eligibility criteria for selecting studies: Randomised controlled trials (RCTs) published in English before 31 December 2010 evaluating physiotherapy management of patients (>16 years), experiencing whiplash associated disorder II. Any physiotherapy intervention was included, when compared with other types of management, placebo/sham, or no intervention. Measurements reported on ≥1 outcome from the domains within the international classification of function, disability and health, were included.

Results: 21 RCTs (2126 participants, 9 countries) were included. Interventions were categorised as active physiotherapy or a specific physiotherapy intervention. 20/21 trials were evaluated as high risk of bias and one as unclear. 1395 participants were incorporated in the meta-analyses on 12 trials. In evaluating short term outcome in the acute/sub-acute stage, there was some evidence that active physiotherapy intervention reduces pain and improves range of movement, and that a specific physiotherapy intervention may reduce pain. However, moderate/considerable heterogeneity suggested that treatments may differ in nature or effect in different trial patients. Differences between participants, interventions and trial designs limited potential meta-analyses.

ARTICLE SUMMARY

Article focus

- Physiotherapy intervention is recommended in whiplash associated disorder II, although the most beneficial intervention and the effectiveness of physiotherapy management are unclear.
- Systematic reviews have not focused on whiplash associated disorder II, which represents approximately 93% of patients presenting for management post-whiplash injury.
- The objective of this systematic review was to evaluate the effectiveness of physiotherapy management in patients experiencing whiplash associated disorder II, on clinically relevant outcomes in the short and longer term.

Key messages

- This systematic review demonstrates inconclusive very low/low quality evidence for the effectiveness of physiotherapy management for whiplash associated disorder II.
- There is potential benefit for improving pain and range of movement short term through active physiotherapy and for improving pain through specific physiotherapy interventions.
- This potential benefit merits further consideration in a properly powered clinical trial with attention to ensure low risk of bias.

Strengths and limitations of this study

- The strengths of this review are its focus to physiotherapy intervention and the most common whiplash associated disorder II classification requiring physiotherapy intervention.
- A limitation is that differences between participants, interventions and trial designs limited potential meta-analyses.
- Surprisingly, no chronic interventions were comparable for analysis, considering the high number of patients experiencing chronicity with whiplash associated disorder.

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Conclusions: Inconclusive evidence exists for the effectiveness of physiotherapy management for whiplash associated disorder II. There is potential benefit for improving range of movement and pain short term through active physiotherapy, and for improving pain through a specific physiotherapy intervention.

INTRODUCTION

Road traffic accidents are the primary cause of whiplash, a soft tissue injury to the neck following an acceleration–deceleration mechanism of injury. The cumulative incidence of patients seeking healthcare post-whiplash from a road traffic accident has increased during the last 30 years to recent estimates of >3/1000 inhabitants in North America and Western Europe and 1.0–3.2/1000 inhabitants in Sweden. In the UK, insurance statistics indicate that 300,000 patients present per annum with whiplash associated disorders. Whiplash associated disorders are the resulting clinical presentations following the injury and can range in severity, clinical symptoms and physical findings. Many patients with whiplash associated disorders experience persistent pain and disability, with reports suggesting that 40–60% of those injured have chronic symptoms. The annual economic cost associated with management of whiplash associated disorders and associated time off work is estimated as $3.9 billion in the USA and €10 billion in Europe.

Patients experiencing whiplash associated disorders may be regarded as a distinct group within the broader non-specific neck pain population, although following review of trial data (n = 4 trials), recent evidence questions this distinction for a primary care population and has identified a need for further research. Whiplash associated disorders can be categorised as grades 0–IV, where a higher grade indicates increased severity. The classification system is widely used in clinical practice and guidelines. Patients with whiplash associated disorder II who experience neck pain accompanied by stiffness or tenderness, and musculoskeletal signs, for example a reduced range of available movement, form the major group of patients (93.4%) who might benefit from conservative management, commonly involving physiotherapy intervention. A recent best evidence synthesis recommended a focus of research to the most common whiplash associated disorder I and II classifications, excluding classification III and above (ie, patients with neurological signs and fracture and/or dislocation) and classification 0 (no complaint at the neck, and no physical signs). However, a classification of whiplash associated disorder I is less commonly seen by physiotherapists as there are no accompanying physical findings (neck pain, stiffness or tenderness but with no physical findings) and patients are known to recover within 6 months post-injury.

Evidence of the effectiveness of physiotherapy intervention for the treatment of whiplash associated disorder II is scarce. Existing systematic reviews instead tend to focus on a range of whiplash associated disorder classifications and a broad range of conservative intervention strategies such as educational videos, include studies of non-traumatic neck pain, and lack rigorous assessment of the risk of bias of included studies. The most robust evidence, a Cochrane review, on the management of whiplash associated disorder I/II patients does not specifically assess physiotherapy. No review has included trials published post-2006. The effectiveness of physiotherapy for the whiplash associated disorder II population is therefore unclear.

The objective of this systematic review was to investigate the short and longer term effectiveness of physiotherapy outpatient management of patients presenting with whiplash associated disorder II, in terms of function, disability and health, in patients aged >16 years.

MATERIALS AND METHODS

A systematic review was conducted according to a predefined protocol based on the method guidelines of the back review group of the Cochrane Collaboration and the Cochrane handbook. It is reported in line with the PRISMA statement.

Eligibility criteria

Studies

Randomised controlled trials (RCTs) evaluating the effectiveness of physiotherapy outpatient management of patients experiencing whiplash associated disorder II were included. Studies not written in English were excluded rather than restricting the inclusion of studies, thereby providing information of potential bias. No restrictions were placed on publication date.

Participants

Patients aged >16 years who had experienced a whiplash injury, classified as whiplash associated disorder II, were included. Acute and chronic presentations were included and analysed separately. Mixed populations of different classifications of whiplash associated disorder were included if patients presenting with whiplash associated disorder II formed part of the population.

Interventions

Any physiotherapy outpatient management intervention was included.

Outcome measures

Measures addressing domains within the international classification of function, disability and health, in the short term (approximately 3 months post-injury/intervention) and/or longer term (approximately 12 months) were included.

Information sources

Each of the following databases was searched using sensitive topic based search strategies to the end of December 2010:
Systematic review of physiotherapy management post-whiplash

Box 1 Examples of search strategies

**Medline (Ovid) 1948–31 December 2010**
1. Acute whiplash or cervical spine disorder or cervical spine injury.mp
2. Manual therapy or manipulation or massage.mp
3. Clinical trial or randomised controlled trial or RCT.mp
4. 1 and 2
5. 3 and 4
6. WAD II or whiplash associated disorders or whiplash injury or whiplash patients or whiplash syndrome.mp
7. 2 and 6
8. 3 and 7
9. Conservative approach or conservative intervention or conservative management or conservative therapy.mp
10. Physical approach or physical intervention or physical management or physical therapy.mp
11. Exercise or active range of motion exercise$ or strengthening exercise$ or stretching exercise$ or therapeutic exercise$ or endurance training or home exercise$ or proprioception exercise$
12. Transcutaneous electrical nerve stimulation or TENS or thermotherapy or electrical stimulation or heat or electrotherapy.mp
13. Pain management program$.mp
14. Patient education or educational or self management program$.mp
15. Posture or (postural and balance) or traction.mp
16. 1 and 9
17. 3 and 16
18. 6 and 9
19. 3 and 18
20. 1 and 10
21. 3 and 20
22. 6 and 10
23. 3 and 22
24. 1 and 11
25. 3 and 24
26. 6 and 11
27. 3 and 26
28. 1 and 12
29. 3 and 28
30. 6 and 12
31. 3 and 30

**Embase (Ovid) 1947–31 December 2010**
1. Acute whiplash or cervical spine disorder or cervical spine injury.mp
2. Manual therapy or manipulation or massage.mp
3. Clinical trial or randomised controlled trial or RCT.mp
4. 1 and 2
5. 3 and 4
6. WAD II or whiplash associated disorders or whiplash injury or whiplash patients or whiplash syndrome.mp
7. 2 and 6
8. 3 and 7
9. Conservative approach or conservative intervention or conservative management or conservative therapy.mp
10. Physical approach or physical intervention or physical management or physical therapy.mp
11. Exercise or active range of motion exercise$ or strengthening exercise$ or stretching exercise$ or therapeutic exercise$ or endurance training or home exercise$ or proprioception exercise$
12. Transcutaneous electrical nerve stimulation or TENS or thermotherapy or electrical stimulation or heat or electrotherapy.mp
13. Pain management program$.mp
14. Patient education or educational or self management program$.mp
15. Posture or (postural and balance) or traction.mp
16. 1 and 9
17. 3 and 16
18. 6 and 9
19. 3 and 18
20. 1 and 10
21. 3 and 20
22. 6 and 10
23. 3 and 22
24. 1 and 11
25. 3 and 24
26. 6 and 11
27. 3 and 26
28. 1 and 12
29. 3 and 28
30. 6 and 12
31. 3 and 30

Box 1 Continued

11. Exercise or active range of motion exercise$ or strengthening exercise$ or stretching exercise$ or therapeutic exercise$ or endurance training or home exercise$ or proprioception exercise$
12. Transcutaneous electrical nerve stimulation or TENS or thermotherapy or electrical stimulation or heat or electrotherapy.mp
13. Pain management program$.mp
14. Patient education or educational or self management program$.mp
15. Posture or (postural and balance) or traction.mp
16. 1 and 9
17. 3 and 16
18. 6 and 9
19. 3 and 18
20. 1 and 10
21. 3 and 20
22. 6 and 10
23. 3 and 22
24. 1 and 11
25. 3 and 24
26. 6 and 11
27. 3 and 26
28. 1 and 12
29. 3 and 28
30. 6 and 12
31. 3 and 30

- The Cochrane Library: Controlled Trials Register, Health Technology Assessment Database, NHS Economic Evaluation Database.
- CINAHL, EMBASE, MEDLINE, PEDro, ZETOC databases.
- Selected internet sites and indexes: Turning Research into Practice, Health Services/Technology Assessment, PUBMED.
- National Research Register, Current Controlled Trials website (York).
- Cochrane Back Review Group.
- Cochrane Cervical Overview Group.
- Hand searches in key journals, for example *Spine, Manual Therapy, Physiotherapy, Physical Therapy, Australian Journal of Physiotherapy*.
- Science Citation Index and Social Science Citation Index.
- Unpublished research: British National Bibliography for Report literature, Dissertation Abstracts, Index to Scientific and Technical Proceedings, National Technical Information Service, System for Information on Grey Literature.
- Personal citations for key authors in the field.

The searches used predefined terms. Box 1 provides two examples of the searches utilised.

**Study selection**

Two subject experts independently searched information sources (GE/NH), and independently assessed identified studies for inclusion by grading each criterion...
Risk of bias was independently assessed by the same reviewers for each included study. Risk of bias, and homogeneity of participants, interventions and outcomes were key considerations informing the potential for including trials in meta-analyses, in line with Cochrane. The third reviewer again mediated. Agreement between reviewers was evaluated using Cohen’s k. All processes and tools were piloted.

### Data collection process

Two reviewers (AR/CW) independently extracted the data using a standardised form. A third independent reviewer (NH) checked for consistency and clarity.

### Data items

Data extracted for each trial included: design, participants and indication, whiplash associated disorder categorisation, interventions, study setting, outcome measures, timing of assessments, power calculations, loss to follow-up, intention to treat analyses and main results. Key outcome measures were predefined as valid tools to measure pain, disability, function, physical impairment, social impact and patient satisfaction, reflecting domains from the International Classification of Functioning, Disability and Health. Based on recommendations, a maximum of two primary outcomes were considered acceptable, when more than one primary outcome was reported and alpha spend was not considered.

### Risk of bias in individual studies

The Cochrane ‘risk of bias’ assessment tool was used to appraise the internal validity of each included trial. In contrast to the majority of quality scales used in health research, the Cochrane tool is informed by empirical research. Each component of bias was reported independently and considered with regard to each key outcome measure. The component including ‘blinding’ the treating therapist has been acknowledged as generally impossible and this formed part of the appraisal by the reviewers as the Cochrane tool also permits evaluation of the likely influence of any lack of blinding. The rigour of the risk of bias assessment was ensured through strict application of the defined criteria to inform conclusions, making explicit the trials of high risk of bias or poor reporting.

### Summary measures

Quantitative synthesis was conducted in line with the protocol on comparable key outcomes across trials evaluating similar interventions (nature of intervention, and timing of assessments at approximately 3 months and/or 12 months post-injury or intervention). Results were reported in the context of overall risk of bias. Comparable outcomes were defined as tools developed to measure the same underlying domain. Two subject experts and two methodological experts identified the combinations of studies and outcomes on which to conduct meta-analyses.

### Table 1 Criteria for inclusion and exclusion of studies in the review

| Criteria | Inclusion criteria | Exclusion criteria |
|----------|--------------------|--------------------|
| Study design | RCT | Initial search: studies stated as RCTs but do not have a comparison group or random allocation to groups |
| Population | Age: 16 years or older | Multiple pathology |
| Subjects | Human; outpatients | Whiplash associated disorder not classified according to severity to provide clarity of whiplash associated disorder II population |
| Condition | Post-whiplash injury | |
| | Experiencing whiplash associated disorder II | |
| Intervention | Conservative physiotherapy outpatient management | |
| | | |
| Comparison group(s) | At least one comparison group: placebo/other intervention/no intervention | |
| Outcome | Measurement of at least one of the following outcomes: disability; functional status; physical impairment; impact on social and occupational levels of fitness; pain; quality of life; patient satisfaction | |
| | Measurement of short term outcome (approx 3 months post-surgery) and/or long term outcomes (≥1 year post-surgery) | |
| Time frame | All studies conducted from 1979 onwards | |

RCT, randomised controlled trial.
Using RevMan\textsuperscript{31} meta-analyses compared standardised differences in means using DerSimonian—Laird random effects\textsuperscript{32} for the principal analyses to allow for systematic differences in effects estimated across the included trials.\textsuperscript{22} For summary statistics, 95% CIs were reported. Standardised mean differences were selected to make comparisons across studies that used different tools to measure the same outcome,\textsuperscript{22} or reported a mixture of final value scores and change from baseline scores.\textsuperscript{33} Hedges—Olkin fixed effects\textsuperscript{34} were used as the supportive analyses.

### Planned methods of analysis

Data were requested from all authors, except for those with no comparability of outcome measures to other trials.\textsuperscript{35} Data defined by whiplash associated disorder classification was also requested from all authors of trials that reported combined whiplash associated disorder classifications. Analyses were conducted on final summary statistics when reported or the raw data where supplied. When necessary, standard deviations were estimated from reported CIs or percentiles.\textsuperscript{33} In line with the use of random effects as primary analyses,\textsuperscript{32} change scores were used for studies when no other data were forthcoming. Heterogeneity in treatment effects was evaluated through computation of $I^2$.

### Risk of bias across studies

A summary assessment for risk of bias was tabulated across studies, and consensus agreed concerning the overall potential risk of bias. It was not helpful to attempt to assess potential publication bias visually using Funnel plots\textsuperscript{22} as less than 10 trials were included in meta-analyses.\textsuperscript{37}

### Additional analyses

No post-hoc supportive analyses were conducted owing to the inconsistency of outcome measures across the trials.

### RESULTS

#### Study selection

Included trials were grouped according to the whiplash associated disorder classification\textsuperscript{1} into five categories:

- **Whiplash associated disorder II**: five articles and five trials,\textsuperscript{36} 38—41 from four countries were included.
- **Whiplash associated disorders I/II**: eight articles and eight trials,\textsuperscript{42} 43 from six countries were included.
- **Whiplash associated disorders II/III**: four articles and four trials,\textsuperscript{35} 50—52 from three countries were included.
- **Whiplash associated disorders 0/I/II**: three articles and two trials,\textsuperscript{53} 54—55 from two countries were included.
- **Whiplash associated disorders I/II/III**: three articles and two trials,\textsuperscript{56} 57—58 from one country were included.

Most retrieved trials were published in English with only two in other languages. One relevant unpublished study was found (Managing Injuries of the Neck Trial, accessible at http://www.hta.ac.uk/1399, due to be published 2011). Figure 1 presents the numbers of studies at each stage of selection. Complete inter-reviewer agreement was achieved on study inclusion across all categories following discussion.

#### Study characteristics

Descriptive data for the 21 included trials are summarised in online table 1.

#### Methods

Eighteen trials randomised participants across two groups, one trial across three groups, and two trials across four groups. Eight trials compared a specific physiotherapy intervention, for example manipulation, to no management, sham or placebo. Thirteen trials compared an active physiotherapy intervention to standard care; the active approaches were characterised by additional interventions, a multimodal intervention or a progressive intervention. Duration of interventions ranged from one treatment session to 12 months. The number of assessments varied from 1 to 4, occurring immediately post-treatment to 3 years.

#### Participants

The 21 trials randomised 2126 participants. Age varied from 16 to 70 years. A total of 271/2126 participants were randomised in trials focused to whiplash associated disorder II.\textsuperscript{5} Of the authors who responded, no authors were able to provide data for their included whiplash

\textsuperscript{5}In Aigner et al\textsuperscript{38}, three subject experts agreed that the Kramer grade II evaluated as equivalent to the WADII classification.
associated disorder classifications separately. In the eight whiplash associated disorder I/II category trials, 934 participants were randomised but no distinction of whiplash associated disorder II participants was possible. In the four whiplash associated disorder II/III category trials, 333/409 (81.5%, two trials) participants were classified as whiplash associated disorder II; in a further 111 participants (two trials), no distinction of whiplash associated disorder II participants was possible. In the two whiplash associated disorder O/I/II category trials, 302 participants were randomised with no distinction of whiplash associated disorder II participants possible. In the two whiplash associated disorder I/II/III category trials, 49/66 (74%, 1 trial) participants were classified as whiplash associated disorder II; in a further 33 participants (1 trial), no distinction of whiplash associated disorder II participants was possible. A total of 1395 participants were randomised in the 12 trials included in the meta-analyses.

Interventions
Eight trials were conducted at single centres that included physiotherapy clinics or outpatient departments. Both a clinic and home setting were used in one trial. The setting was unclear in 12 trials. One trial investigated a group intervention. Interventions could be grouped according to whether they were a specific physiotherapy intervention or an active intervention comprising different components. Timing of interventions included acute/sub-acute (13 trials) and chronic stages (8 trials), ranging from 2 days to 15 years post-injury.

Primary outcomes
Only six (28.5%) trials specified primary outcomes a priori that included: Neck Pain and Disability Index, Nociceptive Flexion Reflex, Neck Disability Index, Pain Visual Analogue Scale (VAS), Pain VAS and Work Activities VAS, and Pain VAS and Disability VAS. One trial specified three primary outcome measures with no adjustment for alpha spend and was therefore evaluated as unacceptable in specifying primary outcomes.

Secondary and additional outcomes
Most trials reported some assessment of pain (general or specific to the neck) (15 trials), and range of movement (ROM) (13 trials). Nine trials reported assessment of disability. A wide range of other outcomes included: work status, SF36, Tampa, patient satisfaction, muscle stability, posture and kinaesthetic sensibility. Two trials reported outcomes that were not consistent with any other trial, for example temperature pain threshold and the tandem standing balance test.

Risk of bias within studies
‘Almost perfect’ 93% inter-reviewer agreement was achieved on risk of bias assessment prior to discussion (Cohen’s k = 0.90, p < 0.0005) and 100% agreement was reached following discussion. Only two trial protocols were available. Of the 21 included trials, 20 were evaluated as high risk of bias and one as unclear risk of bias (table 2). The very high proportion of trials identified as high risk of bias should affect the interpretation of results.

Risk of bias across studies
Only trials evaluated as high risk of bias were available for meta-analysis. Although reasons for the high risk components provided concern for potential bias, results from meta-analyses evaluated critically within this context enabled an overview of the evidence to be presented, strength of effect to be presented, and tentative conclusions to be proposed to advance research.

Results of individual studies and synthesis of results
Comparability of interventions, timing of assessments and outcome measures were considered to determine appropriate quantitative synthesises of trials. In exploring the compatibility of outcomes for management in the acute/sub-acute and chronic stages, no possible quantitative synthesises within the five categories of whiplash associated disorders were possible. No further information regarding whiplash associated disorder classification was provided by authors to assist potential comparisons regarding whiplash associated disorder II. In comparing across categories, no comparison was possible for intervention in the chronic stage or long term. The following meta-analyses were conducted in the acute/sub-acute stage in the short term:

- Active intervention versus standard intervention for: pain, 4–12 weeks (n = 6 trials); ROM flexion/extension (flex/ext), 12 weeks (n = 3 trials); ROM rotation (Rot), 12 weeks (n = 4); ROM side flexion (SF), 12 weeks (n = 3); total ROM, 4–12 weeks (n = 3); disability, 6–12 weeks (n = 5).
- Specific intervention versus control post-intervention for: pain (n = 4 trials); ROM flex/ext, ROM Rot, and ROM SF (n = 3 trials).

Active versus standard intervention short term
Evidence from two trials suggested that intervention might reduce pain, with active intervention being beneficial compared to standard intervention (figure 2). This was not supported by four trials. The pooled random effects (−0.35, 95% CI −0.63 to −0.07) did support evidence of an effect short term. Evidence from one trial suggested that intervention might improve ROM flex/ext and ROM SF, with active intervention being beneficial compared to standard intervention (figures 3 and 4). This was not supported by two trials. The pooled random effects (ROM flex/ext: 0.39, 95% CI 0.04 to 0.74; ROM SF: 0.45, 95% CI 0.17 to 0.73) did support evidence of an effect short term. Evidence from three trials suggested that

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6 Excluded Rosenfeld et al as short term assessment was 6 at months. 
7 Included Thuile and Walzl although timing of intervention and assessment was unclear from trial. 
8 Aigner et al n = 5 loss to follow up but not clear from which group.
| Study (authors, year, country) | Components of risk of bias | Summary risk of bias | Comments, high risk components |
|-------------------------------|---------------------------|----------------------|--------------------------------|
| **WAD II**                    |                           |                      |                                |
| Aigner et al\textsuperscript{38} (2006) | U  U  U  U  U  U  H | High (1)             | One high risk component: 6     |
|                               |                           |                      | No primary outcome measure specified |
|                               |                           |                      | No primary endpoint specified  |
|                               |                           |                      | No ITT reported                |
| Dehner et al\textsuperscript{30} (2009) | L  L  U  U  U  N/A  H | High (1)             | One high risk component: 6     |
|                               |                           |                      | Design problematic with comparison to a previous non-randomised group. |
|                               |                           |                      | Assessment ROB excluded previous group |
|                               |                           |                      | No primary outcome measure specified |
|                               |                           |                      | No primary endpoint specified  |
|                               |                           |                      | No ITT reported                |
| Gonzalez-Inglesias et al\textsuperscript{40} (2009) | L  L  L  L  U  N/A  H | High (1)             | One high risk component: 6     |
|                               |                           |                      | No primary outcome measure specified |
|                               |                           |                      | No primary endpoint specified  |
| Jull et al\textsuperscript{41} (2007) | L  L  L  L  U  N/A  L | Unclear (1)          | No high risk components        |
| Sterling et al\textsuperscript{36} (2010) | L  U  L  L  U  N/A  H | High (1)             | One high risk component: 6     |
|                               |                           |                      | No ITT reported                |
| **WAD I/II**                  |                           |                      |                                |
| Ask et al\textsuperscript{42} (2009) | U  L  L  L  U  U  H | High (1)             | One high risk component: 6     |
|                               |                           |                      | No primary endpoint specified  |
| Bonk et al\textsuperscript{43} (2000) | U  U  H  L  U  N/A  H | High (2)             | Two high risk components: 3, 6 |
|                               |                           |                      | 3: Assessors not blinded beyond baseline |
|                               |                           |                      | 6: No primary outcome measure specified |
|                               |                           |                      | No primary endpoint specified  |
|                               |                           |                      | No ITT reported                |
| Pato et al\textsuperscript{44} (2010) | U  U  L  L  U  N/A  H | High (1)             | One high risk component: 6     |
|                               |                           |                      | No primary endpoint specified  |
| Scholten-Peeters et al\textsuperscript{45} (2006) [Scholten-Peeters et al\textsuperscript{60} (2003) trial protocol] | L  L  L  L  L  L  H | High (1)             | One high risk component: 6     |
|                               |                           |                      | No primary endpoint specified  |
| Study (authors, year, country) | Components of risk of bias | Summary risk of bias | Comments, high risk components |
|--------------------------------|---------------------------|----------------------|--------------------------------|
| Stewart et al\textsuperscript{46} (2007), [Stewart et al\textsuperscript{61} (2003) trial protocol] | L L L L L N/A H | High (1) | One high risk component: 6 Co-interventions by 6 weeks: A: n=10 (15%) and B: n=15 (23%) reported seeking additional treatment Co-interventions by 12 months: A: n=18 (29%) and B: n=35 (56%) reported seeking additional treatment No primary outcome measure specified No primary endpoint specified |
| Thuile and Walzl\textsuperscript{47} (2002) | U U U U U N/A H | High (1) | One high risk component: 6 No primary outcome measure specified No primary endpoint specified |
| Vassiliou et al\textsuperscript{48} (2006) | L L L H U N/A H | High (2) | Two high risk component: 4, 6 4: Losses at 6 weeks (6 months): A: 15% (30%) B: 36% (46%) n=12 (6%) participants excluded due to incomplete outcome data. 6: No primary endpoint specified Two high risk components: 4, 6 4: Losses of 20% at 12 months (10% at 4 months) 6: No primary outcome measure specified No primary endpoint specified No ITT reported |
| Vikne et al\textsuperscript{49} (2007) | U L L H U U H | High (2) | Two high risk components: 4, 6 4: Losses of 20% at 12 months (10% at 4 months) 6: No primary outcome measure specified No primary endpoint specified No ITT reported |
| WAD II/III Armstrong et al\textsuperscript{50} (2005) | U U U L U N/A H | High (1) | One high risk component: 6 Problematic design and data analysis combining groups No primary outcome measure specified No ITT reported |
| Fernandez-de-las-Penas\textsuperscript{51} (2004a) | L U U U U N/A H | High (1) | One high risk component: 6 No primary outcome measure specified No primary endpoint specified No ITT reported Selection bias as participants were volunteers |

Continued
| Study (authors, year, country) | Components of risk of bias | Summary risk of bias | Comments, high risk components |
|--------------------------------|-----------------------------|----------------------|--------------------------------|
| Fernandez-de-las-Penas (2004b) | L U U U U N/A H           | High (1)             | One high risk component: 6     |
|                                 |                             |                      | No primary outcome measure specified |
|                                 |                             |                      | No primary endpoint specified |
|                                 |                             |                      | No ITT reported |
| Hansson et al (2006)            | L L L H U N/A H            | High (2)             | Two high risk components: 4, 6 |
|                                 |                             |                      | 4: Drop outs 38%               |
|                                 |                             |                      | 6: Differences at baseline on two outcomes |
|                                 |                             |                      | No primary outcome measure specified |
|                                 |                             |                      | No primary endpoint specified |
|                                 |                             |                      | No ITT reported |
| WAD 0/II                        | U L L H U U H              | High (2)             | Two high risk components: 4, 6 |
| Rosenfeld et al (2003), [Rosenfeld et al (2006) reporting same trial] |                             |                      | 4: High loss to follow-up. Drop out at 6 months (and 3 years): 8% (13%). |
|                                 |                             |                      | Exclusions at 6 months (and 3 years): 11% (8%). Includes eligibility errors with participants excluded post-randomisation for not meeting inclusion criteria |
|                                 |                             |                      | 6: Co-interventions: 25% participants received treatment outside of study by 6 months; nearly 50% by 3 years |
|                                 |                             |                      | No primary outcome measure specified |
|                                 |                             |                      | No primary endpoint specified |
|                                 |                             |                      | No ITT reported |
| Schnabel et al (2004)           | H U U H U N/A H            | High (3)             | Three high risk components: 1, 4, 6 |
|                                 |                             |                      | 1: Inappropriate method of randomisation |
|                                 |                             |                      | 4: Loss to follow-up from groups: A: 36% |
|                                 |                             |                      | B: 15% |
|                                 |                             |                      | 6: No primary outcome measure specified |
|                                 |                             |                      | No ITT reported |
| WAD II/III                      | U U U L U N/A H            | High (1)             | One high risk component: 6     |
| Soderlund et al (2000)          |                             |                      | No primary outcome measure specified |
|                                 |                             |                      | No primary endpoint specified |
|                                 |                             |                      | No ITT reported |
| Soderlund and Lindberg (2001), [Soderlund and Lindberg (2007) reporting same trial] | U U L L U N/A H | High (1)             | One high risk component: 6     |
|                                 |                             |                      | No primary outcome measure specified |
|                                 |                             |                      | No primary endpoint specified |
|                                 |                             |                      | No ITT reported |

Components of risk of bias: 1, sequence generation; 2, allocation concealment; 3, blinding of participants, personnel and outcome assessors; 4, incomplete outcome data; 5a, short term selective outcome reporting; 5b, long term selective outcome reporting; 6, other potential threats to validity.

Levels of risk of bias: H, high risk of bias; U, unclear risk of bias; L, low risk of bias. N/A, not applicable, no investigation of long term outcome.
intervention might improve ROM Rot, with active intervention being beneficial compared to standard intervention (figure 5). This was not supported by one trial.42 The pooled random effects (0.68, 95% CI 0.38 to 0.99) did support evidence of an effect short term.

Overall, there was no evidence of short term benefit of active over standard intervention on total ROM (pooled random effects 0.28, 95% CI −0.03 to 0.59) or disability (figure 6: −0.26, 95% CI −0.57 to 0.05).

Specific physiotherapy intervention versus control
Evidence from four trials40 47 51 52 suggested that intervention might reduce pain short term, with specific physiotherapy intervention being beneficial compared to control. The pooled random effects (−2.11, 95% CI −3.85 to −0.36) did support evidence of an effect short term. Overall, there was no evidence of short term benefit of specific physiotherapy intervention over control on ROM flex/extension (pooled random effects 0.83, 95% CI −3.79 to 5.44), ROM Rot (pooled random effects −1.02, 95% CI −3.73 to 1.68) or ROM SF (pooled random effects −1.21, 95% CI −3.11 to 0.69).

**DISCUSSION**

**Summary of evidence**
Evidence was assessed from 21 RCTs (2126 participants) conducted across nine countries. Only one trial investigated a group intervention. Interventions were grouped into active versus standard intervention, and specific physiotherapy intervention versus control. No meta-analyses were possible exclusively on a whiplash associated disorder II population, as most trials included combined classifications of whiplash associated disorders in their populations. Disappointingly, as many trials were recent, 20/21 trials were assessed as high risk of bias, and one as unclear risk. All 12 trials (1395 participants from six countries) included in the meta-analyses were assessed as high risk. Comparable outcomes across trials included pain, ROM flex/ext, ROM Rot, ROM SF, total ROM and disability in the short term. There was no evidence beyond individual results of benefit in the longer term as no meta-analyses were possible. The one trial that evaluated as unclear risk of bias was, therefore, not included in any meta-analyses.41

In evaluating short term outcome in the acute/subacute stage, there was some evidence that active physiotherapy intervention reduces pain. This was supported by statistically significant differences found in two trials.39 48 Although the finding is interesting, further trials are required since one trial possessed one high risk component of bias, and the other possessed two. Only one trial43 suggested that active physiotherapy intervention changes ROM (flex/ext and SF); three trials43 45 56 suggested a change in ROM Rot. There was evidence from the meta-analyses to support this. Again, risk of bias was high for all trials, with two high risk components for one trial43 and one high risk component for the two other trials. There was no evidence that active physiotherapy intervention affects disability.

In evaluating short term outcome in the acute/subacute stage, there was some evidence that specific physiotherapy intervention reduces pain. This was supported by statistically significant differences found

| Study or subgroup | Mean (SD) Activity | Mean (SD) Standard | Std. mean difference IV, random, 95% CI | Std. mean difference IV, random, 95% CI |
|------------------|--------------------|--------------------|----------------------------------------|----------------------------------------|
| Bork 2000        | 19.4 (1.8)         | 18.3 (1.6)         | 0.64 (0.23 to 1.05)                     |                                        |
| Ask 2009         | 109.7 (22.2)       | 124.9 (14)         | 0.39 (-0.41 to 1.19)                    |                                        |
| Scholten-Peeters 2006 | 13.7 (22.1) | 20.3 (42)         | 0.12 (-0.32 to 0.56)                    |                                        |
| Total (95% CI)   | 96                 | 106                | 0.39 (0.04 to 0.74)                     |                                        |

Heterogeneity: $\chi^2 = 3.03$, df = 2 (p = 0.24); $I^2 = 31$

Test for overall effect: Z = 2.19 (p = 0.03)

**Figure 3** Pain short-term.

**Figure 3** ROM (range of movement) flexion/extension short-term.

| Study or subgroup | Mean (SD) Active | Mean (SD) Standard | Std. mean difference IV, random, 95% CI | Std. mean difference IV, random, 95% CI |
|------------------|------------------|--------------------|----------------------------------------|----------------------------------------|
| Denker 2009 (1)  | 27 (3)           | 32                 | -1.00 (-1.52 to -0.48)                  |                                        |
| Ask 2009         | 19.8 (22.1)      | 12.12              | 0.12 (-0.32 to 0.56)                    |                                        |
| Scholten-Peeters 2006 | 13.7 (22.1) | 20.3 (42)         | 0.12 (-0.32 to 0.56)                    |                                        |
| Total (95% CI)   | 96               | 106                | 0.39 (0.04 to 0.74)                     |                                        |

Heterogeneity: $\chi^2 = 3.03$, df = 2 (p = 0.24); $I^2 = 31$

Test for overall effect: Z = 2.19 (p = 0.03)
in four trials\(^{40,47,51,52}\) using interventions of Kinesio taping, magnetic therapy and manipulation. Although the finding is interesting, further trials are required because all trials possessed one high risk component of bias and two trials had an additional four unclear risks. Only one individual trial\(^{47}\) suggested that specific physiotherapy intervention (magnetic therapy) changes ROM (flex/ext or Rot or SF) in the short term. There was no evidence from the meta-analyses to support this.

**Limitations**

The strengths of this review are its focus to physiotherapy intervention and the most common whiplash associated disorder II classification requiring physiotherapy intervention. Heterogeneity in treatment effects can be explained by variation in the quality of administration of interventions. Differences were evident in the outcome measures, assessment points, and classification of whiplash associated disorder participants, where many trials combined whiplash associated disorder classifications even though interventions in practice would vary between classifications.\(^{15,16}\) Differences in components of the physiotherapy interventions were also evident, with some variation explained by diversity in practice across countries. The differences limited the possible comparisons in the meta-analyses. Surprisingly, no chronic interventions were comparable for analysis, considering the high number of patients experiencing chronicity with whiplash associated disorder.\(^{7,8}\) Also surprisingly, work status was not possible for analysis considering the economic implications of whiplash associated disorder.\(^{9,10}\)

Moderate heterogeneity (I\(^2\)=57\%) was present in the evidence for active intervention for pain,\(^{33}\) identifying significant difference in treatment effects between trials. However, heterogeneity might not be important for ROM flex/ext, Rot and SF (I\(^2\)=31\%, 25\% and 0\%, respectively). Substantial heterogeneity (I\(^2\)=64\%) was
present in the evidence for active intervention for disability, perhaps explaining the lack of evidence of an effect. Considerable heterogeneity was present in the evidence for specific physiotherapy intervention for pain, ROM flex/ext, Rot, and SF (F = 98.1%, 99.0%, 98.1% and 96.6%, respectively), perhaps explaining the lack of evidence of an effect for all ROM evaluations. This anticipated heterogeneity was accounted for by using the random effects model.

Using GRADE (the Grading of Recommendations Assessment, Development and Evaluation system), the quality of the body of evidence for physiotherapy rehabilitation in the management of whiplash associated disorder II, based on the 12 trials included in the meta-analyses, is ‘very low’ for pain, ROM flex/ext and SF (active vs standard intervention), and ‘low’ for ROM Rot (active vs standard intervention) and pain (specific intervention vs control) in the short term. These estimates are interpreted as ‘little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect’ (very low) and ‘confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect’ (low). Downgrading of quality was due to high risk of bias, and issues of imprecision and inconsistency.

The limitations in the context of the high risk of bias and number of trials available necessitate urgent attention to focus a future high quality and properly powered trial to evaluate a whiplash associated disorder II population. The very low/low quality of trials is consistent with earlier findings for physiotherapy management post-lumbar discectomy. There is limited scope at present for good quality meta-analyses in physiotherapy with rigorous and well reported trial inclusion. Physiotherapy trials need to avoid risk of bias. Planning for quality is important, particularly for issues that present known problems for physiotherapy trials, for example loss to follow-up. Consensus for minimum core sets of outcome measures for specific populations is also required.

Conclusions

This systematic review has identified inconclusive very low/low quality evidence for the effectiveness of physiotherapy management for whiplash associated disorder II. Inclusion of large numbers of participants in the poorly designed trials published to date is unethical. Best practice for physiotherapy management, therefore, remains unclear. This lack of clarity might explain the variability of interventions across the trials that made comparability of interventions difficult. There is potential benefit for improving pain and ROM flex/ext, Rot and SF short term through active physiotherapy, and for improving pain through specific physiotherapy interventions. This potential benefit merits further consideration in a properly powered clinical trial with attention to ensure low risk of bias.

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Competing interests

None

Contributors AR and GE are senior lecturers in Physiotherapy and NH is a lecturer. MC and CW are both senior lecturers. NF is Professor of Clinical Epidemiology and Biostatistics. AR, MC, CW and NF have longstanding professional interests in the quality and reporting of randomised controlled trials in medicine and physiotherapy. AR, NH and GE have a professional focus to musculoskeletal physiotherapy. AR and CW were responsible for the conception of the study. All authors have contributed to the systematic review and have been involved in developing the content of the article. AR wrote the first draft of the paper and developed it initially with CW. AR has worked with all authors reworking content into subsequent drafts. All authors gave final approval of the version to be published. AR is the guarantor.

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| Section/topic          | Item No | Checklist item                                                                                                                                                                                                                                                                                                                                 | Reported on page No |
|-----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| **Title**             |         |                                                                                                                                                                                                                                                                                                                                                           |                     |
| Title                 | 1       | Identify the report as a systematic review, meta-analysis, or both                                                                                                                                                                                                                                                                                    | 2                   |
| **Abstract**          |         |                                                                                                                                                                                                                                                                                                                                                           |                     |
| Structured summary    | 2       | Provide a structured summary including, as applicable, background, objectives, data sources, study eligibility criteria, participants, interventions, study appraisal and synthesis methods, results, limitations, conclusions and implications of key findings, systematic review registration number | 4-5                 |
| **Introduction**      |         |                                                                                                                                                                                                                                                                                                                                                           |                     |
| Rationale             | 3       | Describe the rationale for the review in the context of what is already known                                                                                                                                                                                                                                                                         | 7-8                 |
| Objectives            | 4       | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS)                                                                                                                                                                                                 | 8                   |
| **Methods**           |         |                                                                                                                                                                                                                                                                                                                                                           |                     |
| Protocol and registration | 5     | Indicate if a review protocol exists, if and where it can be accessed (such as web address), and, if available, provide registration information including registration number                                                                                                                                                                                  | 9                   |
| Eligibility criteria  | 6       | Specify study characteristics (such as PICOS, length of follow-up) and report characteristics (such as years considered, language, publication status) used as criteria for eligibility, giving rationale                                                                                                                                                                           | 9                   |
| Information sources   | 7       | Describe all information sources (such as databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched                                                                                                                                                                                   | 9-10                |
| Search                | 8       | Present full electronic search strategy for at least                                                                                                                                                                                                                                                                                                   | 10                  |
| Study selection 9 | State the process for selecting studies (that is, screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis) |
|------------------|-------------------------------------------------------------------------------------------------|
| Data collection process 10 | Describe method of data extraction from reports (such as piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators |
| Data items 11 | List and define all variables for which data were sought (such as PICOS, funding sources) and any assumptions and simplifications made |
| Risk of bias in individual studies 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis |
| Summary measures 13 | State the principal summary measures (such as risk ratio, difference in means). |
| Synthesis of results 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (such as I² statistic) for each meta-analysis |
| Risk of bias across studies 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (such as publication bias, selective reporting within studies) |
| Additional analyses 16 | Describe methods of additional analyses (such as sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified |

**Results**

| Study selection 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram |
| Study characteristics 18 | For each study, present characteristics for which data were extracted (such as study size, PICOS, follow-up period) and provide the citations |
| Risk of bias within studies 19 | Present data on risk of bias of each study and, if available, any outcome-level assessment (see item 16) |
| Section                              | Item | Description                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Results of individual studies       | 20   | For all outcomes considered (benefits or harms), present for each study (a) simple summary data for each intervention group and (b) effect estimates and confidence intervals, ideally with a forest plot                                                                                      |
| Synthesis of results                | 21   | Present results of each meta-analysis done, including confidence intervals and measures of consistency                                                                                                                                                                                                                                       |
| Risk of bias across studies         | 22   | Present results of any assessment of risk of bias across studies (see item 15)                                                                                                                                                                                                                                                             |
| Additional analysis                 | 23   | Give results of additional analyses, if done (such as sensitivity or subgroup analyses, meta-regression) (see item 16)                                                                                                                                                                                                                      |
| **Discussion**                      |      |                                                                                                                                                                                                                                                                                                                                            |
| Summary of evidence                 | 24   | Summarise the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (such as health care providers, users, and policy makers)                                                                                                                                                |
| Limitations                         | 25   | Discuss limitations at study and outcome level (such as risk of bias), and at review level (such as incomplete retrieval of identified research, reporting bias)                                                                                                                                                              |
| Conclusions                         | 26   | Provide a general interpretation of the results in the context of other evidence, and implications for future research                                                                                                                                                                                                                         |
| **Funding**                         |      |                                                                                                                                                                                                                                                                                                                                            |
| Funding                             | 27   | Describe sources of funding for the systematic review and other support (such as supply of data) and role of funders for the systematic review                                                                                                                                                                                                   |
| Study        | Design | Participants & indication | Intervention & setting | Outcome measures | Main results | Analysis / comments |
|--------------|--------|---------------------------|------------------------|------------------|--------------|---------------------|
| Aigner et al (2006) | RCT | Two groups: A: Laser acupuncture with cervical collar | **Intervention:** Both groups: cervical collar for wearing first 1-2 weeks including at night if required (maximum duration 4 weeks), muscle relaxant combined with analgesic. Intervention A or B commenced at first follow up visit and not immediately post baseline. | **Short term:** ROM total flex/ext (cm measure), rotation, and side-flexion (goniometer). **Long term:** Duration of condition, neck pain, headaches, dizziness, wearing collar, drug use. | No statistically significant advantage of A for any outcome. | No primary outcome measure specified |
| Austria       |        | A: Placebo laser with cervical collar                 | **Assessments:** Recurrence of myofascial pain, headaches, dizziness. |                  | No results reported. | No primary endpoint specified |
| Acute         |        | Recruitment strategy unclear. | **Setting:** Baseline (within 4 days of injury): n=50 (8 men, 42 women) |                  | Authors did not respond to request for data. | No *a priori* power calculation |
|               |        | A: n=25 B: n=25 | |                  |              | Loss to follow up: Drop outs: N=5 (10%) - 2 from A & 3 from B |
|               |        | | |                  |              | No exclusions | |
|               |        | | |                  |              | No management of losses described | |
|               |        | | |                  |              | Co-interventions not explored | |
|               |        | | |                  |              | No ITT analyses reported | |
| Dehner et al (2009) | RCT | Two groups: A: Active physical therapy | **Intervention:** Both groups: NSAIDS and soft cervical collar for 7 days. Post 7 days of collar and medication, patients commenced a standardised programme (A or B) three times per week for seven weeks. | **Short term (2 months):** Pain score VAS (100mm): mean of “average degree of pain” and “most severe pain” Deficit in ROM of cervical spine: sum of individual ROM in 6 directions (flex/ext/side- | Group A statistically significant greater decrease (p=.009) in median pain score at 2 months | No primary outcome measure specified |
| Germany       |        | A: Passive physical therapy | | | No primary endpoint specified | No *a priori* power calculation |
| Acute         |        | Note: **Comparison** | | | Loss to follow up: | |
|               |        | | | | | |
|               |        | | | | | |
| Study | Design | Participants & indication | Intervention & setting | Outcome measures | Main results | Analysis / comments |
|-------|--------|---------------------------|-----------------------|-----------------|-------------|---------------------|
| to patients in a previous study excluded from extraction from trial report | Recruitment in emergency department. | Baseline: 1 week post injury. n=70 patients | A: Soft tissue, trigger point, joint mobilisation (excluding cervical spine) techniques, posture training, and electrotherapy. Progressed to include: coordination training, training of the trunk and extremities, and stabilisation techniques with short segmental leverage (week 3); three-dimensional training with the head’s weight as the limit of resistance (week 6); joint mobilisation cervical spine (week 8). | flexion/rotation) subtracted from pre-defined normal value (330 degrees). Measured by goniometer. | No significant inter-group differences on deficit ROM (p=.65) | No drop outs |
| | | A: n=35 (n=32 after exclusions due to loss-to-follow-up); 10 male, 22 female. | B: Moist heat, classic massage and electrotherapy. | | Confusing section on statistical methods – apparently reporting use of Wilcoxon signed ranks tests for inter-group comparisons | Exclusions: n=3 from each group (9%) did not complete interventions |
| | | B: n=35 (n=32 after exclusions due to loss-to-follow-up); 12 male, 20 female. | Setting: Physical therapy department | | No management of losses described | |
| Gonzalez-Inglesias et al (2009) | RCT | Acute injury (within 40 days of injury), QTF II, neck pain and musculoskeletal signs, no evidence of conduction loss on clinical neurological examination, concussion during accident, treatment for neck pain prior to accident, previous whiplash, neck pain, headaches, psychiatric or psychologic condition, another somatic condition (e.g. fibromyalgia), current claim for litigation or compensation. | A: Water proof porous adhesive Kinesio Taping, width 5cm, thickness 0.5mm. Standardised therapeutic application to apply tension to the posterior cervical structures. Taping applied in positions of LSF, RSF and flex. | | | |
| Spain | Two groups: | | | | | No ITT analyses reported |
| | A: Kinesio Taping to the cervical spine (with tension) | Baseline: 72 hours post recruitment, within 40 days of injury. n=41 patients | B: Kinesio Taping similarly to group A but under no tension with neck positioned in neutral. | | | |
| | B: Sham Kinesio Taping (without tension) | | | | | |
| | Recruitment of patients referred by a primary care physician to physiotherapy | | | | | No ITT analyses reported |
| | | Intervention | Short term (3-6 months): | | | |
| | | Both groups: No analgesia or anti-inflammatory medication prior to study. Interventions A and B implemented 1 day post baseline. | Period of disability: days off work | | | No a priori power calculation |
| | | A: Kinesio Taping, width 5cm, thickness 0.5mm. Standardised therapeutic application to apply tension to the posterior cervical structures. Taping applied in positions of LSF, RSF and flex. | Sickness costs: Costs of physical therapy and patient’s lost income. | | | No loss to follow up |
| | | B: No tension with neck positioned in neutral. | Assessments: Short term: | | | Co-interventions not explored |
| | | | 2 months post injury | | | |
| | | | By telephone after 3-6 months. | | | No ITT analyses reported |
| | | | | | | Group A statistically significant greater decrease in mean neck pain at immediate and 24 hour follow-ups. (p<.001) |
| | | | | | | Group A statistically significant greater improvement in all ranges of movement at immediate and 24 hour follow-
| Study          | Design | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures                                                                 | Main results                                                                 | Analysis / comments |
|---------------|--------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------|
| Jull et al    | RCT    | Chronic whiplash resulting from road traffic accident, WADII, aged 18-65, persistent problems 3 months to 2 years post injury, and no WADIII, WADIV, previous neck pain, previous road traffic accident, not fluent in English, or currently receiving physical therapy. | Setting: Unclear                                                                        | Short term:                                                                                   | Significantly greater reduction mean NPI in group A (p=.04); greater improvement in mean muscle function CCFT in group A (p<.018), but, significantly lower mean change on TSK in group A (p=.02). | Primary outcome measure specified |
| Australia     |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 | Drop outs: 2/35 lost to follow up in group B                                      | Primary endpoint specified |
| Chronic       |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 | No exclusions                                                          | A priori power calculation conducted on NPI (alpha =.05; power = 90%) |
| A: Multimodal |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 | No management of losses described                                              | ITT analyses performed |
| B: Self-      |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| Management    |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| Programme     |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| Recruitment   |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| by referral   |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| from General  |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| Practitioner  |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| or general    |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| advert in     |        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| popular press.|        |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| Stratification for presence or not of widespread mechanical or cold hyperalgesia. |       |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| A: n=36, 63% female | Multimodal programme |    | A: Multimodal programme delivered by a physiotherapist. Intervention of 10 weeks and 10-15 treatments, respecting chronicity. Low load to avoid provocation. Included exercises to: re-educate muscle control of the neck and scapular, posture, functional activities, retraining kinaesthetic sense. Included low velocity mobilisation techniques, education and assurance, advice to continue exercise at home. |                                                                                     |                                                                                     |                                                                                 |                                                                                  |                         |
| B: n=35, 80.6% female | Self-management programme |    | B: Information about whiplash and advice to stay active and exercise documented in a booklet, that included: education about the mechanism of WAD, assurance re recovery, advice to stay active, ergonomic advice re ADL, advice re an exercise programme. The advice and exercise programme were similar to that provided to group A. Encouraged to perform exercises twice per day. |                                                                                     |                                                                                     |                                                                                 |                                                                                  |                         |
| A: n=21, 10 male, 11 female | n=20 |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |不愿回答                         |
| B: n=20, 10 male, 10 female | n=20 |                                                                                         |                                                                                         |                                                                                     |                                                                                 |                                                                                  |                         |
| Study               | Design | Participants & indication | Intervention & setting | Outcome measures | Main results                                                                 | Analysis / comments |
|--------------------|--------|---------------------------|------------------------|------------------|-------------------------------------------------------------------------------|---------------------|
| Sterling et al     | RCT    | Chronic WAD II. Aged 18-65| A: Three sets of one-minute cervical lateral glide spine manual therapy away from the nominated side of pain, with a one minute rest between sets. Patient positioned in supine and treatment at C5-6 level. Pain free technique. | Short term: PPT: hand held algometer (Somedic), evaluations at cervical spine, median nerve, and Tibialis Anterior sites. | Significantly greater increase in mean NFR threshold in group A (p=.04). A priori specification of primary outcome measure assumed owing to power calculation |
| Australian Chronic | Chronic| Two groups: A: Cervical spine manual therapy technique (lateral glide). Baseline: n=39 participants. > 3 months post injury | B: Hand placement and positioning as for group A, but with no neck movement. Pain free for the participant. | No significant difference between interventions for NFR pain rating (p=.063), PPT cervical spine (p=.78), PPT median nerve (p=.068), PPT Tibialis Anterior (p=.49), and TPT heat (p=.55) or cold (p=.48). | No statistically significant difference between groups for any outcome. No primary endpoint specified |
|                    |        | B: Manual contact control intervention. A: n=22. 14 females. Age years: mean 41 ( SD 14) | Setting: Unclear | Primary outcome measure specified No a priori power calculation | Loss to follow up for NFR: A: n=3 (14%) B: n=2 (12%) |
|                    |        | B: n=17. 13 females. Age years: mean 39.1 (SD 13.2) | Assessment: Short term immediately post treatment. | NFR threshold and VAS pain measured at right sural nerve. | NFR could not be elicited. No management of losses for NFR described |
|                    |        |                          | | | Data not requested from authors as no comparable outcomes to other trials. |
| Ask et al          | RCT    | Sub-acute (> 6 weeks and < 3 months) whiplash injury from car collision, symptoms within 48 hours of injury, WADI or WAD II, NDI ≥10, aged 18-67 years with no cervical fracture or dislocation, neurological deficit, head injury or concussion related to the injury, serious mental disease, inflammatory rheumatic disease, prior cervical surgery, alcohol or | Intervention: Both groups: to maintain usual activities and avoid using a soft collar. Both interventions 1-1 physiotherapy, with 1-2 sessions per week, over 6 weeks, with a minimum of 6 & maximum of 10 sessions. Each session lasted approximately 30 minutes. Both groups encouraged to perform daily home exercises and to participate in common activities. Exercise programmes were adjusted if pain were exacerbated during the | Short term: Primary outcome: NDI (0-50). | No statistically significant difference between groups for any outcome. On NDI (primary outcome): p=.912 at short-term and p=.783 at long-term assessments. |
| Norwegian Sub acute|        |                          | | | No statistically significant difference between groups for any outcome. On NDI (primary outcome): p=.912 at short-term and p=.783 at long-term assessments. |
|                    |        |                          | | | Authors did not |
|                    |        |                          | | | Primary outcome measure specified No primary endpoint specified No a priori power calculation Loss to follow up: Drop outs: (same at 6 weeks and 1 year): |
| Study | Design | Participants & indication | Intervention & setting | Outcome measures | Main results | Analysis / comments |
|-------|--------|---------------------------|------------------------|-----------------|-------------|-------------------|
| Bonk et al. (2000) | RCT | Acute WAD I or II, aged 16-60 years with no: prior neurological disease, prior neck injury, x-rays showing old fractures or skeletal malformations, spondyloarthropathy, symptom onset > 3 days | Both groups could use analgesics, anti-inflammatories | retraction, lumbo-sacral, head nod, head rotation. | respond to request for data. | No statistically significant differences between groups on any outcome at 6 or 12 weeks follow-up. No a priori power calculation |
| Germany | Acute | A: Active therapy. | A: Motor control exercises. | Number of tender points (max 18). | A: n=2 (1 other illness) B: n=3 (no time for treatment) | No primary outcome measure specified |
| | | B: Collar | Motor relearning programme. Initial focus on coordination/holding neck flexor/extensor and shoulder girdle muscles, at low load and pain free x 10 reps; using pressure biofeedback. Mean of 8.0 treatments. | Isometric endurance neck flexors and extensors. | | No primary endpoint specified |
| | | | B: Endurance and strength training exercises. 5 minute warm up. Higher load to recruit deep and superficial flexor and extensor muscles, using rubber band; upper body strengthening; 15-20 reps with no discomfort. 5 minute stretching. Mean of 8.4 treatments. | CROM (Myrin goniometer / compass) flex/ext, rotation, side flexion. | | |
| Study | Design | Participants & indication | Intervention & setting | Outcome measures | Main results | Analysis / comments |
|-------|--------|---------------------------|------------------------|------------------|-------------|---------------------|
| Pato et al (2010) Switzerland | RCT | WADI or II, due to hyperflexion or hyperextension injury, symptoms > 6 months, < 12 months post injury, with no fracture / dislocation, injuries to other areas of the body from the accident, head trauma, loss of consciousness, post traumatic amnesia, head injury, previous brain injury, previous neurological deficit, previous whiplash, pre-existing neck pain, or previous neck surgery. | Mobilisation of neck in supine, active mobilisation neck, strengthening and isometric exercises. Supine week 1, sitting week 2. Week 3 – interscapular muscle strengthening exercises, advice re posture. | Shoulder pain prevalence (%) | Authors did not respond to request for data. |
| | 3 groups: | | | Arm pain prevalence (%) | | Loss to follow up: |
| | A: Local anaesthetic infiltration. | | B: Collar therapy. Wearing a collar for 3 weeks during day. No physiotherapy, activity, exercises or mobilisation. | Neck ROM flex/ext cm | | |
| | B: Physiotherapy. | | Baseline: Within 3 days of injury. | Neck ROM side flexion goniometer (degrees). | | No drop outs |
| | C: Medication. | | A: n=53 n=47 analysed. 19 female, 28 male age mean 26.7 (SD 7.7) years | Neck ROM rotation goniometer (degrees). | | Exclusions: A: 1 developed neurological symptoms, n=5 non-compliant with therapy (11%). n=47 analysed. |
| | Followed by randomization to CBT or no CBT in each group (1:1). | | B: Massage, learned relaxation techniques of myogelotic muscles, programme of isometric and low intensity isotonic training neck muscles, continued as home exercises. 2 sessions per week. | Subjective outcome rating (4 categories: worse / unchanged / improved / resolved) | CBT had a significant effect but only in women, for pain. |
| | Recruitment of participants identified through Swiss WADII: No separation of data for WADI and WADII. | | | Pain McGill | Results reported for n values of: A: 27 B: 23 C: 23 No CBT: 33 CBT: 40. |
| | | | | Pain VAS (0-10 scale). | | |
| | | | | Working capacity (%) determined by physician | | |
| | | | | Secondary outcome measures: | A priori specification of primary outcome measure assumed owing to power calculation |
| | | | | Primary outcome measures: | No primary endpoint specified |
| | | | | CBT: | No statistically significant difference in efficacy between the 3 interventions. |
| | | | | CFQ to evaluate cognitive ability | A priori power calculation conducted on pain intensity (alpha = 0.05; power 0.8; effect size 0.6). |
| | | | | | Loss to follow up: |
| | | | | | Drop outs: |
| | | | | | Losses of 16% reported. |
| | | | | | A: n=3 discontinued, 2 did not tolerate intervention, 1 on lawyer’s advice (n=27 in... | | |
| Study                                      | Design   | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures                                                                 | Main results                                                                 | Analysis / comments                                                                 |
|--------------------------------------------|----------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Accident Insurance Fund and Swiss Insurance Association registers. All patients meeting criteria referred to a coordinator. |          | Baseline: 6-12 months post injury.                                                        | 2 sessions per week by psychologist (16 sessions), 60 mins per session. Followed a therapy manual provided to participants. Aimed to teach control of pain through control of physical reaction to stress and chronic pain management techniques. | Assessments:                                                                     | No statistically significant difference between groups for primary outcomes of neck pain or headache intensity at 12 or 52 weeks, or work activities at 12 weeks (adjusted and unadjusted for baseline characteristics). | No ITT analyses reported. A priori specification of primary outcome measures assumed owing to power calculation. |
| Stratification: Gender, age and education. |          | A: n=30 67% women age mean 38 (SD 11) randomised to: CBT n=16 No CBT n=14                  | No CBT: No additional management.                                                       | Setting:                                                                        |                                                                                | No exclusions. A priori power calculation conducted on pain and work activities VAS (alpha = 0.05; power 0.8; difference of 20%). |
|                                            |          | B: n=29 57% women age mean 40(SD 12) randomised to: CBT n=14 No CBT n=15                  | Unclear                                                                                 |                                                                                |                                                                                | No management of losses reported. Co-interventions not explored.                 |
|                                            |          | C: n=28 61% women age mean 43(SD 13) randomised to: CBT n=14 No CBT n=14                  |                                                                                |                                                                                |                                                                                | No ITT analyses reported.                                                      |
| Scholten-Peeters et al (2006)               | RCT      | Acute WAD I or II as a result of a road traffic accident, with symptoms (neck pain/headache/dizziness) within 48 hours injury, living in Netherlands, aged 18-55, with no: cervical hernia, past cervical spondylodessis, loss of consciousness, history of previous neck or head injury in past 3 years, insufficient knowledge of Dutch language, or co-morbidities. No separation of data for WADI and WADII. | Both interventions: Both interventions were delivered according to a dynamic biopsychosocial treatment protocol using treatment goals and corresponding interventions. Patient centred. Treatment commenced 4 weeks post injury. Maximum duration interventions 9 months. No limit to number of sessions. Treatment ended when problem was resolved or treatment goals achieved, or when plateau of improvement reached. | Primary outcome measures (short and long term): Neck pain VAS (0-100) Headache intensity VAS (0-100) Work activities in daily living VAS (0-100) Secondary outcome measures: Functional recovery VAS | No statistically significant difference between groups for primary outcomes of neck pain or headache intensity at 12 or 52 weeks, or work activities at 12 weeks (adjusted and unadjusted for baseline characteristics). | Trial protocol published with a priori specification. |
| Netherlands Sub-acute                       |          | Recruitment from 122 GP practices and 3 emergency departments. Eligibility checked at 2 weeks post |                                                                                |                                                                                |                                                                                | No primary endpoint specified.                                                   | A priori power calculation conducted on pain and work activities VAS (alpha = 0.05; power 0.8; difference of 20%). |
|                                            |          | Acute WAD I or II as a result of a road traffic accident, with symptoms (neck pain/headache/dizziness) within 48 hours injury, living in Netherlands, aged 18-55, with no: cervical hernia, past cervical spondylodessis, loss of consciousness, history of previous neck or head injury in past 3 years, insufficient knowledge of Dutch language, or co-morbidities. No separation of data for WADI and WADII. | Both interventions: Both interventions were delivered according to a dynamic biopsychosocial treatment protocol using treatment goals and corresponding interventions. Patient centred. Treatment commenced 4 weeks post injury. Maximum duration interventions 9 months. No limit to number of sessions. Treatment ended when problem was resolved or treatment goals achieved, or when plateau of improvement reached. | Primary outcome measures (short and long term): Neck pain VAS (0-100) Headache intensity VAS (0-100) Work activities in daily living VAS (0-100) Secondary outcome measures: Functional recovery VAS | No statistically significant difference between groups for primary outcomes of neck pain or headache intensity at 12 or 52 weeks, or work activities at 12 weeks (adjusted and unadjusted for baseline characteristics). | Trial protocol published with a priori specification. |
|                                            |          |                                                                                |                                                                                |                                                                                |                                                                                | No exclusions. A priori power calculation conducted on pain and work activities VAS (alpha = 0.05; power 0.8; difference of 20%). | A priori specification of primary outcome measures assumed owing to power calculation. |
|                                            |          |                                                                                |                                                                                |                                                                                |                                                                                | No management of losses reported. Co-interventions not explored.                 | No ITT analyses reported.                                                        |
|                                            |          |                                                                                |                                                                                |                                                                                |                                                                                | No exclusions. A priori power calculation conducted on pain and work activities VAS (alpha = 0.05; power 0.8; difference of 20%). | A priori power calculation conducted on pain and work activities VAS (alpha = 0.05; power 0.8; difference of 20%). |
| Study          | Design | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures                                                                 | Main results                                                                 | Analysis / comments                                                                 |
|---------------|--------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Australia     | RCT    | Patients presenting for medical care of WAD I-III within one month of injury, reporting at least mild disability, score at least 20% on pain or disability primary outcome measure; with no: | Both groups received advice based on the baseline assessment prior to randomisation. | **Primary outcome measures**                                                          | Statistically significant improvement in mean pain (p=.005), bothersomeness (p=.019) and       | No primary outcome measure specified (multiple measures specified)                |
|               | 2 groups | A: Exercise and advice                                                                   | A: 6 week graded exercise programme under supervision by physiotherapist (12 sessions), | Pain intensity VAS (0-10) over previous 24 hours.                                   |                                                                                 |                                                                                  |
|               |         |                                                                                          |                                                                                       | Pain bothersomeness VAS (0-10) over previous 24 hours.                               |                                                                                 |                                                                                  |
| Stewart et al (2007) [Stewart et al (2003)] |        | Injury.                                                                                    | A: 10 minute sessions with GP. Education and advice on graded activity, dependent upon treatment goals. Reassurance, remain active, and resume activity as soon as possible, and expected prognosis. Emphasis that withdrawal from activity, soft collar use and reliance on medication may delay recovery. Decreased focus on pain and encouraged patient to take responsibility. Mean no of treatment sessions 3.9(2.9), mean treatment episode at 18.8(15.2) weeks. B: 30 minute sessions with physiotherapist. Education, advice, graded activity, as for GP. Graded activities with supervision, motivation, reassurance. Exercise – progressive loading cervical and shoulder muscles, active movements, posture and balance. Function – carrying, lifting, pushing and cycling using graded progression. Manual techniques as indicated, but not first choice of treatment. Mean no of treatment sessions 12.7(12.1), mean treatment episode at 19.9(13.5) weeks. | General Health Status SF36 (0-100)                                            | Group A significantly better than B for work activities (unadjusted for baseline characteristics) at 52 weeks. | Loss to follow up: Drop outs: At 12 weeks (4%): A: n=1 loss of motivation, n=1 recovered B: n=1 not satisfied with treatment |
|               |        | Stratification for: general practice / emergency department, region of Netherlands (middle/south). |                                                                                       | ROM cervical spine (degrees): flex/ext, side flexion, rotation, total ROM.         |                                                                                 |                                                                                  |
|               |        | Baseline: 4 weeks post injury.                                                             |                                                                                       | Fear of movement Tampa (17-68)                                                      |                                                                                 |                                                                                  |
|               |        | A: n=42                                                                                   |                                                                                       | Coping PCI                                                                        | Some statistically significant differences on secondary outcomes but inconsistent across unadjusted and adjusted analyses | Loss to follow up greater for secondary outcome measures.                     |
|               |        | Mean age (SD) 33.8(10.3) 61.9% women                                                      |                                                                                       | Disability NDI (0-50)                                                              |                                                                                 | No exclusions                                                                    |
|               |        |                                                                                          |                                                                                       | Disability in housekeeping and social activities VAS (0-100)                       |                                                                                 | Management of losses: Missing values imputed using group means/medians          |
|               |        |                                                                                          |                                                                                       | **Assessments:**                                                                   |                                                                                 | Co-interventions: Received co-interventions at 12 weeks (7%):                    |
|               |        |                                                                                          |                                                                                       | Short term:                                                                       |                                                                                 | A: n=6 B: n=0                                                                     |
|               |        |                                                                                          |                                                                                       | 8 weeks post injury.                                                              | Authors did not respond to request for data.                                    | Received co-interventions at 52 weeks (15%):                                      |
|               |        |                                                                                          |                                                                                       | 12 weeks post injury.                                                             |                                                                                 | A: n=12 B: n=4                                                                    |
|               |        |                                                                                          |                                                                                       | 26 weeks post injury                                                               |                                                                                 | ITT analyses performed                                                               |
|               |        |                                                                                          |                                                                                       | Long term:                                                                       |                                                                                 | Per protocol analyses also performed                                              |
|               |        |                                                                                          |                                                                                       | 52 weeks post injury, 52 week follow up by questionnaire only.                    |                                                                                 |                                                                                  |
|               |        |                                                                                          |                                                                                       | **Settings:**                                                                     |                                                                                 |                                                                                  |
|               |        |                                                                                          |                                                                                       | Unclear                                                                          |                                                                                 |                                                                                  |

Note: High initial pain intensity and work disability compared to other studies.
| Study       | Design                                        | Participants & indication                                                                 | Intervention & setting                                                                                                                                                                                                 | Outcome measures                                                                                      | Main results                                                                                           | Analysis / comments                                      |
|------------|-----------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Chronic    | B: Advice alone                               | previous neck surgery, known or suspected serious pathology, nerve root compromise (WAD III), contraindication to exercise, severe depressive symptoms (DASS), neck radiograph since accident, current physiotherapy treatment, poor use of English. No separation data WAD I II or III. Authors confirmed only WAD I and II participants. Baseline: 3-12 months post injury. N=134 randomised. | including 1 hour exercise – 30 mins supervised by physiotherapist. Individualised, progressive, sub-maximal programme designed to enable completion of functional activities specified by the participant as difficult owing to whiplash, including: aerobic exercise, stretches, functional activities, focus to build speed, endurance and coordination, trunk and limb strengthening exercises, principles of CBT, goal setting, self monitoring of progress, self reinforcement, encouragement to continue as home programme. Mean number of sessions 9.9 (range 0-12). | Functional ability using PSFS (0-10). Secondary outcome measures: Disability using NDI (0-50). GPE 11 point scale (-5 to 5) Health related quality of life using physical and mental summary scores of SF36. Work status | PSFS (p=.006) in group A at 6 weeks. No statistically significant differences at 12 months. Statistically significant improvement in mean NDI (p=.004), SF36 physical (p=.003), SF36 Mental (p=.005) and GPE (p=.006) in group A at 6 weeks. No statistically significant differences at 12 months. Authors provided data. | A priori power calculation conducted on VAS pain intensity and pain bothersomeness and NDI (alpha = 0.05; power 80%) with no adjustment for alpha spend. Loss to follow up: Drop outs: A: total losses 3 (4.5%) B: total losses 6 (8.8%) A: No loss to follow up at 6 weeks B: 2 lost to follow up at 6 weeks A: 3 lost to follow up at 12 months B: 4 further lost to follow up at 12 months Management of losses: Missing data were imputed using appropriate mean item score (for that participant) Participants were omitted from analyses if all follow up data were missing. Co-interventions: Co-interventions by 6 weeks: A: n=10 (15%) B: n=15 (23%). Co-interventions by 12 months: A: n=18 (29%) B: n=35 (56%). ITT analyses performed |
| Study            | Design      | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures                                                                 | Main results                                                                 | Analysis / comments                                                                 |
|------------------|-------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Thuile and Walzl (2002) | RCT         | Kramer whiplash grades I and II, with pain (neck pain, post head pain, shoulder / arm pain, stiffness neck), loss of mobility in three directions. | A: Standard medication with diclofenac and tizanidine. With magnetic field system 'Vitalife MRS 2000' at intensity 50% (10,000 nano Tesla) for first 2 days, then 100% (20,000 nano Tesla) for two subsequent days, then 150% (30,000 nano Tesla) for a further 10 days. MRS cushion for 16 minutes and whole body mat for 8 minutes. Polarity switched every 2 minutes. B: Control of standard medication with diclofenac and tizanidine. | Pain VAS (0-10) for head, neck and shoulder/arm areas. ROM in three planes (degrees): Flex/ext Rotation Side flexion No detail of measurement tool. | Statistically significant lower pain in head, neck and shoulder/arm for A (p<.003). Statistically significant higher ROM in all three planes for A (p<.05). | No primary outcome measure specified No primary endpoint specified No a priori power calculation Loss to follow up: No data reported on loss to follow up No management of losses described. Co-interventions not explored No ITT analyses reported |
| Austria Acute (? Unclear) | 2 groups: A: Standard medication with magnetic therapy. B: Standard medication. Recruitment of patients reporting for treatment. | Baseline: Unclear A: n=44 21 men, 23 women Mean (SD) age 37.2(17.8) B: n=48 31 men, 17 women Mean (SD) age 44.8(22.6) | A: Physical therapy 10 sessions within the first 14 days post injury. Heat to neck for 5 minutes, lymph drainage for 10 minutes, massage for 10 minutes, active exercises with elastic resistance to neck and shoulder for 10 minutes. Home exercises for 20 minutes each day. In addition to medication (diclofenac and ranitidine). Use of soft collar allowed as demanded by patient for first 2 days post injury. B: Standard treatment of soft collar continuously worn for first 7 days in addition to medication (diclofenac and ranitidine). Then no specific treatment. | **Primary outcomes** Pain intensity NRS (0-10) Disability intensity NRS (0-10) **Secondary outcomes** Days with oral medication. Period of immobilisation with soft collar. Localisation of injury-associated pain disorder (marked on a dermatomal map) Resolution of pain. | Statistically significant lower pain (p=.002) and disability (p=.002) for group A at 6 weeks, and at 6 months (p<.001 for pain and for disability). Used 1 tailed test for primary outcomes. Authors did not respond to request for data. | Primary outcome measures specified No primary endpoint specified A priori power calculation conducted on pain intensity and disability (alpha 0.05; power 0.9; anticipated 30% benefit) Loss to follow up: Drop outs: 1 week post baseline: A: n=7 B: n=14 6 weeks post baseline: A: n=15 (15%) B: n=35 (36%) |
| Study          | Design    | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures                                      | Main results                                                                 | Analysis / comments |
|---------------|-----------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------------------------------|---------------------|
| Vikne et al   | RCT       | Patients aged 18-60 who have experienced a traffic accident 6-12 months previously, WADI or II, with no: ongoing treatment, pregnancy, alcohol or drug abuse, serious illness, language difficulties. | Home programmes started after 3 weeks in all groups.                                     | Complaints on a scale (1-9)                           | No statistically significant differences between groups (p=.07 to .82) except for small effect for home training on pain during rest (p=.05) and reported fatigue (p=.02). | No primary outcome measure specified |
| Norway Chronic| 4 groups: |                                                                                                | A: Traditional physiotherapy with usual exercises focused to strength and endurance training of the neck, back and abdominal muscles. Using patient’s body weight as resistance, patient manuals, and fixed training devices. Passive modalities including electrotherapy, massage, manipulation and acupuncture as required but emphasis on active treatment. Training stopped at 4 months. Contacted by physiotherapist by telephone and encouraged to train every fourth month for 12 months. Plus home training programme based on exercises covered in traditional physiotherapy sessions. | Pain neck/shoulder past 14 days VAS                  | Pooling AB v CD small effect (p=.01) on neck endurance for AB.                  | No primary endpoint specified |
|               |           | B: Traditional physiotherapy with home training                                             | B: As above but home training                                                           | Modified RMDQ                                          | Authors did not respond to request for data.                                  | No a priori power calculation |
|               |           | C: Sling exercise therapy with no home training                                             | C: n=51                                                                                 | Sick leave                                             |                                                                              | Loss to follow up: |
|               |           | D: Sling exercise therapy with home training                                               |                                                                                         | Psychological distress using Hopkins Symptom Checklist (HSCL) 25 item reporting previous week. | Drop outs: At 4 and 12 months (1 drop out prior to intervention):              | Drop outs: |
|               | Recruitment |                                                                                           |                                                                                         | Cervical ROM: Flexion, extension, left rotation, right rotation in degrees. | A: n=6, n=5 (21%)                                      | A: n=6, n=5 (21%) |
|               |           |                                                                                            |                                                                                         | Neck stabilisation/endurance hold in seconds.         | B: n=5, n=5 (18%)                                      | B: n=5, n=5 (18%) |
|               |           |                                                                                            |                                                                                         | Cervico kinaesthetic sensibility                       | C: n=6, n=5 (22%)                                      | C: n=6, n=5 (22%) |
|               |           |                                                                                            |                                                                                         |                                                        | D: n=4, n=6 (19%)                                      | D: n=4, n=6 (19%) |

VADII: No separation of data for WADI and WADII.

Baseline: Within 48 hours of injury. Mean time interval between injury and enrolment 8.5(9.3) hours.

A: n=103
Age mean(SD) 30.1(10.3)
62.1% female

B: n = 97
Age mean(SD) 28.3(8.9)
60.8% female

Setting: Unclear

Assessments:
Short term: 1 week post baseline
6 weeks post baseline
6 months post baseline

6 months post baseline: A: n=31 (30%) B: n=45 (46%)

Management of losses:
Missing values imputed using last value carried forward.

Co-interventions not explored

ITT analyses performed

Per protocol analyses also reported

Consistent findings for per protocol analysis
| Study | Design | Participants & indication | Intervention & setting | Outcome measures | Main results | Analysis / comments |
|-------|--------|---------------------------|------------------------|-----------------|--------------|---------------------|
| Armstrong et al (2005) | RCT | Patients with minimum of 1 whiplash injury, > 3 months previously, < 5 years previously, WAD II/III; with no therapy at time of study, previous history of head injury, spinal fracture/dislocation, spinal surgery, systemic inflammatory disorders, neurological disorders, Meniere’s Disease, disabling vertigo, medication for vertigo, inner ear damage, large metallic implants. | A: Cranio-cervical action in sitting as a stabilizing exercise of the cervical spine, combined with scapular stabilising. 4/5 practices with simultaneous performance of head and neck joint position tasks, with and without a blindfold. | Head and neck position sense (Fastrak) | Design not followed through to make any comparisons on outcomes for A and B. | No primary outcome measure specified |
| | | | B: Rest in a lightened room for 15 reading a magazine. | B: Immediately post treatment | | Primary endpoint specified |
| | | | Setting: Unclear | No statistical tests reported on whiplash participants only. | No a priori power calculation |
| | | | Exclusions: N=6 excluded owing to incomplete adherence, and unclear whether exclusions are included as part of drop out figures. | Authors did not respond to request for data. | No management of losses described |
| Chronic | 4 groups: A: Cranio-cervical stability exercises | Patients with minimum of 1 whiplash injury, > 3 months previously, < 5 years previously, WAD II/III; with no therapy at time of study, previous history of head injury, spinal fracture/dislocation, spinal surgery, systemic inflammatory disorders, neurological disorders, Meniere’s Disease, disabling vertigo, medication for vertigo, inner ear damage, large metallic implants. | C: Protocol of 10 graded exercises using ceiling mounted sling with patient sitting and supine to mobilise and strengthen. Combined with traditional physiotherapy intervention. 24 sessions over 4 months. Training stopped at 4 months. Contacted by physiotherapist by telephone and encouraged to train every fourth month for 12 months. Plus home training programme using ceiling mounted sling at home. | Short term: 4 months post baseline | No comparative analysis reported |
| | | D: n= 54 | programme continued to 12 months, and changed once a month. D: As above but home training programme continued to 12 months, and changed once a month. | Long term: 12 months post baseline | No ITT analyses reported |
| | B: Control | | Setting: Institute | | |
| Study involved two cohorts of whiplash and healthy control patients. Whiplash only cohort reported | Recruitment by local newspaper advertisement | | | |

**Physiotherapy management Whiplash Associated Disorder (WAD) II/III**
| Study                             | Design         | Participants & indication                                                                 | Intervention & setting                                                                 |
|----------------------------------|----------------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Fernandez-de-las-Penas et al (2004a) | RCT            | Participants with a history of whiplash injury WAD II / III, for 3 weeks to 3 months; with no prior whiplash injury, articular instability (fracture, luxation), degenerative cervical alteration. | Both groups – conventional physiotherapy treatment – consisting of active exercises at home, electrotherapy, ultrasound therapy, muscle stretching, multimodal therapy, and manual therapy. 15 sessions of treatment. |
| Spain                            |                | No separation data for WAD II and III.                                                     | A: Dorsal manipulation at 5th and 10th treatment sessions. HVLA 'Dog' technique. Single technique with cavitation, and conventional physiotherapy. |
| Acute / subacute                  |                | Recruitment through a private clinic for physical therapy and osteopathy. N=88 volunteers from and initial sample of n=120 were recruited. | A: Conventional physiotherapy treatment only.                                       |
| Study involved two cohorts of whiplash and mechanical neck pain patients. |                |                                                                                           | Setting: Private clinic for physical therapy and osteopathy, although not explicitly stated. |
| Whiplash only cohort reported     |                |                                                                                           | VAS (1-100mm) neck pain, dorsal region pain, and head pain. Statistically significant mean reduction in neck pain for group A (p=.002) after 15 treatment sessions. |
|                                  |                |                                                                                           | Assessments: After 10 treatment sessions (one week after dorsal manipulation at 5th treatment session). |
|                                  |                |                                                                                           | After 15 treatment sessions) one week after dorsal manipulation at 10th treatment session). |
|                                  |                |                                                                                           | Setting: Private clinic for physical therapy and osteopathy, although not explicitly stated. |
|                                  |                |                                                                                           | VAS head and neck pain (0-100mm). Statistically significant mean reduction in neck pain for group A (p=.002) after 15 treatment sessions. |
|                                  |                |                                                                                           | No statistically significant change in mean head pain (p>.20)                        |
|                                  |                |                                                                                           | Authors no longer possess data.                                                      |

| Fernandez-de-las-Penas (2004b)   | RCT            | Acute whiplash injury < 3 months duration, WAD II / III, for < 3 months; with no prior whiplash injury, previous cervical surgery, having manipulative or manual therapy within past | A: Manipulative protocol including high velocity low amplitude techniques, soft tissue mobilisation techniques and mobilisation techniques. Weekly manipulative treatment. Mean of 9 (SD 1.5) sessions. |
| Spain                            |                |                                                                                           | VAS head and neck pain (0-100mm). Statistically significant mean reduction in neck pain for group A (p=.002) after 15 treatment sessions. |
| Acute                            |                |                                                                                           | Cervical active range of movement (CROM) flexion and rotation using a goniometer. |
|                                  |                |                                                                                           | No comparison of outcome measures at same time interval post baseline.               |
|                                  |                |                                                                                           | No primary outcome measure specified.                                               |
|                                  |                |                                                                                           | No primary endpoint specified.                                                      |
|                                  |                |                                                                                           | No a priori power calculation.                                                      |
| Study                                      | Design       | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures                                                                 | Main results                                                                 | Analysis / comments |
|-------------------------------------------|--------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------|
| B: Control of conventional physiotherapy  | RCT          | Baseline: A: n=190, females n=50, age mean (SD) 27 (7), WAD II n=155, WAD III n=35           | B: Conventional physiotherapy treatment – consisting of active exercises at home, electrotherapy, ultrasound therapy, muscle stretching, multimodal therapy, and manual therapy. 15 sessions of treatment. Mean of 23 (SD 3.2) sessions. | Number of sessions needed to complete treatments                                | Comparison for whole treatment packages A and B possible at end of treatment.  | Loss to follow up: No apparent losses but not explicitly reported. |
| Recruitment from a private clinic for manual therapy and physiotherapy |              | B: n=190, females n=30, age mean (SD) 28 (7), WAD II n=150, WAD III n=40                    | **Setting:** Private clinic for manual therapy and physiotherapy, although not explicitly stated. |                                                                                |                                                                               | Co-interventions not explored. |
|               |              |                                                                                           | **Assessments:** Short term: A: after each 4 sessions (i.e. monthly).                     |                                                                                |                                                                               | No ITT analyses reported. |
|               |              |                                                                                           | B: after each 10 sessions (i.e. 2 weeks).                                                |                                                                                |                                                                               |                     |
|               |              |                                                                                           | Apparent assessment at end of treatment reported in Tables and Figures.                  |                                                                                |                                                                               |                     |
| Hansson et al (2006)                      | RCT          | Baseline: Median 1 year post injury (6 months to 15 years)                                   | A: Vestibular rehabilitation programme of group sessions. 50 minutes twice a week for 6 weeks. Consisting of 10 minute warm up, exercises to stimulate vestibular system using eye, head and trunk movements, progressing to closed eyes. | 4 balance measures                                                              | Statistically significant higher median SOLEO for group A at 6 weeks (p<.0005) and 3 months (p<.0005). | No primary outcome measure specified |
| Sweden Chronic                              | 2 groups     | A: n=16, n=0 WAD II, duration dizziness median (range): 2(0-8)                              | B: Control. No intervention.                                                            |                                                                                | Statistically significant longer median tandem standing (closed) for group A at 6 weeks (p<.045). | No primary endpoint specified |
| Patients with WAD with reported dizziness. WAD II / III. |              | B: n=13, n=12 WAD II, duration dizziness median (range): 2(0-15)                            | **Setting:** Physiotherapy centre                                                      |                                                                                | Statistically significant lower median DHI for group A at 6 weeks on total. | No a priori power calculation |
| Recruitment from general practitioners and physiotherapists in primary healthcare, orthopaedic physicians in private practice, |              |                                                                                           |                                                                                      |                                                                                |                                                                               | Loss to follow up: |
| B: Control, no intervention.               |              |                                                                                           |                                                                                      |                                                                                |                                                                               | Drop outs: 11 drop outs (38.0%) (3 other sickness, 3 lack of time, 1 could not tolerate treatment, 4 reason unknown) |                     |
| A: Vestibular rehabilitation programme.    |              |                                                                                           |                                                                                      |                                                                                |                                                                               | A: n=8 B: n=3                                                               | No exclusions         |
| Study                                      | Design | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures                                                                 | Main results                                                                 | Analysis / comments                                                                 |
|-------------------------------------------|--------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| administrators of rehabilitation at a regional social insurance office, and an orthopaedic hospital clinic. |        | Females n= 10 Age: median 43 (range 23-76)                                                  |                                                                                       |                                                                                  | (p=.047), functional (p=.005) and physical (p=.033); and at 3 months on physical (p=.04). | Management of losses: Last observation carried forward. |
| Rosenfeld et al (2003)                    | RCT    | Individuals exposed to whiplash trauma in motor vehicle collisions, seeking healthcare. Trauma caused by rapid movement of the head resulting in acceleration forces. WAD 0 I or II, with no: neurological deficit WADIII or fracture / dislocation WADIV, head injury, previous symptomatic chronic neck problem, alcohol abuse, dementia, serious mental disease, or diseases that could lead to death before study completion. | A and C: Active intervention – active exercise protocol of early and repeated movements consistent with McKenzie principles. Two phases 1] information, postural control, cervical rotation exercises, home exercises, exercises within limits of pain, in sitting if tolerated; 2] if symptoms unresolved 20 days post injury, evaluation and treatment according to McKenzie principles. Treatment for 6 weeks unless symptoms resolved earlier. Mean number of treatments 3.95. | Statistically significant greater reduction on pain intensity in groups A and C at 6 months (p=.0004) and 3 years follow-up (p=.020). | No primary outcome measure specified |
| Sweden                                    | RCT    | Individuals exposed to whiplash trauma in motor vehicle collisions, seeking healthcare. Trauma caused by rapid movement of the head resulting in acceleration forces. WAD 0 I or II, with no: neurological deficit WADIII or fracture / dislocation WADIV, head injury, previous symptomatic chronic neck problem, alcohol abuse, dementia, serious mental disease, or diseases that could lead to death before study completion. | B and D: Standard intervention – written information on injury, advice re activity, postural correction. Rest in first weeks with soft collar for comfort and limiting excessive movements. Active movement 2/3 | As above but with no evaluation of additional interventions. | No primary endpoint specified |
| Acute                                     | RCT    | Individuals exposed to whiplash trauma in motor vehicle collisions, seeking healthcare. Trauma caused by rapid movement of the head resulting in acceleration forces. WAD 0 I or II, with no: neurological deficit WADIII or fracture / dislocation WADIV, head injury, previous symptomatic chronic neck problem, alcohol abuse, dementia, serious mental disease, or diseases that could lead to death before study completion. | Of the n=97/102 who received allocated intervention, n=4 were classified as WADO at baseline. | Any additional interventions received. | No a priori power calculation |
| Authors responded to request for data.    |        |                                                                                           |                                                                                       |                                                                                  | Loss to follow up: 8% at 6 month follow up: A: 1 refused participation B: n=3 refused participation C: n=1 not contactable, n=1 moved abroad D: n=1 refused participation, n=1 not needed | Drop outs: 21% overall |
| Analyses performed                      |        |                                                                                           |                                                                                       |                                                                                  | Further drop outs at 3 year follow up (13%): A: n=1 no time, n=2 not contactable B: n=1 travelling, n=1 not contactable | 8% at 6 month follow up: A: 1 refused participation B: n=3 refused participation C: n=1 not contactable, n=1 moved abroad D: n=1 refused participation, n=1 not needed | Drop outs: 21% overall |

**Physiotherapy management Whiplash Associated Disorder (WAD) 0/I/II**

**Study**
- Rosenfeld et al (2003)
- Rosenfeld et al (2006) (reporting same trial)
- Sweden
- Acute

**Design**
- RCT

**Participants & indication**
- Individuals exposed to whiplash trauma in motor vehicle collisions, seeking healthcare. Trauma caused by rapid movement of the head resulting in acceleration forces. WAD 0 I or II, with no: neurological deficit WADIII or fracture / dislocation WADIV, head injury, previous symptomatic chronic neck problem, alcohol abuse, dementia, serious mental disease, or diseases that could lead to death before study completion.

**Intervention & setting**
- A: Active intervention within 96 hours injury.
- B: Standard intervention within 96 hours injury.
- C: Active intervention 14 days post injury.
- D: Standard intervention 14 days post injury.

**Outcome measures**
- Pain VAS: combined head, neck, shoulder region
- CROM lateral flexion (degrees)
- CROM rotation (degrees)
- CROM flexion/extension (degrees)

**Main results**
- Statistically significant greater reduction on pain intensity in groups A and C at 6 months (p=.0004) and 3 years follow-up (p=.020).
- No primary outcome measure specified
- No primary endpoint specified
- No a priori power calculation

**Analysis / comments**
- Management of losses: Last observation carried forward.
- Co-interventions not explored
- ITT analyses performed
- Per-protocol analyses also performed

**Data not requested from authors as no comparable outcomes to other trials.**
| Study           | Design | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures | Main results                                                                 | Analysis / comments                                                                 |
|----------------|--------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Schnabel et al (2004) | RCT    | Motor vehicle accident causing at least one of pain, stiffness or numbness in spine, head or limbs, within | Both groups: Diclofenac 50mg 3 x daily. Requested to not undertake other therapies. | Short term       | Group B had statistically significant lower prevalence of Symptom prevalence: neck pain, headache, shoulder pain, | No primary outcome measure specified                                                                                                     |

| Study | Design | Participants & indication | Intervention & setting | Outcome measures | Main results | Analysis / comments |
|-------|--------|---------------------------|------------------------|------------------|--------------|---------------------|
|       |        |                           |                        |                  |              |                     |
| care units, 3 emergency wards and several private clinics. | Baseline: Within 96 hour of injury. AT 3 year follow up, subjects matched to a comparison group for gender and age. | times per day a "few weeks" after injury. Setting: Unclear | Long term at 3 years. | C: n=1 no time, n=1 travelling, n=1 not contactable, n=1 re-injury D: n=1 refused, n=3 not contactable | Exclusions: 11% participants excluded at 6 months. n=5 patients excluded post randomisation A: n=3 (not meet inclusion(2), re-injury(1)) B: n=0 C: n=2 (not meet inclusion) D: n=1 (not meet inclusion) Further participants excluded at 3 years (8%): A: n=3 (not meeting inclusion(2), re-injury(1)) B: n=0 C: n=2 (not meeting inclusion) D: n=3 (not meeting inclusion(1) re-injury(2)) Exclusions 19% overall. No management of losses described Co-interventions: Numbers of participants receiving interventions outside of study within 6 months: A: n=3 B: n=9 C: n=5 D: n=9 ITT analyses performed |
### Acute

**Participants & indication**
- A: 48 hours of injury, ≥ 18 years old, with no: WAD III or IV, loss of consciousness, fracture, or pregnant.
- B: WADII
- No separation of data for WAD I and WAD II.

**Intervention & setting**
- A: Collar for 1 week day and night, no advice re sleeping, posture.
- B: Physiotherapy exercises for mobilisation. 2-5 visits in the first week dependent upon needs.

**Outcome measures**
- A: Neck pain (p=.025), headache (p=.028), shoulder pain (p=.008), and unresolved symptoms (p=.010)
- B: Average total pain VAS (0-10)

**Main results**
- Group B had statistically significant lower mean pain (p=.047) and mean disability (p=.042).

**Analysis / comments**
- Authors no longer possess data.
- A priori power calculation conducted on unknown outcome measure (alpha 0.05; power 0.9; on 30% benefit)
- Loss to follow up: Drop outs:
  - A: 14% (n=8) group A and 19% (n=7) group B.
  - B: 3% (n=2) were WAD III.

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### Soderlund et al (2000)

**Participants & indication**
- Acute whiplash injury with report of acceleration-deceleration movement of the head but without direct trauma, WAD I-III. Aged 18-60 years, with good understanding of Swedish; and no previous neck injury. Mean of 20 days post injury.
- 35 women and 24 men. n=66.

**Intervention & setting**
- A: Exercise programme of alternating rest with exercises, keeping the neck warm, walking daily, maintaining an upright posture when sitting, standing and walking, not lifting or carrying heavy objects, and, not to sit with head flexed forward during the first few weeks post injury. Patients were instructed to restore normal neck movements as soon as possible including: cervical rotation, flexion, shoulder elevation, deep breath with shoulder girdle elevation. All exercises were performed cautiously, within pain limits, at least three times a day.
- B: As above, complemented by

**Outcome measures**
- A: PDI generic and domain specific disability related to chronic pain. Score 0-70.
- B: SES completion of daily living despite pain. Score 0-200.

**Main results**
- No statistically significant differences between groups on any outcome.

**Analysis / comments**
- Authors did not respond to request for data.
- A priori power calculation conducted on unknown outcome measure (alpha 0.05; power 0.9; on 30% benefit)
- Loss to follow up: Drop outs:
  - A: 36% B: 15%.
  - B: 14% (n=8) group A and 20% (n=7) group B.

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### Physiotherapy management Whiplash Associated Disorder (WAD) I/II/III

**Participants & indication**
- Acute whiplash injury with report of acceleration-deceleration movement of the head but without direct trauma, WAD I-III. Aged 18-60 years, with good understanding of Swedish; and no previous neck injury. Mean of 20 days post injury.
- 35 women and 24 men. n=66.

**Intervention & setting**
- A: Exercise programme of alternating rest with exercises, keeping the neck warm, walking daily, maintaining an upright posture when sitting, standing and walking, not lifting or carrying heavy objects, and, not to sit with head flexed forward during the first few weeks post injury. Patients were instructed to restore normal neck movements as soon as possible including: cervical rotation, flexion, shoulder elevation, deep breath with shoulder girdle elevation. All exercises were performed cautiously, within pain limits, at least three times a day.
- B: As above, complemented by
| Study                          | Design | Participants & indication                                                                 | Intervention & setting                                                                 | Outcome measures                                                                 | Main results                                                                 | Analysis / comments                                                                 |
|-------------------------------|--------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Soderlund and Lindberg (2001) | RCT    | Baseline: mean of 20 days post injury.                                                     | exercises for improving kinaesthetic sensibility and coordination of neck muscles, three times a day. | Cervico-thoracic posture using universal goniometer.                             | Statistically significant lower patient perception of pain for group A immediately post treatment (p<.05), significantly better patient perceived ability in group A to perform daily activities at 3 months (p<.05); and significantly better long-term compliance in group A to manage / prevent neck pain at 3 months (p<.05) | No primary outcome measure specified |
| Sweden Chronic                | RCT    | Patients with continuous symptoms 3 months after a whiplash injury with reports of an acceleration – deceleration movement of the head, but without direct head trauma. WAD I – III. Aged 18-60 years, good ability to understand Swedish. Baseline: after 3 month follow up appointment in clinic. | A: Individualised four phases of treatment 1) learning of basic physical and psychological skills 2] application and 3] generalisation of skills into general everyday activities 4] maintenance of these skills. Using a functional behaviour analysis approach, and treatment goal setting. Aiming to change problem behaviours and recognise the factors that perpetuate muscular dysfunction. Included techniques of relaxation, re-education posture, muscle stabilisation, mobilisation exercises, and re-education of humeroscapular rhythm. | Cervico-thoracic posture using universal goniometer. CROM degrees using goniometer. Cervicocephalic kinaesthetic sensibility, right and left relocation from rotation. Patient perception of treatment result 4 questions (only at immediate post treatment follow up) | Treatment integrity was measured. | No primary endpoint specified |
| Soderlund and Lindberg (2007) | RCT    | Recruitment from Orthopaedic clinic of patients with significant symptoms presenting to a 3 month follow up appointment | B: Individualised exercises to enhance muscular stabilisation of neck, neck and shoulder mobility with stretching and coordination of head movement, and exercise to maintain body posture and arm muscle strength. Exercises carried out at physiotherapy department and at home. Treatment could also include: pain relieving methods of PDI generic and domain specific disability related to chronic pain; 0-70. NRS pain intensity (0-10). | PDI generic and domain specific disability related to chronic pain; 0-70. NRS pain intensity (0-10). | No a priori power calculation | Loss to follow up: |
|                               |        | No separation data for WAD I II or III.                                                   |                                                                                         |                                                                                |                                                                                | No drop outs |
|                               |        | Baseline: after 3 month follow up appointment in clinic.                                   |                                                                                         |                                                                                |                                                                                | Exclusions: |
|                               |        | n=33.                                                                                      |                                                                                         |                                                                                |                                                                                | B: n=1 did not comply with treatment |
|                               |        | A: n=16. Female n=9 mean age 38 years                                                      |                                                                                         |                                                                                |                                                                                | No management of losses described |
|                               |        | B: n=17. Female n=10 mean age 44 years                                                     |                                                                                         |                                                                                |                                                                                | Co-interventions not explored |
|                               |        |                                                                                           |                                                                                         |                                                                                |                                                                                | No ITT analyses reported |

**Notes:**
- Setting: Unclear
- Assessments:
  - Short term:
    - 3 months (unclear whether post baseline or intervention)
    - 6 months (unclear whether post baseline or intervention)
  - Insufficient data at 3 month follow up.
  - B: n=3 excluded owing to insufficient data at 3 month follow up.
  - No management of losses described
  - Co-interventions not explored
  - No ITT analyses reported
| Study | Design | Participants & indication | Intervention & setting | Outcome measures | Main results | Analysis / comments |
|-------|--------|---------------------------|------------------------|------------------|--------------|---------------------|
|       |        |                           | relaxation, TENS, acupuncture, heat etc. | immediate post treatment | Results not reported on CSQ and SES to compare patients with high and low self efficacy. | Authors did not respond to request for data. |
|       |        |                           | Both interventions with a physiotherapist, maximum of 12 treatment sessions. | 3 months follow up |              |                     |

Setting:
A: Patient’s home.
B: Physiotherapy department gym & home

Footnote: ADL = Activities of Daily Living; CBT = Cognitive Behavioural Therapy; CCFT = Cranio-Cervical Flexion Test; CFQ = Cognitive Failures Questionnaire; CI = Confidence Interval; CROM = Cervical Range of Motion; CSQ = Coping Strategies Questionnaire; ext = extension; DASS = Depression Anxiety Stress Scale; DHI = Dizziness Handicap Inventory; flex = flexion; GHQ-28 = General Health Questionnaire 28; GPE = Global Perceived Effect; HAQ = Health Assessment Questionnaire; IES = Impact of Events Scale; ITT = Intention to Treat; L = left; LR = Left Rotation; LSF = Left Side Flexion; McGill = McGill Pain Questionnaire; NDI = Neck Disability Index; NFR = Nociceptive Flexion Reflex; NPI = Northwick Park Neck Pain Index; NPRS = Numerical Pain Rating Scale (11 point scale); NRS = Numerical Rating Scale; NSAID = Non-Steroidal Anti-inflammatory agent; PCI = Patient Coping Inventory; PDI = Pain Disability Index; PGIC = Patients’ Global Impression of Change; PPT = Pressure Pain Threshold; PSFS = Patient Specific Functional Scale; QTF – Quebec Task Force; R = right; RCT = Randomised Controlled Trial; reps = repetitions; ROM = Range of Motion; RR = Right Rotation; RSF = Right Side Flexion; RMDQ = Roland Morris Disability Questionnaire; SD = standard deviation; SES = Self Efficacy Scale; SF-36 = Short Form 36 Health Survey; TPT = Thermal Pain Threshold; TSK = TAMPA Scale of Kinesophobia; TENS = transcutaneous electrical nerve stimulation; VAS = Visual Analogue Scale; WAD = Whiplash Associated Disorders.