A research synthesis of therapeutic interventions for whiplash-associated disorder (WAD): Part 4 – noninvasive interventions for chronic WAD

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Whiplash-associated disorder (WAD) represents a significant public health problem, resulting in substantial social and economic costs throughout the industrialized world. While many treatments have been advocated for patients with WAD, scientific evidence supporting their effectiveness is often lacking. A systematic review was conducted to evaluate the strength of evidence for various WAD therapies. Multiple databases (including Web of Science, EMBASE and PubMed) were searched to identify all studies published from January 1980 through March 2009 that evaluated the effectiveness of any clearly defined treatment for acute (less than two weeks), subacute (two to 12 weeks) or chronic (longer than 12 weeks) WAD. The present article, the fourth in a five-part series, evaluates the evidence for noninvasive interventions initiated during the chronic phase of WAD. Twenty-two studies that met the inclusion criteria were identified, 12 of which were randomized controlled trials with 'good' overall methodological quality (median Physiotherapy Evidence Database score of 6). For the treatment of chronic WAD, there is evidence to suggest that exercise programs are effective in relieving whiplash-related pain, at least over the short term. While the majority of a subset of nine studies supported the effectiveness of interdisciplinary interventions, the two randomized controlled trials provided conflicting results. Finally, there was limited evidence, consisting of one supportive case series each, that both manual joint manipulation and myofeedback training may provide some benefit. Based on the available research, exercise programs were the most effective noninvasive treatment for patients with chronic WAD, although many questions remain regarding the relative effectiveness of various exercise regimens.

Key Words: *Chronic pain; Chronic whiplash-associated disorder; Evidence-based medicine; Exercise; Neck pain; Randomized controlled trials*

Une synthèse de la recherche sur les interventions thérapeutiques à l'égard des troubles liés aux coups de fouet cervicaux (TCFC) : Partie 4 – Les interventions non effractives en cas de TCFC chroniques

Les troubles liés aux coups de fouet cervicaux (TCFC) représentent un problème important en santé publique, associé à des coûts sociaux et économiques substantiels dans le monde industrialisé. De nombreux traitements sont préconisés pour les patients ayant des TCFC, mais souvent, on ne possède pas de données scientifiques probantes en étayant l'efficacité. Les chercheurs ont procédé à une analyse systématique pour évaluer la qualité des preuves associées aux diverses thérapies des TCFC. Ils ont effectué des recherches dans de multiples bases de données (y compris Web of Science, EMBASE et PubMed) pour repérer toutes les études publiées entre janvier 1980 et mars 2009 qui évaluaient l'efficacité de tout traitement clairement défini en cas de TCFC aigu (moins de deux semaines), subaigu (de deux à 12 semaines) ou chronique (plus de 12 semaines). Le présent article, quatrième d'une série de cinq, vise à évaluer les données probantes liées aux interventions amorcées pendant la phase chronique des TCFC. Les chercheurs ont repéré 22 études respectant les critères d'inclusion, dont 12 étaient des essais aléatoires et contrôlés à la qualité méthodologique globale « bonne » (indice médian de la base de données probantes en physiothérapie de 5,5). Pour traiter un TCFC chronique, des données probantes indiquent que les programmes d'exercices sont efficaces pour soulager les douleurs liées aux coups de fouet cervicaux, du moins à court terme. Même si la majorité d'un sous-groupe de neuf études appuyaient l'efficacité des interventions interdisciplinaires, les deux seuls essais aléatoires et contrôlés donnaient des résultats contradictoires. Enfin, des données probantes limitées, provenant d'une série de cas positive pour chaque constatation, indiquaient que la manipulation manuelle des articulations et l'entraînement par myofeedback pouvaient offrir certains effets bénéfiques. D'après les recherches disponibles, le traitement non effractif le plus efficace pour les patients ayant un TCFC chronique était les programmes d'exercices, même si de nombreuses questions demeurent quant à l'efficacité relative de divers régimes d'exercices.

The term 'whiplash-associated disorder' (WAD) describes the consequences of a whiplash injury, defined as bony and soft tissue injuries of the neck caused by rapid acceleration immediately followed by rapid deceleration of the neck and head (1), almost invariably occurring as a consequence of a motor vehicle collision (MVC). With annual North American incidence rates estimated to be between 70 and 329 per 100,000 people (1,2), whiplash injuries are the most common injury following an MVC (2,3). Although it is widely held that the majority of whiplash patients recover naturally within a few months of their injury, more recent research (4) suggests that recovery is often prolonged, with approximately 50% of patients still complaining of neck pain one year after injury. Moreover, WAD is associated with significant economic costs as a result of lost work productivity, medical care, legal services and other disability-related expenses (5,6). Given the scope

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and cost of WAD, the identification of effective therapies for patients with whiplash-related injuries, especially chronic WAD, is of obvious importance.

In 1995, the Quebec Task Force (QTF) published its benchmark review (1) of the scientific literature and expert opinion on WAD. One of the primary conclusions of the report was that the majority of therapeutic interventions used in the treatment of WAD had undergone little to no scientific investigation. Accordingly, the QTF emphasized the need for more and higher quality research. More recently, Conlin et al (7,8) conducted a systematic review of the whiplash treatment literature (including studies published from 1993 to 2003) and noted that despite the QTF's recommendations, "remarkably little quality research" (8) had been published in the area of WAD management.

The objective of the present review was to update and expand on previous work by evaluating the strength of evidence for therapies initiated during the acute (less than two weeks), subacute (two to 12 weeks) and chronic (longer than 12 weeks) stages of WAD. Treatments were grouped according to time from injury to assist clinicians deciding on an appropriate treatment course because therapies that are effective in the treatment of acute and subacute WAD may not necessarily be effective when initiated during the chronic phase. Furthermore, treatments for chronic WAD were divided into two sections: noninvasive interventions, and surgical and injection-based interventions. The present article, the fourth in a five-part series, evaluates the evidence for noninvasive interventions initiated during the chronic phase of WAD.

METHOD

The following is a brief summary of the methods used for the present review. A more detailed explanation of the methodology is provided in the first article of the present series (9). A multistage screening process was conducted to identify all literature that evaluated therapeutic interventions for WAD published from January 1980 to March 2009, regardless of study design. Multiple databases were searched (including PubMed, CINAHL, EMBASE, PsycINFO, Web of Science and the Cochrane Central Register of Controlled Trials [CENTRAL]) using the following search terms: whiplash AND (therapy OR treatment OR intervention OR rehabilitation OR surgery OR neurotomy). The literature search was limited to clinical studies written in English that examined adult (18 years of age and older) human populations. A study was deemed eligible for review if it met the following criteria established a priori:

- The purpose of the study was to evaluate the effects of one or more clearly defined treatment protocols for WAD (eg, 'physiotherapy' without further elaboration was not considered to be a clearly defined protocol).
- At least 60% of the participants in the study sample must have experienced a whiplash injury resulting from an MVC; alternatively, the sample must have included a distinct and separately analyzed subgroup of MVC-related whiplash patients.
- Evaluation of the treatment effect must have involved measurable outcomes.
- Sample included at least three participants with a whiplash injury.

In total, the search procedure yielded 969 citations, 387 of which were duplicated. On screening titles and abstracts for relevance, 121 articles were considered for full review and, after applying inclusion criteria, 83 articles were selected for full review. Information abstracted from studies that met inclusion criteria was organized into tables, and studies were grouped according to the intervention type. For the present article, only studies examining noninvasive interventions initiated during the chronic stage (more than three months postinjury) were included.

All randomized controlled trials (RCTs) that met the inclusion criteria were evaluated for methodological quality using a standardized rating scale, the Physiotherapy Evidence Database (PEDro) scale. This evaluation tool was designed specifically for assessing physical therapy research and has been validated for the quality assessment of RCTs (10). The PEDro scale consists of 10 equally weighted yes/no questions relating to issues of methodological quality and can be accessed at www.pedro.org.au/english/downloads/pedro-scale/. Two independent raters reviewed each article and discrepancies were resolved through consensus or, when that was not possible, by a third rater. Studies with PEDro scores of 9 to 10 were considered to be of 'excellent' methodological quality, while scores of 6 to 8 were considered to be 'good' quality and scores of 4 to 5 were considered to be 'fair' quality. Studies scoring below 4 were judged to be of 'poor' quality and were considered to be methodologically equivalent to non-RCTs for the purpose of formulating conclusions. These descriptive terms of quality assessment were used to simplify the interpretation of results; however, it is important to note that these terms are only intended to provide an indication of a study's rating on the PEDro scale. Non-RCTs were not assigned a PEDro score and were instead given a 'no score' designation.

Due to the limited number of studies investigating each of the specific WAD interventions, it was believed that both meta-analytical and levels-of-evidence approaches would be inappropriate. Therefore, a narrative approach was used to summarize the findings and formulate conclusions.

Because studies employing a nonexperimental or uncontrolled design are generally considered to be of inferior quality, these types of studies were only used to formulate conclusions in the absence of RCTs or when the results of RCTs were conflicting. In addition, when the results of RCTs were conflicting, studies with higher PEDro scores were weighted more heavily.

RESULTS

Twelve RCTs and 10 non-RCTs were identified that evaluated the use of noninvasive therapies for patients with chronic WAD (ie, longer than three months postinjury) and met our inclusion criteria. The median PEDro score of the RCTs was 6, with scores ranging from 2 to 8 (Table 1). The most common methodological limitation of these RCTs was a failure to blind patients and therapists; only two studies blinded patients and only one blinded therapists. Furthermore, only four of the studies used concealed allocation and only five conducted their analyses on an intention-to-treat basis. In all, the studies included in our analysis investigated interventions that covered five different treatment categories: exercise programs, interdisciplinary interventions, chiropractic manipulation, pharmacological interventions and alternative treatments (including myofeedback training and other alternative therapies).

TABLE 1
Physiotherapy Evidence Database (PEDro) scores for randomized controlled trials evaluating noninvasive therapies for chronic whiplash-associated disorder

	PEDro criteria										
Reference, year	RA	CA	BS	SB	TB	AB	AF	ITT	BC	PVM	Total score
Jull et al (14), 2007	✓	✓	✓			✓	✓	✓	✓	✓	8
Stewart et al (11), 2007	✓	✓	✓			✓	✓	✓	✓	✓	8
Ryan (13), 2006	✓		✓	✓		✓	✓	✓	✓	✓	8
Wicksell et al (22), 2008	✓	✓	✓				✓	✓	✓	✓	7
Vikne et al (16), 2007	✓	✓	✓			✓			✓	✓	6
Soderlund and Lindberg (21), 2001	✓		✓			✓	✓		✓	✓	6
van Wieringen et al (30), 2001	✓			✓	✓	✓			✓	✓	6
Klobas et al (17), 2006	✓		✓			✓	✓		✓		5
Hansson et al (18), 2006	✓					✓		✓	✓		4
Humphreys and Irgens (12), 2002	✓						✓		✓	✓	4
Ventegodt et al (32), 2004	✓		✓						✓	✓	4
Fitz-Ritson (15), 1995	✓						✓				2

AB Assessor blinding; AF Adequate follow-up; BC Between-group comparisons; BS Baseline similarity; CA Concealed allocation; ITT Intention-to-treat analysis; PVM Point estimates and variability reported; RA Random allocation; SB Subject blinding; TB Therapist blinding

Exercise programs

Eight RCTs and one non-RCT evaluated the efficacy of exercise programs initiated during the chronic stage of WAD (Table 2). In an RCT of good methodological quality, Stewart et al (11) randomly assigned patients to receive either graded exercise with advice or advice only. The authors reported that while patients in both groups improved, those who participated in the exercise program made significantly greater gains in pain intensity, pain bothersomeness and functional ability; however, group differences were no longer significant at one-year follow-up. It is noteworthy that a substantial percentage of patients in both the experimental and control group reported seeking additional treatments during the treatment period (15% and 23%, respectively) as well as during the follow-up period (29% and 56%, respectively). Similarly, in an RCT of fair quality, Humphreys and Irgens (12) reported that patients who participated in a four-week exercise program experienced significantly greater reductions in pain at the end of treatment than patients randomly assigned to a no-treatment control group. Unfortunately, the results of this study were limited by inadequate randomization, demonstrated by significant between-group differences at baseline and the inclusion of 11 patients (39%) without whiplash-related injuries.

Four RCTs compared one type of active exercise program with another. In an RCT of good quality, Ryan (13) used a mechanical neck rotator to compare strength training with endurance training in a cohort of neck pain patients, 75% of whom had WAD. The author found that while patients in both groups improved in terms of pain intensity and muscle strength, the strength training group experienced significantly greater reductions in functional limitations. In another RCT of good quality, Jull et al (14) compared supervised physiotherapy with a similar self-managed home program and found that while patients in both groups showed improvement over time, patients in the supervised group experienced a significantly greater reduction in neck pain and disability; however, it should be noted that patients and treating therapists were not blinded. In an RCT of poor quality, Fitz-Ritson (15) randomly assigned patients to perform either 'standard' exercises or 'phasic' exercises, with all patients also receiving chiropractic therapy. Although patients in both groups improved by the end of the eight-week treatment, the author reported that patients in the phasic group improved 'substantially' more than patients in the standard group; however, it is difficult to determine the validity of this statement given that between-group analysis was not reported. Finally, in an RCT of good quality, Vikne et al (16) found no benefit associated with adding a ceiling-mounted sling exercise program (designed to help patients perform specific stabilizing exercises) to traditional physiotherapy.

Two RCTs of fair quality examined the effectiveness of an exercise program in the treatment of specific whiplash-related disorders. While Klobas et al (17) found that therapeutic jaw exercises were ineffective in reducing temporomandibular disorders, Hansson et al (18) reported that a six-week program aimed at stimulating the vestibular system was significantly more effective than no treatment in increasing postural control and reducing self-perceived handicap. Unfortunately, the results from Hansson et al (18) are difficult to interpret given that there were significant between-group differences at baseline and more than one-half of the patients in the control group were lost to follow-up. Also investigating balance, Stapley et al (19) found that in a case series of 13 patients, seven showed electromyographic signs of fatigue and/or body sway after 5 min of neck muscle contractions before participating in a physiotherapy program. Following two weeks of treatment, no signs of fatigue or imbalance were recorded for any of the patients.

Conclusions regarding exercise programs in chronic WAD: Despite recurring methodological shortcomings in the research studies, it appears that exercise programs provided during the chronic phase of WAD are effective in relieving pain, although it does not appear that these gains are maintained over the long term. While there is some evidence regarding the relative effectiveness and potential benefits of specific exercise protocols, further research is needed before any definitive conclusions can be drawn.

Interdisciplinary interventions

Two RCTs and seven non-RCTs evaluated an intervention that combined an exercise program with some form of psychological counselling during the chronic stage of WAD (Table 3).

TABLE 2
Summary of studies evaluating exercise programs for chronic whiplash-associated disorder (WAD)

Reference, year, country, score	Population and methods	Outcome measures	Results
Jull et al (14), 2007, Australia, PEDro score = 8	Randomized controlled trial. 71 participants with chronic WAD were randomly assigned to receive a 10-week intervention consisting of either a self-management program (education and information about exercise) or a multimodal physiotherapy program (including low-load exercises, low-velocity mobilizing techniques, and education and assurance)	The primary outcome was change in score on the Northwick Park Neck Pain Questionnaire, which is a measure of pain and disability. Assessment was conducted at baseline and immediately following the last treatment	Changes in self-rated pain were significantly greater for patients in the multimodal physiotherapy group (–10.4±14 versus –4.6±8.8, P<0.05), with an effect size of 0.48
Vikne et al (16), 2007, Norway, PEDro score = 6	Randomized controlled trial. 214 patients with chronic WAD were randomly assigned to 4 treatment groups to receive either traditional physiotherapy (with or without home training) or sling exercise therapy (with or without home training)	Pain intensity (VAS), disability (modified Roland-Morris Disability Questionnaire), psychological distress (Hopkins Symptom Checklist), sick leave and physical tests (range of motion, neck stabilization and kinesthetic sensibility) were assessed after the intervention and at the 12-month follow-up	No significant differences were found between the traditional physiotherapy group and the sling exercise group. However, at the 12-month follow-up, both groups that received home training reported significantly less pain during rest and less fatigue in the final week of treatment (P<0.05)
Stewart et al (11), 2007, Australia, PEDro score = 8	Randomized controlled trial. 134 participants with chronic WAD were enrolled in this study. All participants received 3 advice sessions; those randomly assigned to the experimental group also received 12 exercise sessions over 6 weeks	Primary outcomes were pain intensity, pain bothersomeness (both on a scale of 0–10) and functional disability (Patient-Specific Functional Scale) measured at baseline, 6 weeks and 12 months after the intervention	At the 6-week follow-up, compared with advice alone, exercise and advice were associated with significant improvements in pain intensity (3.2±2.2 versus 4.3±2.5, P<0.01), pain bothersomeness (3.6±2.6 versus 4.8±2.9, P<0.05) and functional disability (6.4±2.1 versus 5.6±2.0, P<0.01). However, no significant differences remained at the 12-month follow-up
Klobas et al (17), 2006, Sweden, PEDro score = 5	Randomized controlled trial. 55 patients diagnosed with temporomandibular disorders and chronic WAD were enrolled in this study. All patients participated in a general rehabilitation program consisting of physical therapy, occupational therapy and training in pain management, whereas those randomly assigned to the experimental group also participated in a therapeutic jaw exercise program	Assessed at baseline, 3 weeks and 6 months, the primary outcome was a clinical examination of the stomatognathic system (including measurements of active mandibular movements, pain during mandibular movements, and pain on palpation of the masticatory and neck muscles)	No significant differences were found between the experimental and control groups at either the 3-week or 6-month follow-up
Hansson et al (18), 2006, Sweden, PEDro score = 4	Randomized controlled trial. 29 patients with chronic WAD and dizziness reported as a symptom were randomly assigned to either a control group or an intervention group that participated in a vestibular rehabilitation program twice a week for 6 weeks	4 different balance measures (tandem standing and standing on one leg, both performed with eyes open and eyes closed) and the Dizziness Handicap Inventory were assessed at baseline, 6 weeks and 3 months	After 3 months, the intervention group improved significantly compared with the control group on the following measures: standing on one leg (eyes open) (P<0.001), tandem stance (P<0.05) and the Dizziness Handicap Inventory physical score (P<0.05)
Ryan (13), 2006, Australia, PEDro score = 8	Randomized controlled trial. 103 patients with 'chronic neck pain' of unspecified duration (75% sustained a whiplash injury) were included. Strength training involved one set of slow cervical rotations using progressive weights. Endurance training involved one set of 20 quick cervical rotations using a minimal weight with an increase in repetitions. Both protocols involved 2 half-hour individual sessions/week for 8 to 12 weeks	The role emotional, physical function and role physical subscales of the Short-Form 36 Health Survey as well as pain intensity and affective pain (VAS) were assessed at baseline and at an unspecified follow-up	The strength training group had significantly greater improvement in physical functioning than the endurance group (P<0.05). No other between-group comparisons achieved statistical significance. Both groups had significant reductions in pain and depression (significance levels not reported)
Humphreys and Irgens (12), 2002, United Kingdom, PEDro score = 4	Randomized controlled trial. 28 patients with neck pain for ≥3 months (61% secondary to whiplash) and 28 sex- and age-matched healthy controls were randomly assigned to an exercise or no-treatment control group. The 4-week home exercise program consisted of slow eye-head-neck coordination exercises twice daily	Pain intensity (VAS) and cervicocephalic kinesthetic sensibility (head repositioning accuracy) were assessed at baseline, and at 2 and 4 weeks post-treatment	At 4 weeks, the neck pain-exercise group had improved significantly in terms of head repositioning accuracy (P<0.001) and pain intensity (P<0.001). No between-group comparisons were reported
Fitz-Ritson (15), 1995, USA, PEDro score = 2	Randomized controlled trial. 30 patients with WAD for ≥12 weeks received chiropractic therapy. The control group performed standard stretching, isometric and isokinetic exercises; the treatment group did 'phasic exercises' (including rapid eye-head-neck-arm movements)	The Neck Disability Index was administered at baseline and immediately following the 8-week treatment period	Significant improvement in pain-related disability was seen in both the experimental (48.3% improvement; P<0.001) and control group (7.4% improvement; P<0.05). No between-group comparisons were reported. The control group reported worse disability at baseline

TABLE 2 – CONTINUED
Summary of studies evaluating exercise programs for chronic whiplash-associated disorder (WAD)

Reference, year, country, score	Population and methods	Outcome measures	Results
Stapley et al (19), 2006, Italy, no score	Case series. 13 patients with ≥1 year of whiplash-related dizziness and chronic neck pain or stiffness participated in an individually tailored 2-week (5 45 min sessions per week) physiotherapy program consisting of soft tissue treatment, isometric and isotonic exercises, and advice regarding relaxation techniques, posture and home exercise	The Dizziness Handicap Inventory and the Northwick Park Neck Pain Questionnaire were administered pre- and post-treatment. Electromyography measurements of body sway and neck muscle fatigue were also collected	Of 13 patients, 7 showed electromyographic signs of fatigue and/or body sway after 5 min of neck muscle contractions. Following 2 weeks of treatment, no signs of fatigue or imbalance were recorded for any of the patients

PEDro Physiotherapy Evidence Database; VAS Visual analogue scale

However, it is important to note that the treatments discussed in this section were quite diverse; that is, while some studies primarily examined the benefits of psychological counselling, others used psychotherapy in a more peripheral role. Following a successful case series in which three patients made significant improvements following a course of physiotherapy and cognitive behavioural therapy (CBT) (20), Soderlund and Lindberg (21) compared patients who received CBT in addition to physiotherapy with those who received physiotherapy alone. While both groups of patients experienced significant improvements in pain intensity and disability, no significant between-group differences were found at three-month follow-up.

In another RCT of good quality, Wicksell et al (22) randomly assigned 21 patients already receiving usual treatment to participate in a CBT program aimed at promoting the acceptance of pain and distress, or to a wait-list control group. Four months following the intervention, the authors found that patients in the experimental group experienced significantly greater improvements in terms of pain disability, life satisfaction, kinesiophobia, depressive symptomology and psychological flexibility. However, this study had some methodological shortcomings; in particular, the study was not blinded, enrolled only self-selected volunteers and did not standardize cointerventions.

The remaining six non-RCTs evaluated a diverse number of treatments examining a wide range of outcomes. Taken together, five of these studies reported that interdisciplinary treatment was associated with significant benefit in terms of pain intensity, disability, psychological distress (23), return to work rates (24), head repositioning accuracy (25), the proportion of tender muscles in whiplash-related temporomandibular disorder (26), coping skills and life satisfaction (27). In contrast, only one non-RCT failed to find a significant treatment effect following an interdisciplinary intervention (28). Although the majority of studies suggest that interdisciplinary interventions are beneficial, it is difficult to formulate conclusions given the heterogeneity of the interventions.

Conclusions regarding interdisciplinary interventions in chronic WAD: Although the majority of studies support its benefit, there is conflicting evidence regarding the effectiveness of interdisciplinary interventions for patients with chronic WAD.

Manual joint manipulation

One study examined the treatment of chronic WAD with manipulation of the neck joints by a chiropractor (Table 4). In a case series involving 28 individuals with chronic WAD, Woodward et al (29) classified patients according to their level of disability. Following chiropractic treatment, the authors found that 26 patients (93%) had improved by at least one classification category. Interestingly, the authors also reported that, of 17 patients who completed the treatment before assessment, four (24%) reported a recurrence of symptoms for which they were considering further treatment.

Conclusions regarding manual joint manipulation in chronic WAD: Although the results of one case series suggest that chiropractic manipulation may reduce chronic whiplash-related disability over the short term, the evidence is insufficient to determine the effectiveness of this intervention.

Pharmacological interventions

One RCT of good methodological quality evaluated the use of melatonin in the treatment of chronic whiplash-related sleep disturbances (Table 5). Melatonin is involved in synchronizing circadian rhythms and, in healthy individuals, melatonin levels begin to rise between 20:00 and 21:30. Van Wieringen et al (30) randomly assigned 81 patients with chronic WAD who also suffered from delayed melatonin onset to either active treatment with a melatonin supplement or placebo. Although patients in the active treatment group experienced significant increases in melatonin onset time and actigraphically registered wake-up time, treatment was not associated with reductions in pain or any of the cognitive deficits associated with delayed melatonin onset.

Conclusions regarding pharmacological interventions in chronic WAD: Although melatonin supplements may increase melatonin onset time, this treatment does not appear to be effective in reducing whiplash-related symptoms.

Alternative treatments

Myofeedback training: One case series examined myofeedback training in the treatment of chronic WAD (Table 6). Voerman et al (31) provided 11 patients with an ambulant feedback system designed to vibrate when the relative duration of muscle relaxation declined to less than 20% during 10 s intervals. Following treatment, six patients reported clinically relevant reductions in neck and back pain intensity, while four patients reported clinically relevant reductions in disability. It should be noted, however, that clinically relevant increases in neck and back pain were reported by one and two patients, respectively.

Conclusions regarding myofeedback training in chronic WAD: Based on the results of one small case series, there is limited evidence that myofeedback training may be beneficial for some patients with chronic WAD.

TABLE 3
Summary of studies evaluating interdisciplinary interventions for chronic whiplash-associated disorder (WAD)

Reference, year, country, score	Population and methods	Outcome measures	Results
Wicksell et al (22), 2008, Sweden, PEDro score = 7	Randomized controlled trial. 21 participants with chronic WAD were randomly assigned to either a wait-list control group or to receive the intervention – a 10-session protocol emphasizing values-based exposure and acceptance strategies intended to improve functioning and life satisfaction	Outcomes assessed at baseline, immediately following treatment and after 4 months include the following: Pain Disability Index, Satisfaction with Life Scale, Tampa Scale for Kinesiophobia, Impact of Event Scale, Hospital Anxiety and Depression Scale, Psychological Inflexibility in Pain Scale, and average pain intensity and interference (VAS)	At the 4-month follow-up, significant differences were reported in favour of the intervention group in terms of pain disability (31.6±14.3 versus 40.9±13.2, P<0.01), life satisfaction (23.4±5.9 versus 17.8±6.8, P<0.01), fear of movements (28.7±6.4 versus 35.2±10.4, P<0.01), depression (4.1±2.6 versus 9.8±5.6, P<0.001), post-traumatic stress symptoms (11.8±14.7 versus 24.9±24.2, P<0.05) and psychological flexibility (27±2.6 versus 9.8±5.6, P<0.001); however, there were no significant changes in levels of pain intensity
Soderlund and Lindberg (21), 2001, Sweden, PEDro score = 6	Randomized controlled trial. 33 patients with WAD for ≥3 months received regular primary care physiotherapy (exercises to enhance muscular stabilization of the neck, shoulder mobility, body posture and arm muscle strength) or physiotherapy with integrated cognitive-behavioural components, in accordance with a functional behavioural analysis	The Pain Disability Index, cervical ROM and cervicothoracic posture (assessed with a goniometer) were assessed at baseline, immediately after treatment and at a 3-month follow-up. Pain intensity was also measured using a numerical rating scale in a 7-day diary	No differences were reported for pain intensity, disability, cervical ROM or cervicothoracic posture. However, those in the experimental group reported a greater ability to perform activities of daily living than those in the comparison group at 3 months (P<0.05)
Sullivan et al (24), 2006, Canada, ns	Cohort study. 130 patients with WAD for a mean of approximately 30 weeks duration were drawn from 5 rehabilitation clinics. The control treatment was a functional restoration program employing a sports medicine approach; the experimental group participated in the same program but also received individualized therapy to maximize activity involvement and minimize psychological barriers to progress	The Pain Catastrophizing Scale, Tampa Scale for Kinesiophobia, Pain Disability Index, pain rating index of the McGill Pain Questionnaire and return to work status were assessed at baseline and a 4-week follow-up	More participants in the experimental group had returned to work full-time at the 4-week follow-up (75% versus 50%; P<0.01). The experimental group also had a greater reduction of pain catastrophizing than controls (10.3±1.1 versus 6.7±1.1, P<0.05). No other outcomes differed significantly between the groups
Soderlund and Lindberg (20), 2001, Sweden, ns	Case series. 3 patients with WAD for ≥4 months participated in an individualized cognitive behavioural treatment program with an exercise component. The program consisted of learning basic and applied skills, and application and generalization of those skills in everyday activities	The Self-Efficacy Scale, Coping Strategies Questionnaire, Pain Disability Index, cervicothoracic posture and cervical ROM (goniometer), and kinesthetic sensibility of neck muscles were recorded at baseline and at 6, 7 and 11 months post-treatment. Pain intensity was also reported through the use of daily diaries	At follow-up, all patients had reduced pain intensity and improved cervicothoracic posture; two had improved kinesthetic sensibility, cervical ROM and pain disability. Statistical significance was not reported
Sterner et al (28), 2001, Sweden, ns	Case series. 90 subjects with WAD of between 3 to 12 months entered a similar 5- or 8-week multimodal rehabilitative program. The program included group and individual sessions on ergonomics, physical activity with hydrotherapy, body awareness therapy, pharmacology, and education in pain and its psychological consequences	Pain intensity in the neck, head, shoulders and upper back (VAS), a modified version of the Life Satisfaction Questionnaire, the Beck Depression Index, the Coping Resource Index, the Multidimensional Pain Inventory and sick leave were assessed at baseline, immediately after the program and at a 6-month follow-up. A series of questions relating to pain, disability and satisfaction with the program were also assessed at program completion and at 6 months	At 6 months, significant reductions were reported in terms of intensity of neck pain (from 62.3±19.3 to 58.2±20.2, P<0.05) and upper back pain (from 50.7±28.8 to 41.7±25.1, P<0.05), while a significant increase was noted in the distraction behaviour Multidimensional Pain Inventory index (from 2.2±1.1 to 2.5±1.0, P<0.05); these differences were no longer significant following a Bonferroni correction. While sick leave was found to increase from 55.9% to 80.3% at 6 months, a greater proportion of patients reported increased ability to cope with their pain, although significance was not reported
Vendrig et al (23), 2000, The Netherlands, ns	Case series. 26 patients with WAD ≤6 months who were partially or completely unable to work entered a daily, 4-week interdisciplinary treatment program intended to abolish inappropriate pain behaviour, restore muscle strength and endurance, and enhance aerobic fitness. The treatment team consisted of physical therapists, occupational therapists and psychologists	Pain intensity (VAS), number of painful sites (pain drawing), Quebec Back Pain Disability Scale, sections of the Minnesota Multiphasic Personality Inventory (symptoms of somatic and psychological distress and cognitive complaints), work status, medication use and medical treatment were assessed before, immediately after and 6 months following treatment	At 6 months, significant reductions were reported in pain intensity (from 46.5±17.5 to 28.0±30.6, P<0.01) and number of painful sites (from 8.4±5.4 to 5.4±7.0, P<0.01). Significant reductions were also noted on Minnesota Multiphasic Personality Inventory scores in terms of somatic, psychological and cognitive symptoms (P<0.01). 65% returned to regular full-time work duties, while a further 27% returned to part-time and/or modified work. 81% did not seek any additional medical care, and 58% abstained from using analgesics

TABLE 3 – CONTINUED
Summary of studies evaluating interdisciplinary interventions for chronic whiplash-associated disorder (WAD)

Reference, year, country, score	Population and methods	Outcome measures	Results
Heikkila et al (27), 1998, Sweden, ns	Cohort study. 40 patients with whiplash-associated neck pain for ≥11 months and 33 patients with neck or back pain of nontraumatic origin participated in an individualized 6-week multidisciplinary rehabilitation program consisting of graded exercise and cognitive behavioural therapy intended to reorient patients toward realistic and rewarding goals, and to promote return to work	Coping resources (Coping Resources Inventory) and life satisfaction were measured at baseline, during the sixth week of rehabilitation and at a follow-up 24–36 months post-treatment. Sick leave was calculated for the 2 years pre- and post-treatment	Whiplash patients experienced an increase in coping resources (from 152.1 to 160.5, P<0.01) and life satisfaction (from 32.8 to 36.2, P<0.01). However, WAD patients also had an increase in sick leave days, with a mean increase of 33 days during the first year and 80 days during the second year following rehabilitation (both significant at P<0.05)
Krogstad et al (26), 1998, Norway, ns	Cohort study. 16 patients with painful TMD secondary to whiplash injury were compared with 16 age- and sex-matched patients with TMD only. All patients had experienced symptoms for 1–3 years. Both groups had 8 weeks of conservative TMD treatment consisting of counselling, progressive muscle relaxation exercises and a stabilization splint	Headache intensity and TMD symptom severity (VAS), headache frequency (on a scale of 1–5) and number of tender palpated muscles were assessed at the start of treatment and 8 weeks later	While patients with TMD only improved on all outcomes measures, those with TMD and whiplash only improved in terms of the number of tender palpated muscles (from 10.0 at baseline to 6.2 at follow-up, P<0.01). Notably, compared with patients with both conditions, those with TMD only reported significantly lower headache intensity (43 versus 19) and TMD symptom severity (60 versus 27) at follow-up (P<0.01)
Heikkila and Astrom (25), 1996, Sweden, ns	Cohort study. 8 patients with WAD of 2–3 years participated in an individualized 6-week multidisciplinary rehabilitation program. Counselling was provided by physical and occupational therapists, psychologists and social workers; exercise programs were based on a behavioural therapy approach. 34 healthy and uninjured subjects formed the no-treatment comparison group	A kinesthetic sensibility test (measuring active head repositioning) and active cervical ROM (goniometer) were assessed during the first and sixth weeks in the treatment group, and during the fourth and eighth weeks in the control group	Kinesthetic sensibility was less accurate (P<0.001) in whiplash subjects than in healthy controls following treatment. The WAD group had a mean overall kinesthetic sensibility improvement from 1 week to 6 weeks (P<0.05). No significant differences were found between assessments for pain intensity or cervical ROM

ns No score; PEDro Physiotherapy Evidence Database; ROM Range of motion; TMD Temporomandibular disorder; VAS Visual analogue scale

TABLE 4
Summary of a study evaluating manual joint manipulation for chronic whiplash-associated disorder

Reference, year, country, score	Population and methods	Outcome measures	Results
Woodward et al (29), 1996, United Kingdom, no score	Case series. 28 patients with whiplash-associated disorder for ≥3 months received chiropractic treatment of undefined duration, consisting of spinal manipulation, proprioceptive neuromuscular facilitation and cryotherapy	Reports of pain, analgesic use and function were used to classify patients into four categories before and after treatment	A significant proportion (93%; P<0.001) of patients showed categorical improvement following treatment. 16 patients improved by one symptom group while 10 patients improved by two symptom groups

Alternative therapies: One RCT of fair quality investigated the use of alternative therapies in the treatment of chronic WAD (Table 7). Ventegodt et al (32) randomly assigned patients to an experimental group that received a combination of Gestalt therapy, Rosen bodywork and craniosacral therapy, or to a no-treatment control group, and found no significant differences between these two groups at three-month follow-up. While it does not appear that this more holistic approach provided significant benefit to patients with chronic WAD, it should be noted that the study suffered from several methodological limitations, including an attrition rate of 50% in the experimental group.

Conclusions regarding alternative therapies in chronic WAD: The combination of Gestalt therapy, Rosen bodywork and craniosacral therapy does not appear to be beneficial during the chronic phase of WAD.

DISCUSSION

Within the whiplash literature, the majority of studies investigate treatments for patients with chronic WAD. In total, 22 studies were identified that examined noninvasive interventions for this population; however, many of these studies were of poor methodological quality. With the exception of articles that evaluated exercise programs, only two studies were RCTs of at least good quality. Accordingly, the conclusions reached in the present review should be viewed with appropriate caution.

As was the finding in the treatment of acute WAD (33), exercise programs appear to be the most effective noninvasive intervention for chronic WAD. However, many questions remain regarding the relative effectiveness of different exercise regimens. Considering Scholten-Peeters et al (34) found the addition of an exercise component to a program of education and advice during the subacute phase of WAD actually

TABLE 5
Summary of a study evaluating a melatonin supplement for chronic whiplash-associated disorder

Reference, year, country, score	Population and methods	Outcome measures	Results
van Wieringen et al (30), 2001, The Netherlands, PEDro score = 6	Randomized controlled trial. 81 patients with ≥6 months whiplash-induced delayed melatonin onset (surge of melatonin after 21:30) and associated sleep and concentration disturbances (ie, delayed sleep onset, fatigue and memory problems) were randomly assigned to receive melatonin or placebo. Tablets containing 5 mg of melatonin mixed with cellulose were ingested daily 5 h before endogenous dim light melatonin onset	Dim light melatonin onset (salivary sample), quality of life (Short-Form 36 Health Survey), sleep quality and duration (diary, electroencephalogram and actigraphy), duration of daily pain and pain intensity (on a scale of 1–4), and cognitive processing speed and vigilance (Mackworth clock test and simple reaction time task) were assessed during a 1-week baseline period and during the fourth week of treatment	Compared with participants in the placebo group, those in the melatonin treatment group experienced a significantly greater reduction in time of dim light melatonin onset (–79 min versus –22 min, P<0.05) and in actigraphic awakening time (–52 min versus +20 min, P<0.05). No significant differences were reported for the other sleep parameters, quality of life, pain, or cognitive processing speed and vigilance

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TABLE 6
Summary of a study evaluating myofeedback training for chronic whiplash-associated disorder

Reference, year, country, score	Population and methods	Outcome measures	Results
Voerman et al (31), 2006, The Netherlands, no score	Case series. 11 patients with whiplash-associated disorder symptoms persisting for at least 6 months after the injury received ambulatory myofeedback training, with feedback provided when muscle relaxation was insufficient. The intervention lasted 4 weeks, with participants required to wear the feedback device for at least 2 h per day, 2 days per week and 8 h per week during occupational activities and activities of daily living	Pain in the neck, shoulders and upper back (visual analogue scale) disability (Neck Disability Index) and muscle activation patterns during rest, typing and stress tests (surface electromyography) were assessed at baseline and following 4 weeks of training	Compared with preintervention scores, pain intensity was decreased to a clinically relevant degree in the neck and upper back region for 55% of patients, the right shoulder for 64% of patients and the left shoulder for 18% of patients. Although changes in median disability scores were nonsignificant, there was a trend toward decreased disability

TABLE 7
Summary of a study evaluating alternative therapies for chronic whiplash-associated disorder

Reference, year, country, score	Population and methods	Outcome measures	Results
Ventegodt et al (32), 2004, Denmark, PEDro score = 4	Randomized controlled trial. 87 patients with ≥6 months of moderate to severe whiplash-related pain were randomly assigned to receive no treatment or 2 days of 'philosophy-of-life' training followed by 6–8 days of an individualized combination of Gestalt therapy, Rosen bodywork and craniosacral therapy	Pain level, daily functioning, sick leave and global quality of life were assessed at baseline and 3 months after the last session	There were no significant differences between the treatment group and the control group on any of the outcome measures

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impeded recovery, there is a need to identify which exercise programs are helpful and which hinder recovery. There is also some limited evidence in favour of chiropractic manipulation and myofeedback training, based on one small case series for each. As such, the evidence is insufficient to establish the effectiveness of either of these treatments. Conversely, it does not appear that the use of either melatonin supplements or a specific combination of 'alternative' therapies are beneficial during the chronic phase of WAD, although these conclusions are based on limited evidence.

While the majority of studies suggested that interdisciplinary interventions were effective, the results of the only two RCTs provided conflicting results. Further complicating this issue is the heterogeneity of the interventions included in this section; specifically, although all of these studies typically involve some form of physical therapy combined with some form of psychological counselling, these components were quite diverse and also combined in different ways. Given this, it is perhaps not surprising that there is significant variation in the findings. More research is needed but until there is greater standardization of therapeutic interventions, there will continue to be concerns about the variable nature of the interventions provided. Nevertheless, interdisciplinary interventions, particularly the use of acceptance-based CBT to reduce whiplash-related disability, represent a promising advancement in the treatment of chronic WAD.

The present review was limited by several methodological concerns. First, because of the small number of studies in the whiplash literature, the criteria for inclusion were quite broad. All studies were included regardless of study design as long as 60% of the sample experienced a WAD and they included a sample of at least three participants with a whiplash injury. This may have resulted in the inclusion of some studies of lower scientific merit; however, such studies were only used to formulate conclusions in the absence of superior RCTs and these limitations were noted in the conclusions themselves as well as in the discussion. Second, there are limitations with the quality assessment process used in the current review to evaluate the methodological quality of RCTs. For example, it is possible that an RCT with significant between-group differences at baseline that does not blind patients, therapists or assessors could still have a PEDro score of 6 and be considered a study of

TABLE 8
Summary of evidence for noninvasive chronic whiplash-associated disorder (WAD) therapies

Intervention	Conclusions
Exercise programs	Despite recurring methodological shortcomings in the research studies, it appears that exercise programs provided during the chronic phase of WAD are effective in relieving pain, although it does not appear that these gains are maintained over the long term. While there is some evidence regarding the relative effectiveness and potential benefits of specific exercise protocols, further research is needed before any definitive conclusions can be drawn
Interdisciplinary	Although the majority of studies support its benefit, there is conflicting evidence regarding the effectiveness of interdisciplinary interventions for patients with chronic WAD
Manual joint manipulation	Although the results of one case series suggest that chiropractic manipulation may reduce chronic whiplash-related disability over the short term, the evidence is insufficient to determine the effectiveness of this intervention
Pharmacological	Although melatonin supplements may increase melatonin onset time, this treatment does not appear to be effective in reducing whiplash-related symptoms
Myofeedback training	Based on the results of one small case series, there is limited evidence that myofeedback training may be beneficial for some patients with chronic WAD
Alternative therapies	The combination of Gestalt therapy, Rosen bodywork and craniosacral therapy does not appear to be beneficial during the chronic phase of WAD

good methodological quality despite these significant limitations. Again, these issues were noted in relevant conclusions and study descriptions. Nevertheless, these measures do not negate the need for readers to be 'critical consumers' of the material presented.

Few research topics generate more controversy than chronic WAD, particularly regarding the proportion of patients with whiplash injuries who develop chronic symptoms and subsequent disability. However, recent research suggests that approximately 60% of whiplash patients are still symptomatic three months postinjury, with 37% complaining of moderate to severe levels of pain (4). Moreover, Bylund and Bjornstig (35) found that in a study of WAD patients seen in emergency rooms, 58% of patients reported having symptoms 30 months or longer postinjury that they attributed to the collision. Given the personal and socioeconomic burden experienced by individuals with chronic WAD, it is important that we understand the role of treatment, and that such treatments are rigorously evaluated to ensure the best use of limited resources. Unfortunately, with the exception of studies evaluating exercise programs, the majority of studies included in the current review were non-RCTs predominated by small sample sizes, generic inclusion criteria, poor methodological design (eg, inadequate length of follow-ups) and poor reporting quality (eg, lack of statistical findings reported). Based on the available evidence, it appears that exercise programs still remain the most effective treatment options for patients with chronic WAD (Table 8); however, further research is needed to determine which exercise regimens are most efficacious and which unique patient characteristics predict improvement for a given intervention. CBT also appears to be useful, particularly as an acceptance-based approach. More research is needed to establish the effectiveness of other treatment regimens.

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