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Review

Exercise training for non-operative and post-operative patient with cervical radiculopathy: a literature review

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Abstract. [Purpose] Cervical radiculopathy is a clinical condition associated with pain, numbness and/or muscle weaknesses of the upper extremities due to a compression or irritation of the cervical nerve roots. It is usually managed conservatively but surgical intervention is sometimes required for those who fail to respond adequately. This study performed a literature review to determine the effects of exercise on non-operative and post-operative cervical radiculopathy patients. [Methods] The PubMed, MEDLINE, CINAHL and Scopus databases were searched to identify relevant articles published from January 1997 to May 2014, which explicitly stated that an exercise program was employed as an intervention for cervical radiculopathy. The therapeutic effectiveness and outcomes were then classified based on the International Classification of Functioning, Disability and Health (ICF) model. [Results] Eleven studies were identified and included in the final analysis. In these studies, the main forms of exercise training were specific strengthening and general stretching exercises. Levels of evidence were graded as either I or II for all studies according to the Oxford Centre for Evidence-based Medicine. The PEDro Scale score of these studies ranged from 5 to 8. [Conclusion] A review of eleven high-level evidence and high-quality studies revealed that, based on the ICF model, exercise training is beneficial for improving the body function as well as activity participation of cervical radiculopathy patients.
Key words: Cervical radiculopathy, Exercise training, ICF model

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INTRODUCTION

Cervical radiculopathy is caused by the compression of the cervical nerves or nerve roots[1]. A herniated intervertebral disc, bone spur development, or facet joint problem can lead to the compression. The common symptoms of cervical radiculopathy involve pain, muscle weakness spreading into the neck and upper extremities, loss of sensation[2], and proprioception deficits[3]. Although the symptoms experienced by patients with cervical radiculopathy vary, the symptoms generally appear at certain regions and with specific characteristics depending on the level of nerve compression.

The treatment options for cervical radiculopathy can be divided into surgical and conventional treatments, both of which aim to reduce pain and symptoms, increase nerve function, and prevent recurrence of cervical radiculopathy. No study with a high level of evidence has proved that surgical intervention alone for cervical radiculopathy is effective[4]. Surgical interventions are often combined with conventional nonsurgical treatments, such as medications, use of a cervical collar, cervical traction, and manual therapy. These conventional treatments, however, have not been proven effective by studies with a high level of evidence either[5, 6].

Among the methods used for pain and symptom relief in cervical radiculopathy, exercise training has gained popularity through promising results[7, 8]. However, no systematic review has been made summarizing the effects of the exercise training on cervical radiculopathy, either as an alternative to surgery or as a post-operative treatment option. The present study searched the literature to determine the

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treatment effects of exercise interventions for patients with cervical radiculopathy after receiving nonsurgical or surgical treatments.

SUBJECTS AND METHODS

Studies from January 1997 to May 2014 found on four online databases (i.e., MEDLINE, CINAHL, Scopus and PubMed) were searched using the following key words: (a) cervical radiculopathy or cervical spondylotic radiculopathy; (b) exercise training or physiotherapy. The selection criterion was that the exercise programs used to treat the radiculopathy must be detailed in the articles. Review articles or studies involving patients with the whiplash syndrome or low back disorders were excluded. Individual assessors were assigned and conducted the literature search of each of the databases using the search terms listed above. All of the identified relevant articles were then collectively presented to one of the authors who then determined their eligibility and inclusion for further analysis.

The quality of the identified studies was assessed using the Physiotherapy Evidence Database (PEDro) Scale, a scale that is used to assess the strength of the evidence in therapeutic research. The PEDro Scale consists of 11 items and has been shown to be reliable and valid[9]. The total score of the PEDro Scale ranges from 0 to 10 points, and studies with high, medium, and low quality are accredited 6–10 points, 4–5 points, and 0–3 points, respectively. The levels of evidence of the identified studies were evaluated using the Oxford Centre for Evidence-Based Medicine (OCEBM) Levels of Evidence. Based on the definition of OCEBM, studies are classified as Levels 1 to 5 according to the research design structure and the highest evidence level (Level 1) is given to systematic literature reviews of randomized controlled trials (RCTs).

The therapeutic effectiveness and outcomes of the identified studies were classified based on the three major components of the International Classification of Functioning, Disability and Health (ICF) model: (1) body function and structure, including the numeric pain rating scale (NPRS), visual analogue scale (VAS), craniovertebral angle, peak-to-peak amplitude of dermatomal somatosensory evoked potentials (DSEP) as an assessment of nerve root function, pain location chart, global rating of change scale (GROC), grip strength, active range of motion (AROM), neck endurance, manual dexterity, and arm elevation during neck extension; (2) activity and participation, including the neck disability index (NDI), patient-specific functional scale (PSFS), coping strategies questionnaire, and disability index rating (DIR); and (3) personal factors, including the Mood Adjective Check List, Hospital Anxiety and Depression Scale, patient satisfaction, and fear-avoidance beliefs questionnaire (FABQ).

RESULTS

Eleven studies that met our search terms and inclusion criteria were examined in this study (Fig. 1), and all involved randomized controlled trials. All the studies were categorized as OCEBM Levels 1 and 2, indicating a high level of evidence. Table 1 provides quality assessments of the 11 studies according to the PEDro Scale. Because exercise was employed as the main intervention, the practice of blinding the research participants and surveying personnel was impractical; consequently, no scores were obtained for Questions 5 and 6 of the PEDro assessment. Nevertheless, most of the studies scored 6 to 8 points and thus were categorized as high-quality studies.

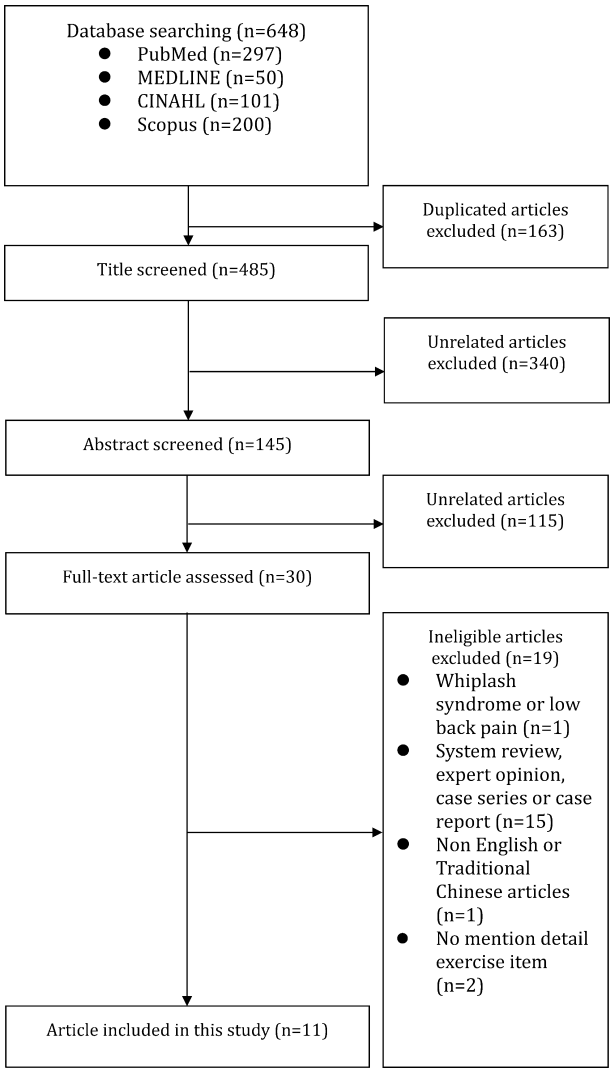

Fig. 1. Flowchart of the selection of articles

In the six studies[10–15] of non-surgical exercise interventions, not all the participants were diagnosed as having cervical radiculopathy using the magnetic resonance imaging (MRI) or computed tomography (Table 2). The duration of exercise interventions ranged from 10 days to 10 weeks, while the exact time of each intervention session was not clearly defined. The exercise intervention items incorporated strength training (eg, isometric exercises of the deep cervical flexor muscles, shoulder retraction muscles, and scapular muscles) and stretching exercises (stretches for the neck and chest muscles). The outcome measures primarily focused on pain (VAS or NPRS) and disability (NDI). The results of these six studies indicate that patients in the exercise groups

Table 1. PEDro and Oxford Centre for Evidence-based Medicine Levels of Evidence of the included articles

Article	PEDro												Levels of Evidence *
	1	2	3	4	5	6	7	8	9	10	11	Total	
Exercise Intervention													
Diab, 2012[10]	1	1	1	1	0	0	0	1	1	1	1	7	I
Fritz, 2014[11]	1	1	1	1	0	0	1	1	1	1	1	8	II
Joghataei, 2004[12]	1	1	0	1	0	0	1	1	0	1	1	6	I
Kuijper, 2009[13]	1	1	1	1	0	0	0	1	0	1	1	6	I
Nar, 2014[14]	1	1	0	1	0	0	0	1	1	1	1	6	I
Young, 2009[15]	1	1	1	1	0	0	1	1	1	1	1	8	I
Post-Surgical Exercise Intervention													
Engquist, 2013[16]	1	1	1	1	0	0	0	0	0	1	1	5	II
Peolsson, 2013[17]	1	1	1	1	0	0	1	0	0	1	1	6	II
Surgery vs. Exercise Intervention													
Persson, 1997[18]	1	1	1	1	0	0	0	1	1	1	1	7	I
Persson, 2001[19]	1	1	1	1	0	0	0	1	1	1	1	7	I
Persson, 1998[20]	1	1	1	1	0	0	0	1	1	1	1	7	I

exhibited alleviated pain and reduced levels of disability. A significantly increased peak-to-peak amplitude of DSEP, elevated grip strength, and improved craniovertebral angle to lessen the forward head posture (FHP) were also reported.

Among the five studies that involved a surgical control group, two studies[16, 17] were published by the same research group and had identical participants (Table 3). After being diagnosed as having cervical radiculopathy by MRI, the participants in these two studies received exercise treatments that continued for 3 months after surgery. The protocols involved in the post-surgical exercise interventions were similar to those in the nonsurgical exercise interventions, with nursing education additionally incorporated. The outcome measurements were pain, disability, range of motion of the cervical joint, muscular endurance, and hand dexterity. Compared with patients in an exercise-only group, the patients who received post-surgical exercise interventions experienced favorable improvements in terms of neck pain at the initial stage of the post-surgical exercise intervention. However, no significant difference was observed between the two groups at the 2 year follow-up testing. Regarding neck disability, no significant difference was observed between the exercise and control groups before and after the patients received treatments. While no significant differences in cervical joint angle and neck muscular endurance were found between the two groups, both groups demonstrated a post-treatment increase in neck muscle endurance.

The other three studies with surgical control groups[18–20] compared the outcomes between the surgical and exercise treatments, and they were also published by the same research group (Table 4). The participants were all recruited after being diagnosed as having cervical radiculopathy by MRI. Unlike the exercise interventions employed in the studies mentioned above, aerobic exercise was performed in these studies. Outcome measurements included pain and disability as well as a questionnaire for assessing physical function and psychological state. At the initial stage, surgical treatment showed a favorable effect in terms of the neck pain; however, no significant difference was observed between the two groups at 1 year follow-up. No differences were observed between the two types of treatment regarding improvements in the cervical joint angle, range of motion of the shoulder joint, or anxiety.

DISCUSSION

Our systematic review indicates that exercises for patients with cervical radiculopathy primarily incorporated strength training and stretching of the neck muscles. Exercise intensity ranged from twice per week to once per day, with intervention periods lasting from 10 days to 10 weeks. Exercise treatment primarily reduced pain and disability. Strength training of the neck and chest can increase the proprioception of patients and promote muscle strength balance around the neck, thereby potentially reducing pain, strengthening body function, and preventing recurring injury[21]. Cervical radiculopathy is frequently associated with inactivity and thus the aerobic capacity of patients may decrease rapidly and their deconditioned state may prevent them from participating in strength training[22]. Consequently, aerobic exercise training should be considered as one of the exercise programs for patients with cervical radiculopathy. Neck stretching exercises can maintain the active range of motion and normal function of the neck, avoiding scarring, adhesion, and repetitive micro-trauma of the neck[5].

Based on the results of the 11 studies, it is our conclusion that the overall effect of exercise interventions is two-fold: (1) improving body structure and function: pain reduction, FHP reduction, increase of peak-to-peak amplitude of DSEP, and enhanced grip strength, neck muscle endurance, and manual dexterity; (2) facilitating activity and social participation: decreased neck disability and improved patient self-care ability for daily life. The primary difference between the effects of the surgical and exercise treatments or between

Table 2. Summary of the six studies involving exercise intervention without surgical treatments

	Study design	Basic data	Intervention(s)	Outcomes measure & follow-up	Outcome
Diab et al. 2012[10]	RCT 2 groups	N: 96 Age: 46.1 MRI: No mention	**Control group (48)** Ultrasound and infrared **Exercise group (48)** 4 times/week for 10 weeks Exercise, ultrasound, and infrared Posture corrective exercise program • Strengthening (12rep*3set): Deep cervical flexors, shoulder retractors • Stretching (30s*3set): Cervical extensors, pectoral muscles	Peak-to-peak amplitude of dermatomal somatosensory evoked potentials, craniovertebral angle, VAS Follow up: 10-week, 6-month	10-week, 6-month: Significant difference between the exercise & control groups adjusted to baseline value of outcome for all measured variables
Fritz et al. 2014[11]	RCT 3 groups	N:86 Age: 46.9 Neck/ Arm pain: 4.2±2.1/4.3±2.4	Dosage: 3 times/week, 2 weeks→ 2 times/week, 2 weeks **Exercise group (28)** 1. Cervical strengthening 2. Scapular-strengthening exercises **Mechanical traction+Exercise group (31)** Supine, 15 minutes, 5.44 kg **Over-door traction group (27)** Sit, 15 minutes, 3.63–9.07 kg	NDI, NPRS (neck, arm), patients' self-reported global rating of change from beginning of treatment to present Follow up: 4-week, 6-month, 12-month	Mechanical traction+Exercise group v.s. Exercise group: • lower disability and pain in Mechanical traction+Exercise group • No significance for NDI, NPRS
Joghataei et al. 2004[12]	RCT 2 groups	N: 30 Age: 47 MRI	Dosage: 3 times/week, 10 physical therapy sessions **Control group (15)** Electrotherapy/ exercise treatment Exercise: Isometric strengthening neck exercise 8 seconds for 25 repetitions each (twice a day), daily **Experimental group (15)** Cervical traction and electrotherapy/exercise treatment	Grip strength Follow up: 5th sessions, 10th sessions	5th sessions: Greater change of grip strength in experimental group 10th sessions: • Significant increase in grip strength compared with pretreatment • No significant difference between groups
Kuijper et al. 2009[13]	RCT 3 groups	N:205 Age: 47.1 MRI: 1. Diagnosis by doctor 2. No mention Neck/ Arm pain: 6.2±2.8/7.2±1.9	**Semi-hard collar group (69)** 3–6 weeks **Physiotherapy & home exercises group (70)** Mobilizing and stabilizing the cervical spine Twice a week for 6 weeks **Control group (66)** Continuation of daily activities as much as possible without specific treatment	VAS (neck, arm), NDI, treatment, satisfaction, work status Follow up: 3-week, 6-week, and 6-month	3-week and 6-week: Reduced neck and arm pain in Semi-hard cervical collar group and Physiotherapy & home exercises group 6-month: • No or limited pain • No significant differences for other measurements
Nar, 2014[14]	RCT (The description of RCT is not clear.) 2 groups	N:30 Age: 44.5 MRI: 1. Diagnosis by doctor 2. No mention Neck pain: 7.1+1.0	Once daily, 10 days, 6 days/week **Control group (15)** 1. Intermittent Cervical Traction (ICT) 2. Interferential Current Therapy (IFT) 3. Isometric neck exercises for flexion, extension, side flexion and rotation with manual resistance. Sitting position, 10 repetitions, 6 seconds hold. **Experimental group (15)** ICT, IFT, Isometric neck exercises& neural mobilization	VAS Follow-up: no significance	Pain decreased significantly for both groups Greater change of pain in the experimental group

Table 2. Continued

	Study design	Basic data	Intervention(s)	Outcomes measure & follow-up	Outcome
Young et al. 2009[15]	RCT 2 groups	N:81 Age: 47.1 Diagnosis by PT Neck pain: 6.5±1.7	Dosage: 4.2 weeks **MTEX Traction group (45)** Manual therapy, Exercise, & intermittent cervical traction **MTEX group (36)** Manual therapy, Exercise, & sham intermittent cervical traction Exercise 1. Cervical retraction 2. Cervical extension 3. Deep cervical flexor strengthening 4. Scapular strengthening	NPRS, PSFS, NDI. FABQ, GROC, patient satisfaction, grip strength Follow up: 2-week, 4-week	No significant differences between groups

Table 3. Summary of the two studies with post-surgical exercise intervention

References	Study design	Basic data	Intervention(s)	Outcomes measure & follow-up	Outcome
Engquist et al. 2013[16]	RCT 2 groups	N: 63 Age: 46 MRI	**Exercise group (32)** 1. Medical exercise (1) Neck stabilization and endurance (2) Strengthening of the scapular muscles (3) Stretching of neck and shoulder muscles (4) Thoracic mobilization (all performed with postural correction) 2. Education (1) Pain management was conducted by 1 time/week for the first 14 weeks (2) Physiology of pain, stress, exercise, breathing technique, coping, pacing, and ergonomics **ACDF+postoperative exercise group (31)**	NDI, VAS (neck, arm)	Significant reduction in NDI, neck pain, & arm pain compared with baseline for both groups Greater reduction of neck pain intensity in ACDF+postoperative exercise group at 6-month & 12-month No significant between-group difference for arm pain intensity & NDI
Peolsson et al. 2013[17]	As above	As above	As above	AROM, neck muscle endurance, hand strength, manual dexterity, arm elevation during neck extension Follow up: 6-month, 1-year, 2-year	No significant differences between the two treatments Both groups showed improvements over time in neck muscle endurance, manual dexterity, and right-hand grip strength

Table 4. Summary of the three studies that involved a comparison between surgery and exercise intervention

References	Study design	Basic data	Intervention(s)	Outcomes measure & follow-up	Outcome
Persson et al. 1997[18]	RCT 4 groups	N: 81+30 Age: 47.5 MRI, CT	**Surgical decompression with fusion group (27)** **Exercise group (27)** 1. Neck and shoulder stretching 2. Flexibility exercises 3. Isometric neck exercises 4. Aerobic exercises 5. Relaxation exercises 6. Coordination exercises 7. Ergonomic instructions 8. Postural corrections 9. TENS, heat 30–45 minutes/time, 15 times/3 months **Neck collar (27)** Daytime for 3 months **Control (30)**	VAS, hand grip strength, pinch strength Follow up: 3-month and 12-month post treatment	3-month: Greater improvement of pain intensity, muscle weakness and sensory loss in surgery group 12-month: no significant differences between surgical and conservative therapy groups
Persson et al. 2001[19]	RCT 3 groups	N:81 Age: 47.5 MRI, CT Neck pain: 5.0±2.1	**Surgical decompression with fusion group (27)** **Exercise group (27)** **Neck collar (27)**	Mood Adjective Check List, Hospital Anxiety and Depression Scale, Coping Strategies Questionnaire, VAS, Disability Index Rating (DIR) Follow up: 3-month and 12-month post treatment	Greater improvement of pain in surgery group but no differences after one year Greater improvement in the surgery and exercise groups than in collar group after 3 months
Persson et al. 1998[20]	RCT 4 groups	N: 81+30 Age: 47.5 MRI, CT	**Surgical decompression with fusion group (27)** **Exercise group (27)** **Neck collar (27)** **Control (30)**	VAS, muscle tenderness, shoulder motion, neck ROM Follow up: 3-month and 12-month post treatment	Lower pain intensity in surgery and exercise groups than in collar group Lower muscle tenderness in surgery group than in exercise and collar groups Greater improvement of shoulder motion in surgery group than in collar group Significantly greater neck ROM in exercise group than in collar group at pre-treatment and 3-month post treatment but no difference at 12-month

those of the post-surgical exercise and exercise-only treatments pertained to pain, especially within the first year of receiving the interventions as no significant differences were reported between the two approaches after one year. In previous studies, there has been controversy over whether or not FHP reduction results from pain relief[23]. Diab et al. used ultrasound therapy and infrared therapy to treat the control group. Although short-term pain was reduced substantially in the control group, no evident improvement was shown in FHP. However, both pain and FHP significantly improved in the exercise group, which was accredited to the amelioration of muscle balance following exercise training. The increased peak-to-peak amplitude of the DSEP suggests that exercise interventions may improve the function of patients' nervous systems[10].

Many of the 11 reviewed studies of exercise interventions also included other auxiliary physical treatments. Only the study by Fritz et al.[11] involved an exercise-only intervention group. The primary purpose of the auxiliary physical treatments was to relieve pain, which may have influenced the treatment effect of the exercise interventions. The baseline conditions of the patients in each study differed, such as the intensity of pain (Tables 2–4). In addition, not all diagnoses of cervical radiculopathy were confirmed by MRI, and the therapeutic doses varied substantially. These factors might have influenced the treatment efficacy and by extension, the validity of the results of meta-analysis.

Several limitations of this study should be addressed. First, three studies exclusively comparing outcomes between surgical and physical treatments[18–20] were from the same research group (hereinafter referred to as the first research group), and the participants in these studies possibly overlapped. In addition, two studies that compared exercise-only treatment and post-surgical exercise treatment[16, 17] were also conducted by the same research group with identical participants (hereinafter referred to as the second research group). Because the first research group provided VAS data at different stages and the second research group showed VAS data as changes between the pre- and post-treatment periods, making direct comparison and meta-analysis impossible. Regarding the range of motion of the cervical spine, the first research group considered the sum of the angles in three orthogonal planes, whereas the second research group provided separate angle data for each plane; consequently, direct comparison and meta-analysis were not possible in this instance. Second, the first research group indicated that no exercise treatments was performed by the patients within 3 months of receiving surgical treatment, but it was not clearly stated whether exercise through self-participation or other methods was prohibited within this 3-month period. Therefore, the results obtained at 1 year after surgery may not be treated as the exclusive effects of the surgical intervention. Third, thus far, patients receiving post-surgical exercise treatment have only been followed for up to 2 years[16, 17].Thus, the long-term effect of exercise treatment beyond 2 years remains unknown. Fourth, these studies did not detail or classify the severity of the nerve root compression experienced by the patients; therefore, the variation in the baseline conditions among the participants may also have influenced treatment effects.

Our systematic review of eleven randomized controlled trial studies indicates that nonsurgical treatments were mostly combined with multiple treatment patterns and that few studies investigated the effects of post-surgical exercise treatment. The exercise treatments for cervical radiculopathy involved deep cervical flexor muscle training, posture correction, and muscle stretching. It appears that exercise treatment can improve body structure and function, as well as the activity participation of the patients. However, these studies were not focused on assessing personal factors and the environment. Future studies are warranted in order to incorporate the ICF model in the assessment, and to yield more evidence capable of verifying that post-surgical exercise interventions are beneficial for patients with radiculopathy.

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