The Effect of Different Exercise Programs on Size and Function of Deep Cervical Flexor Muscles in Patients with Chronic Nonspecific Neck Pain

A Systematic Review of Randomized Controlled Trials

Somayeh Amiri Arimi, PT, Mohammad Ali Mohseni Bandpei, PT, PhD, Khodabakhsh Javanshir, PT, PhD, Asghar Rezasoltani, PT, PhD, and Akbar Biglarian, PhD

Background: Neck pain is one of the major public health problems, which has a great impact on people's lives. Cervical vertebral column is heavily dependent on the muscles for its physical support and activities. There are increasing evidences to support that cervical muscles may impair in patients with neck disorders. It was reported that in the presence of pain, activation, size, strength, and endurance of the deep cervical flexor (DCF) muscles may change in patients with chronic neck pain. This group of muscles consists of longus colli and longus capitis muscles, which provide dynamic cervical spine stability and support the cervical lordosis. They can be assessed and retrained while one study reported no significant difference between this exercise and other cervical exercise programs. From those nine studies, eight studies gave support to the effectiveness of specific low-load exercise training on DCF muscles parameters, while one study reported no significant difference between this exercise and other cervical exercise programs.

Results: Nine articles were identified and evaluated in the final analysis. Four studies had moderate quality, and five studies had good quality. Previous investigations revealed that exercise training may alter the recruitment pattern of these impaired muscles, and superficial muscles during different activities, leading to decreased activation of the DCF, that is accompanied by increased activation of the superficial muscles. This reduction in activity of DCF muscles, which more likely occurs owing to pain inhibition, reduces support and control of the cervical spine joints, and compensatorily enhances activity and fatigability of the superficial muscles. Altered coordination between the deep and superficial flexor muscles should be corrected in patients with chronic neck pain to restore normal neuromuscular strategy of the DCF muscles.

Conclusion: The results of reviewed studies are in favor of specific low-load craniocervical flexion exercise, which seems to be a highly effective exercise regimen compared to other types of exercises in improving DCF muscles impairments in patients with chronic neck pain.

Key Words: Neck Pain, Neck Muscles, Exercise Therapy, Randomized Controlled Trials, Systematic, Review (Am J Phys Med Rehabil 2017;00:00–00)
weak muscles,11,15 On the other hand, clinicians prescribing exercises for patients with mechanical neck disorders need to be aware of the results of different modes of training. So far, several muscles, particularly the DCF muscle group, were targeted in the rehabilitation programs of patients with neck pain.

A number of clinical trials were conducted to investigate the efficacy of different exercise programs in patients with chronic neck pain. There is adequate evidence to support that therapeutic exercise is effective in increasing function and decreasing pain in patients with both acute and chronic neck pain.13 Despite the prevalent clinical use of exercise therapy for treatment of patients with neck pain, no systematic review has been conducted to evaluate the effects of different exercise training on chronic neck pain. There is still no general consensus on optimal exercise prescription in the rehabilitation of these patients. This study was performed to systematically review available published evidences to determine the effects of different exercise programs in the management of DCF muscle impairments in patients with chronic nonspecific neck pain.

METHODS

This systematic review was performed according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), which reports the required information accordingly (Supplementary Checklist, http://links.lww.com/PHM/A400).16

Search Strategy

A literature search of different electronic databases including PubMed, Science Direct, OVID, Google scholar, Cochrane Library, and Physiotherapy Evidence Database (PEDro) were conducted from 1990 through March 2016, using the following key words: neck pain, neck muscles, cervical muscles, cervical flexor muscles, deep cervical flexors, exercise therapy, exercise training, exercise program, and randomized controlled trials (RCTs). Literature search was based on participants (chronic nonspecific neck pain patients), interventions (various exercise therapies), comparisons (between patients groups), outcomes (DCF muscle parameters), and study design (RCT). After removing duplicate articles, the titles and abstracts were screened for eligibility criteria. Then, the relevant full-text papers were assessed. Manual search of the reference list of included articles also was done. The search was performed by two of the authors (S.A.A. and K.J.). These two authors independently screened all titles and abstracts and then relevant full text to determine potentially eligible papers based on inclusion/exclusion criteria. If they did not reach a consensus, a third reviewer (M.A.M.B.) assessed the eligibility of the articles.

Study Selection

Published randomized controlled trials, conducted on chronic nonspecific neck pain with deep cervical flexor muscles impairment, which assessed the effect of therapeutic exercises, and published in English language in full text were included. Articles in the abstract form, or case studies or reports, investigating superficial cervical flexor muscles, conducted in patients with different subcategories of neck pain (eg, whiplash disorder, forward head posture, tension type headache, cervicogenic headache, myofascial trigger points) or conducted in healthy subjects were excluded. From 342 initial records, a total of nine RCTs were included in the study,11,17–24 The search strategy is presented in Figure 1, through PRISMA flowchart.

Quality assessment of the selected articles was performed using the PEDro scale, which is an 11-item scale developed to evaluate methodological quality of randomized controlled trials, with each item scored 0 or 1, except the first item, which needs a “yes” or “no” answer.25 A higher score represents higher methodological quality. Articles with a score of more than 8 are considered high quality; those with a score of 6 to 8 are considered good. Articles with a score of 4 to 5, and less than 4 are considered moderate and poor quality, respectively.25 Table 1 provided quality assessment of the nine studies according to the PEDro scale.

RESULTS

From a total of 342 relevant articles, 74 duplicate articles were removed. Of the remaining 268 articles, 245 articles were excluded based on the titles and abstracts screening for eligibility criteria. Eventually, nine studies met the inclusion criteria and were subsequently included for full review.11,17–24 Table 2 provided details of the studies in chronological order from 1990 to March 2016.

All relevant studies had randomized controlled clinical trial design. The PEDro score of these studies ranged from 4 to 8. Four studies were categorized as moderate-quality18–21 and five as good-quality studies.11,17,22–24 The sample sizes of the reviewed studies ranged from 28 to 145 patients with chronic nonspecific neck pain. The total number of patients was 424 (101 males and 323 females). In one study, the author did not present any data about the sex of the patients and their numbers.23 The duration of exercise interventions ranged from 3 to 10 weeks, with one to three sessions per week. The exercise interventions included low-load CCF exercise, cervical flexion (CF) exercise, general strengthening exercise, stretching exercise, and cervical proprioception exercise.

The primary outcome measures were pain intensity, functional disability, electromyographic (EMG) activity, dimensions, and strength and endurance of DCF muscles. Only one study had follow-up period.17 In one study, EMG activities of DCF muscles were assessed during two tasks, before and after intervention.11 Two studies investigated cross-sectional area (CSA) of the longus colli muscle by an ultrasonography apparatus, as a main outcome measure.19,22 In three articles, strength and endurance of DCF muscles were examined before and after training.17,18,23 In two studies, performance of CCF test was reported as key outcome measure.20,24 In one study, outcome measures were pain intensity and functional disability.21

In most studies, the researchers tried to find out which exercise regimen is most effective in the management of patients with DCF muscle impairments. Of the nine studies, eight studies compared the effects of two exercise programs; whereas in one study, researchers tried to compare the effect of exercise with nonexercise method [such as infrared (IR) and neck care advice].17

From those nine studies, eight studies confirmed the effectiveness of specific low-load exercise training of DCF
whereas only one study found no significant difference between the specific low-load exercise and other cervical exercise programs.18

The results of these eight studies indicated that patients in the CCF exercise groups exhibited alleviated pain, reduced level of functional disability, increased longus colli muscle dimensions, significant improvement in strength and endurance of DCF muscles, and significant increase in the performance (level and range of motion) of the CCF test. Improved neck-shoulder posture and absolute rotation angle were also reported.19,20

In one study, the effect of the CCF exercise was compared with cervical proprioception exercise on the neuromuscular control in patients with chronic neck pain. Those patients who received cervical proprioception exercise also demonstrated favorable improvements in the neuromuscular parameters, and no significant difference was reported between the two exercise groups.24

**DISCUSSION**

This study was carried out to systematically review published studies from 1990 to 2016 to determine the effects of different exercise programs in the management of DCF muscle dysfunctions in patients with chronic nonspecific neck pain. Nine studies were included and reviewed. The results of the present systematic review demonstrated that exercise therapy via improvement of the performance of the DCF muscles has

### TABLE 1. The PEDro scale score of the included studies

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<td>Outcome Measures</td>
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<td>1</td>
<td>Chiu et al.2005</td>
<td>Evaluated the efficacy of a specific exercise program for the management of patients with chronic neck pain</td>
<td>145 patients with chronic neck pain</td>
<td>Group 1: CCF exercise and dynamic strengthening exercise + IR and neck care advice Group 2: none (IR and neck care advice)</td>
<td>6 weeks, and 6 months follow-up</td>
<td>Pain, disability and isometric neck muscle strength</td>
<td>After 6 weeks, patients in exercise group were significantly better in pain, disability, and isometric neck muscle strength than those in the control group. However, the effect of exercise was less favorable at 6 months</td>
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<td>O'Leary et al.2007</td>
<td>Compared the effects of two different exercise methods in training isometric CCF muscles performance</td>
<td>50 women with chronic mild neck pain and disability</td>
<td>Group 1: CCF exercise Group 2: CF exercise</td>
<td>6 weeks</td>
<td>Isometric strength and endurance of Craniocervical flexor muscles (longus capitis, longus colli and rectus capitis anterior)</td>
<td>Isometric CCF muscles performance can be trained with either CCFEx protocol or conventional CFEx protocol in patients with mild neck pain and disability</td>
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<td>Jull et al.2009</td>
<td>Compared the physiological effects of two exercise programs on DCF and superficial cervical muscles activity during two tasks, the CCFT and rapid unilateral arm movements</td>
<td>46 women with chronic neck pain</td>
<td>Group 1: CCF training Group 2: Strength training</td>
<td>6 weeks</td>
<td>EMG amplitude of DCF and SCM and anterior scalene muscles, ROM of the CCFT, and relative latencies between onset of DCF, SCM, and AS EMG with that of deltoid muscle, VAS, NDI, perceived benefit of exercise</td>
<td>Specific training was more efficient than strength training, enhanced the pattern of deep and superficial muscle activity (neuromuscular strategy) in the CCFT, improved temporal characteristics of DCF muscles</td>
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<td>Chung et al.2012</td>
<td>Investigated the effect of CCF exercises on CSA of LC, absolute rotation angle and NDI of chronic neck pain patients</td>
<td>35 patients with chronic neck pain</td>
<td>Group 1: CCF exercises Group 2: Neck isometric exercises</td>
<td>8 weeks</td>
<td>Cross-sectional area of the longus colli, absolute rotation angle, NDI</td>
<td>CCF exercises are an effective treatment for greater improvement of CSA of LC, absolute rotation angle and treating functional disabilities</td>
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<td>5</td>
<td>Lee et al.2013</td>
<td>Examined the effects of DCF muscle-strengthening exercise on neck-shoulder posture and the strength and endurance of DCF muscles</td>
<td>30 female high school students with bad posture and chronic neck-shoulder pain</td>
<td>Group 1: CCF exercise Group 2: basic stretching exercises</td>
<td>8 weeks</td>
<td>Head tilt angle, neck flexion angle, forward shoulder angle, and the result of CCFT</td>
<td>Significantly improvement in neck-shoulder posture, and in strength and endurance of DCF muscles in experimental group than the other group</td>
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<td>6</td>
<td>Iqbal et al.2013</td>
<td>Determined improvement in pain and disability of school teachers with neck pain after DCF training with pressure biofeedback</td>
<td>30 teachers with neck pain and poor Craniocervical flexion test</td>
<td>Group 1: Craniocervical flexion exercise + conventional exercises Group 2: Just conventional exercises</td>
<td>4 weeks</td>
<td>VAS, NDI</td>
<td>Significant improvement in pain and disability in both groups, but better results in experimental group</td>
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7 Javanshir et al.22 2015 Assessed the effect of two exercise programs on cervical flexor muscles dimensions in patients with chronic neck pain

60 patients with chronic neck pain

Group 1: CCF exercise

Group 2: CF exercise

10 weeks

VAS, NDI, dimensions of longus colli and SCM muscles by ultrasonography

Decreases on pain and disability were found for both groups. CCF exercise program increased LC muscle dimensions, whereas the CF exercise program increased SCM thickness.

8 Gogoi23 2015 Compared the efficacy of cervical endurance training with cervical isometric exercise in alleviating symptoms of mechanical neck pain

40 patients with mechanical neck pain

Group 1: Cervical endurance training

Group 2: Cervical (conventional) isometric exercise

3 weeks

Endurance, pain intensity, disability, range of motion, and muscle power

Significantly decrease in pain intensity and disability, and increase in endurance in experimental group than the control group. The posttreatment cervical range of motion does not have significant difference in between the groups. The neck muscle power in the experimental group did not improve compared to the control group.

9 Izquierdo et al.24 2016 Compared the effects of CCF vs cervical proprioception training on neuromuscular control, pressure pain sensitivity, perceived pain and disability in patients with chronic neck pain

28 patients with chronic neck pain

Group 1: CCF exercise

Group 2: Cervical proprioception exercise

2 months

Performance of the CCF test, pressure pain threshold, level of pain and disability

Both groups showed improvement in activation and endurance of deep cervical flexors, pain, and disability. Pressure pain sensitivity did not change for either group. Proprioception training may provide an additional benefit of facilitating the deep cervical flexor muscles.

CCF muscles, craniocervical flexor muscles; CCFEx, craniocervical flexion exercise; CFEx, cervical flexion exercise; CCFT, CCF test; LC, longus colli; NDI, Neck Disability Index; ROM, range of motion; SCM, sternocleidomastoid; VAS, Visual Analog Scale.
been shown to be an effective approach in alleviating chronic neck pain. The primary choice of exercise for patients with DCF muscle impairments was CCF exercise. Cranio cervical flexion exercise is considered an optimized training to address the DCF muscle deficits in patients with neck pain.11,15,19 O’Leary et al.26 reported that the gentle low-load exercise produces a more analgesic effect than higher load exercises. Low-load exercise may be a better approach to manage pain in the initial stages of a rehabilitation program, and it coordinates the activity of the deep and superficial cervical muscles.11,13,23

In these reviewed articles, researchers evaluated the results of the implementation of different interventions through various parameters.

In recent years, EMG technique and ultrasonographic imaging of muscle dimensions have been commonly used for evaluation of muscle behavior and structure.27–29 One study used EMG technique to assess DCF muscle activities before and after the intervention.11 It was reported that specific low-load CCF exercise compared to neck flexor strengthening exercise enhanced spatial and temporal characteristics of DCF muscle activation with respect to surrounding muscles. It was also found that the interaction between the deep and superficial flexor muscles became closer to the normal situation in the CCF training group compared to the strength-training group. Regarding EMG onset activity of the flexor muscles, CCF training shortened the relative latency between the activation of the deltoid and DCF during rapid arm movement compared to the strength-training group. Altered neuromuscular strategy and improvement in automatic feed-forward control of the cervical flexors could be achieved by specific CCF exercise in the rehabilitation program.4,6,12 During CCF exercise, the training method and outcome task are similar; therefore, task-specific improvement can be achieved with training.11

Two reviewed articles reported that dimensions of the DCF muscles increased after specific exercise training.11,19,22 Javanshir et al.22 compared the effect of CCF exercise and CF exercise on cervical flexor muscles’ dimensions [longus colli and sternocleidomastoid muscles] in patients with chronic neck pain using ultrasonography imaging. After a 10-week intervention, CCF exercise, which specifically recruited DCF muscles, significantly increased longus colli muscle dimensions, whereas the CF program increased sternocleidomastoid thickness. These data were consistent with the study conducted by Chung et al.,19 which evaluated the effect of CCF exercise compared to cervical isometric exercise on the CSA of longus colli muscle, absolute rotation angle, and neck disability index in patients with chronic neck pain. Results indicated that the CCF exercise program was an effective treatment to improve CSA of longus colli muscle, absolute rotation angle, and reduced functional disabilities in patients with chronic neck pain.

Some of the reviewed studies have evaluated the endurance and strength of DCF muscles following different exercise interventions.17,18,20,21,23,24 Five studies reported significant improvement in the strength and endurance of DCF muscles and in the performance of CCF test in the CCF exercise compared to other exercise regimens.17,20,21,23,24 In one study, no significant difference was found between the exercise groups.18 O’Leary et al.18 examined the effect of CCF and conventional CF exercises on isometric performance of the CCF muscles including maximum voluntary contraction (MVC) as a strength and 50% MVC using time to task failure and contraction accuracy as an endurance in women with chronic mild neck pain and disability. Both exercise protocols resulted in significant increase in isometric CCF muscle performance, with no significant difference between the groups.18 This conclusion refuted the specificity of DCF muscle training with CCF exercise. It seems that isometric tests of muscular function are not sensitive to dynamically induce training adaptations as may have been expected with both exercise programs. It seems that the contractile demands placed on the CCF muscles in both exercise protocols were adequate to result in similar isometric strength and endurance performance gained in patients with mild neck pain. Specific neuronal, muscular, and functional changes and adaptation in motor output (changes in strength, endurance and skill) in response to exercise seems to be dependent on the mode (primary behavioral demand) of exercise training undertaken.15

In the study conducted by Chiu et al.,17 the efficacy of a specific exercise program in the management of patients with chronic neck pain was evaluated at 6 weeks’ and 6 months' follow-up. After 6 weeks' intervention, patients in the exercise group (CCF exercise and dynamic strengthening exercise + IR and neck care advice) were significantly better in pain, disability, and isometric neck muscles strength than those in the control group (just received IR and neck care advice). However, the effects of exercise were less desirable at 6 months' follow-up.

Improvement in the performance of the CCF test and increased coordination between deep and superficial cervical flexors after proprioception training is a novel finding by Izquierdo et al.24 Izquierdo et al compared the effects of CCF training versus cervical proprioception training on neuromuscular control, pressure pain sensitivity, perceived pain and disability in patients with chronic neck pain. The results indicated that besides CCF training, proprioception training also seems to provide an additional benefit of facilitating the DCF muscles. Since proprioception exercise required fine control of the neck movements, high density of muscle spindles in DCF muscles30 could justify the effect of this type of exercise.

School-related occupations such as teaching and being a student are one of the improper conditions that lead to neck disorders. In this regard, Iqbal et al.21 and Lee et al.20 carried out two studies in this field.20,21 Iqbal et al. have reported improvement in pain and disability of school teachers with neck pain after DCF training with pressure biofeedback. In an experimental group, patients received CCF exercise and conventional exercises, whereas patients in the control group only received conventional exercises. Significant improvements in pain and disability were observed in both groups; however, the results were greater in the experimental group. The findings showed that after training by pressure biofeedback unit, muscles reach to a better neuromuscular control. This unit via feedback in a closed-loop form helps in motor learning that leads to permanent changes in muscle behavior.

Lee et al.20 also examined the effects of DCF muscle-strengthening exercise and basic stretching exercises on neck-shoulder posture, strength and endurance of DCF muscles in female high-school students with bad posture and chronic neck-shoulder pain. They reported that CCF exercise was more effective than basic stretching exercises in improving the strength and endurance of DCF muscles and neck-shoulder posture.

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posture. They suggested that strengthening DCF muscles is important for adjustment of neck posture and maintenance of the stability.

Previous studies indicate that chronic neck pain may be associated with alterations in cervical muscles behavior, structure, and function. Each of these various dysfunctions requires specific retraining in patients with chronic neck pain. The results of all reviewed studies demonstrated that all types of exercise training improved the DCF muscle impairments in patients with neck pain, but the specific CCF exercise, which focuses on repeated activation of DCF muscles, in motor relearning pattern, may be more effective than other exercise regimens. Owing to postural nature and fiber type of the DCF muscles, low-load exercise may develop the performance of these muscles. In other words, specific improvement in muscular function can be achieved with specific training.

It should also be noted that the most important methodological flaws of these studies, which might have an influence on the results, were failure to comply with all types of blindness; small sample size; lack of follow-up period, intention-to-treat analysis, and concealed allocation.

Limitations

Several limitations should be considered about this study. First, there was a publication bias because only studies published in English language were reviewed. Second, only studies in which DCF muscles were trained by one or two exercise programs in patients with chronic neck pain were included, and studies of the other cervical muscles were not reviewed. Third, only randomized controlled trials with two or more groups of patients were reviewed, whereas studies with a single-group design were excluded. However, more studies are needed to assess the short- and long-term effectiveness of the other therapeutic methods in the management of DCF muscle impairments, and the effectiveness of the exercise therapies on the other cervical muscles (superficial neck flexors and extensor muscles) in patients with chronic neck pain.

CONCLUSIONS

According to the results of this systematic review, specific CCF exercise seems to be a highly efficient exercise regimen in improving DCF muscles impairments in patients with chronic neck pain compared to other types of exercises. It is recommended that the low-load CCF exercise may effectively train the DCF, even in the early stages of the rehabilitation when pain or pathologic condition might preclude high-load exercises. However, further well-designed studies with as few methodological flaws as possible are needed to find out the most useful and effective exercise regimens in the management of patients with chronic nonspecific neck pain.

REFERENCES