J. Phys. Ther. Sci. 28: 269–273, 2016

The Journal of Physical Therapy Science

Original Article

Clinical effects of deep cervical flexor muscle activation in patients with chronic neck pain

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Abstract. [Purpose] The purpose of this study was to investigate clinical effects of deep cervical flexor (DCF) muscles exercise on pain, Neck Disability Index (NDI), and neck and shoulder postures in patients with chronic neck pain. [Subjects and Methods] Twenty-eight patients with chronic neck pain were randomly assigned into either the general strengthening exercise (GSE) group or the DCF activation group as control and experimental groups, respectively. All exercises were performed three times per week over 4 weeks. NDI and numeric rating scale (NRS) score for pain were determined and radiological assessment of neck-shoulder postures (head tilt angle [HTA], neck flexion angle [NFA], and forward shoulder angle [FSA]) was performed before (baseline), 4 weeks after, and 8 weeks after exercise in order to directly compare the exercise effects between the groups. [Results] In the DCF group, the NDI, NRS score, and neck-shoulder postures (analyzed by uisng HTA, NFA, and FSA) were significantly improved. [Conclusion] DCF activation exercise was effective to alleviate pain, recover functions, and correct forward head posture in the patients with neck pain. Hence, it might be recommended in the rehabilitation of patients with chronic neck pain.

Key words: Deep cervical flexor, Forward neck posture, Neck pain

(This article was submitted Aug. 25, 2015, and was accepted Oct. 21, 2015)

INTRODUCTION

Minor damages accumulated in the neck due to chronic posture and sudden muscular contraction can further lead to shrinkage of muscles that are not commonly being utilized, thereby inducing mechanical dysfunction and chronic pain[1)]. A previous study reported that approximately 70% of patients with chronic neck pain exhibit decline in muscular strength and endurance of the sternocleidomastoid and deep cervical flexor (DCF) muscles[2)]. The DCF muscles consist of the longus colli and longus capitis muscles, which play important roles in maintaining posture control and stability of the neck[3)]. In the comparison of muscular activation levels, the deep longus colli and longus capitis muscles were less activated than the superficial sternocleidomastoid and longus capitis muscles[4)]. Therefore, maintaining the muscular strength of the DCF muscles is critical for controlling neck posture and stability[5)].

Continuous imbalance between the superficial and deep neck muscles causes the head to position further forward from the body (i.e., forward head posture). The forward head posture is one of the common postural deformities observed in patients with chronic pain in the neck and shoulder[6)]. In this posture, the central line of the head moves toward the front so that further weights could be loaded on the neck, thereby exacerbating projection of the acromion or cervical lordosis and resulting in serious changes in joints between the neck and head[3)].

DCF exercise has been known to alleviate neck pain, to help maintain proper neck and shoulder postures, and to be effective for deep, rather than superficial, cervical muscles[7)]. Chiu et al.[8)] reported that implementation of DCF exercise more significantly suppressed the increase in pain level in patients with neck pain than in those without exercise. Similarly, Jull et

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al.[9] addressed that rehabilitation program, including DCF exercise, effectively alleviated headache in patients. Other studies further investigated the effects of DCF exercise on chronic neck pain and proper postures[10].

As aforementioned, more than one study reported that DCF exercise might be effective to alleviate neck pain and maintain proper postures. Most of these studies were conducted on subjects belonging to specific age groups or only assessed the exercises rather than further monitor their clinical effects. Hence, this study aimed to prospectively compare the effects of DCF exercise on the correction of forward head posture, chronic neck pain, and functional assessments and those of general strengthening exercise (GSE) in order to generate clinical outcomes for the DCF muscle and to provide useful clinical outcome for rehabilitation exercise for chronic neck pain.

SUBJECTS AND METHODS

In this study, 30 patients who visited the S rehabilitation exercise center, located in Gwang-ju City, between May 2014 and June 2014 with a complaint of neck pain were enrolled. This study was approved by the hospital, and all the participants provided written informed consent. The following subjects were selected for the study: 1) subjects with neck pain; 2) subjects with a Neck Disability Index (NDI) score of <15 points whose symptoms could not be exacerbated by muscular strength exercise; 3) subjects who had been experiencing neck pain for more than 3 months; 4) subjects who had never undergone surgical treatments; 5) subjects who were not receiving medications; and 6) subjects who could not maintain blood pressure at increments of 4 mm Hg (i.e., second-stage pressure) from the initial 20 mm Hg, during the head-neck flexion examination[11]. Prior to the study, the participants were fully informed regarding the study procedures and provided written consent for participation.

The DCF group consisted of six men and eight women (mean ± SD: age, 46.7±4.2 years; height, 164.3 ± 6.78 cm; weight, 67.8 ± 7.7 kg), and the GSE group consisted of seven men and seven women (45.4 ± 5.1 years, 166.4 ± 4.3 cm, and 69.2 ± 4.5 kg).

The subjects was recruited by an independent researcher and then randomly assigned into two groups by using a statistical program. The DCF and GSE groups (15 patients per group) were compared in the study. Each exercise was implemented three times per week for 4 weeks. The NDI, numeric rating scale (NRS) score for pain, and radiological assessment parameters of neck-shoulder postures (i.e., head tilt angle [HTA], neck flexion angle [NFA], and forward shoulder angle [FSA]) were analyzed before (baseline), 4 weeks after, and 8 weeks after exercise in order to compare exercise effects between the groups. During the study, two subjects dropped out (one per group); hence, 28 participants were enrolled for the final analysis.

DCF activation exercise aimed to strengthen the upper neck deep flexor muscles (i.e., longus capitis and longus colli). The superficial sternocleidomastoid and anterior scalene muscles were kept relaxed while performing flexor muscle training for the neck and head[12]. The pressure biofeedback device (Stabilizer Pressure Biofeedback, Chattanooga Group, Chattanooga, USA) was positioned on the back head, and then flattened cervical lordosis was confirmed by using the visual feedback obtained via the dials of the device. First, the air bag under the neck was inflated to 20 mm Hg, and then the subject presses the bag slightly with slight increments of pressure through the sensor dial (i.e., 2 mm Hg; up to 30 mmHg), contraction was maintained for about 10–15 seconds. This was repeated 10 times with 3–5 rest periods per session[9].

For the GSE, conventional isocratic and gradual exercise were adopted. In the present study, the exercise for the muscles surrounding the neck, suggested by Axen et al.[13], was slightly modified. In particular, by using an exercise band and a ball, isometric exercise was provided for the first 2 weeks. Then, gradual exercise was performed in the next 4 weeks. The exercise was maintained toward the front, both sides, and backward for 10 seconds in order to contract the muscles surrounding the neck, followed by a rest period. Ten sessions were performed. Five different stretching postures were performed with straight and fixed positions. Neck stretching, neck bending over, neck bending to both sides, and neck rotation were repeated 3–5 times for 10 seconds. Stretching exercises were repeated three times[14].

The study results were analyzed by using SPSS version 18.0 for Windows. The repeated-measures analysis of variance and independent t test were performed to compare effects before and after exercise, and clinical effects between the groups, respectively. The significance level α was set at 0.05.

RESULTS

Changes in NDI showed significant decreases before, 4 weeks after, and 8 weeks after exercise in the DCF group ($p < 0.05$). In the GSE group, significant decreases were observed before and 4 weeks after exercise ($p < 0.05$). However, the reduction in NDI score after 8 weeks was not statistically significant. No significant difference in NDI scores was observed between the groups at baseline and 4 weeks after exercise. However, a significant difference in NDI at 8 weeks after exercise was found between the groups ($p < 0.05$; Table 1).

The DCF activation exercise significantly lowered the NRS scores, specifically from the baseline to 4 and 8 weeks after exercise. In the GES group, the NRS score did not significantly decrease before, 4 weeks after, and 8 weeks after exercise. When the two exercise groups were compared, no significant difference in NRS score was found at baseline and 4 weeks after exercise. However, a significant difference in NRS score was observed between the exercise groups 8 weeks after exercise ($p < 0.05$; Table 1).

Table 1. Comparison of changes in scores

		Baseline	4 weeks	8 weeks
NDI	DCF group	19.2 (4.1)	17.3 (3.0)	15.4 (2.8)*
NDI	GSE group	20.0 (4.7)	18.1 (3.8)	17.4 (3.9)*†
NRS	DCF group	5.2 (2.1)	3.5 (2.0)	1.7 (1.8)*
NRS	GSE group	5.1 (2.7)	3.8 (2.0)	3.1 (1.9)*†

Data are presented as mean ± SD.
*Significantly different from the baseline ($p < 0.05$).
†Significantly different between the groups ($p < 0.05$).
NDI: neck disability index; NRS: numeric rating scale; DCF group: deep cervical flexor exercise group; GSE group: general strengthening exercise group

Table 2. Comparison of changes in neck-shoulder posture

		Baseline	4 weeks	8 weeks
HTA (TA)	DCF	54.6 (1.5)	51.1 (1.5)*	48.4 (0.8)*†
	GSE	54.2 (1.2)	51.7 (1.3)*	51.0 (1.4)
NFA (FA)	DCF	36.6 (1.4)	26.3 (1.6)*	22.8 (2.3)*†
	GSE	35.9 (2.0)	25.7 (1.9)*	24.8 (2.6)
FSA (SA)	DCF	31.3 (1.1)	23.2 (2.0)*	20.7 (1.5)*†
	GSE	30.9 (1.1)	23.5 (2.7)*	23.2 (2.9)

Data are presented as mean ± SD.
*Significantly different from the baseline value ($p < 0.05$).
†Significantly different between the groups ($p < 0.05$).
HTA: head tilt angle; NFA: neck flexion angle; FSA: forward shoulder angle; DCF Group: deep cervical flexor exercise group; GSE group: general strengthening exercise group

Both exercises were effective to improve neck-shoulder angles. However, a statistically significant difference was observed between the groups when the parameters were compared 8 weeks after exercise (Table 2). The HTAs at 4 and 8 weeks after exercise were significantly reduced from the baseline values ($p < 0.05$). On the other hand, in the GSE group, the HTA at 4 weeks after exercise was statistically significantly reduced from the baseline value but the decrease at 8 weeks after exercise was not statistically significant. No significant difference in HTA angle was found between the DFG and GSE groups at baseline and at 4 weeks after exercise. However, a significant difference in HTA was found between the groups 8 weeks after exercise ($p < 0.05$).

The NFA at baseline were statistically significantly decreased at 4 and 8 weeks after exercise ($p < 0.05$). In the GSE group, the NFA at 4 weeks after exercise was significantly lowered from its baseline value. However, no significant reduction was found between 4 and 8 weeks after exercise. Finally, similar to other parameters, NFA did not significantly differ between the groups at baseline and 4 weeks after exercise. However, a significant difference in NFA was found when the two groups were compared 8 weeks after exercise ($p < 0.05$).

In the DCF exercise group, the baseline FSA statistically significantly differed from those measured at the other two time points ($p < 0.05$). In the GSE group, the FSA was reduced after 4 weeks of exercise, but no significant difference was observed between the values at 4 and 8 weeks after exercise. No significant difference in FSA was observed between the groups at baseline and 4 weeks after exercise. However, a significant difference in FSA was found when the two groups were compared 8 weeks after exercise ($p < 0.05$).

DISCUSSION

In the present study, the patients with chronic neck pain underwent either DCF activation exercise or GSE for 4 weeks; and then, relevant parameters were assessed before, 4 weeks after, and 8 weeks after exercise in order to monitor the effects of these exercises on neck pain, functional status, and neck-shoulder postures via prospective comparisons. The results indicated that in both exercise groups, neck pain, NDI, and changes in neck-shoulder postures were considerably improved after 4 weeks of exercise. Furthermore, in the DCF group, these parameters were more significantly affected by the DCF exercise than the GSE after 8 weeks of follow-up.

Recent reports regarding neck pain demonstrated that the strengthening exercise for DCF muscles successfully improved neck and shoulder postures, and reduced symptoms in long-term follow-up[5, 8]. In a study of 40 patients with chronic neck pain, Jull et al.[11] reported that DCF exercise had more favorable effects on pain and functional improvements than simple neck bending exercise. Similarly, Lee et al.[15] reported that DCF exercise alleviated pain, and improved neck and shoulder postures in female high-school students. Moreover, Dusunceli et al.[16] implemented physical therapy, extension exercise, and DCF exercise for patients with neck pain. In the 12-month long-term follow-up, the authors found improvement in pain and functional disability in patients who performed DCF exercise.

In the present study, HTA was significantly reduced after 4 weeks of exercise in both the GSE and DCF groups. To note, after 8 weeks of follow-up, the effect of DCF exercise on HTA was more significant than that of GSE. Although these results are somewhat different from the results of the study of Szeto et al.[7], which assessed postures using a video camera at a distance of 1.5 m. However, the trend in the reduction was similar between the studies. Furthermore, albeit both exercises improved NFA and FSA after 4 weeks of exercise, the effects of DCF exercise were more pronounced than those of GSE at the final follow-up. These results are in agreement with those of other previous studies that assessed angles of head/neck positions in response to chronic neck pain by using a goniometer[17]. A few similar domestic studies are worth mentioning. Choi and Hwang[18] analyzed head-spine and head rotation angles by using radiography for groups of patients who underwent either posture correction alone or posture correction in conjunction with the exercise program. The authors reported that the group of patients who underwent both posture correction and an exercise program significantly reduced neck angles. They found noticeable improvement in the forward head postures of the students. Results herein and in the previous studies might be because the sling exercise program stimulated deep cervical muscles, thereby inducing activation and positively influencing neck-shoulder postures.

In the present study, NDI and NRS, which represent functional status, were improved by both exercises after 4 weeks of follow-up. By contrast, after 8 weeks of exercise, a more significant improvement was observed in the DCF group than in the GSE group. Jull et al.[11] compared the effects of the DCF exercise and those of strengthen exercise for neck muscular strength on NDI and neck pain. In their study, no significant difference was observed in pain alleviation, yet a noticeable difference in NDI was found. Chiu et al.[8] implemented DCF exercise for patients with neck pain for 6 weeks and found a significant reduction in NDI. The above-mentioned results are in good agreement with the results of the present study, showing that DCF exercise improved NDI after 8 weeks of follow-up. In addition, a number of previous studies have demonstrated that DCF exercise relieved neck pain and improved functionality in subjects with diverse occupations[19].

DCF exercise, applied in the present study, has been reported to be an exercise/examination method that is characterized by low loading and induces proper postures and activation of deep, instead of superficial, muscles[20]. This method bends the head instead of the neck so that the deep longus colli and longus colli muscles are activated as opposed to activation of the superficial muscles, including the sternocleidomastoid and anterior scalene muscles. Hence, normal neck postures and arrangement are recovered[9]. In clinical practice, patients with neck pain are common; however, relaxation or strengthening of superficial muscles only has achieved short-term effects and limited to maintaining effective posture correction and mitigation of symptoms[8].

As society ages, the current interests in health and well-being have never been higher. In parallel with this, the number of patients with neck pain, a typical musculoskeletal disorder, has been continuously increasing. Hence, developing effective rehabilitation exercises are critical to cope with this problem. Therefore, the present study confirmed that DCF exercise for patients with chronic neck pain was more effective than GSE in terms of recovering normal posture and arrangement, and reducing pain and NDI via decreases in neck and shoulder angles. Thus, it might be clinically significant as a rehabilitation exercise therapy for patients with neck pain in relation to their postures. However, this study has several limitations. First, owing to the limited sample size, generalization of the results for the entire patient population with neck pain is difficult. Furthermore, the follow-up periods were relatively short. In the future, a long-term follow-up study with a larger number of patients who are under well-controlled conditions might be warranted.

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