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Deep cervical flexor training with a pressure biofeedback unit is an effective method for maintaining neck mobility and muscular endurance in college students with forward head posture

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Abstract. [Purpose] This study investigated the effects of deep cervical flexor training on maintaining forward head posture, muscular endurance, and cervical mobility. It also examined the effectiveness of deep cervical flexor training with a pressure biofeedback unit. [Subjects and Methods] Twenty college students were recruited and randomly assigned to groups that underwent either deep cervical flexor training with a pressure biofeedback unit (experimental group, n=10) or conventional deep cervical flexor training (control group, n=10). The craniovertebral angle of each subject was measured with a lateral-view picture. Neck mobility was assessed using a cervical range of motion device and muscular endurance was measured using a pressure biofeedback unit. Both groups performed conventional deep cervical flexor exercises three times a week for six weeks. The experimental group underwent a pressure biofeedback unit training was 5 to10 minutes/day, thrice a week. [Results] Cervical range of motion in the experimental group increased significantly between the end of training and the end of the four week detraining period, compared to that in control group. [Conclusion] Deep cervical flexor training with a pressure biofeedback unit is a useful method for maintaining neck mobility and muscular endurance in people with forward head posture.
Key words: Forward head posture, Deep cervical flexor, Pressure biofeedback unit

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INTRODUCTION

Forward head posture (FHP) occurs when the head is anterior to a vertical line through the individual's center of gravity[1)]. FHP can include both an upper cervical extension and a lower cervical flexion[2)], and it can induce lengthening and weakness of the anterior cervical muscles and shortening of the posterior region[1)]. If this abnormal change in the muscles and joints of the cervical region is prolonged, it may cause to restrict cervical mobility and decreased muscular performance. Early research on FHP suggested that deep cervical flexor (DCF) play a major role in supporting and straightening the cervical spine[3)]. This research also suggested that the proper use of DCF, before beginning the strengthening of the global cervical muscles, is an effective rehabilitation strategy for cervical disorders[2)]. Previous studies have shown that four weeks of DCF training improved the FHP in dentists with chronic neck pain[3)]. These studies suggest that people with FHP should complete DCF training, because it would help them maintain a proper cervical posture. However, there is still insufficient evidence in support of the use of DCF training for correcting FHP. This may be because many of the previous studies on DCF training were focused mainly on alleviating headaches and neck pain[2–7)].

It has been suggested that using a pressure biofeedback unit (PBU) is a more effective method for DCF strengthening than conventional exercises[4, 5, 8)]. However, until now, there has been little information regarding the ability of subjects to maintain the benefits of DCF training. There are in sufficient data regarding the longevity of these benefits after the completion of training. If physiotherapists are aware of this longevity, they will be able to plan more effective rehabilitation programs. Therefore, it is important to confirm whether there are factors that increase or decrease the angle of FHP, muscular performance, and cervical mobility following DCF training. Therefore, the purposes of this study were to investigate the effects of DCF training on maintenance of FHP, muscular endurance, and cervical mobility. This study also aimed to find an effective method of DCF training with a PBU.

SUBJECTS AND METHODS

The subjects of this study were twenty college students (Table 1). After selection, they were randomly divided into one of two groups: DCF exercise with a PBU (experimental

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Table 1. General characteristics of the subjects

	Age (yrs)	Height (cm)	Weight (kg)	NDI (score)
Experimental group (Males, 5 ; Females, 5)	23.9±3.3	166.9±12.9	61.8±15.5	7.3±3.6
Control group (Males, 6 ; Females, 4)	23.1±3.1	169.0±9.3	60.8±8.0	12.4±8.2

Mean ± SD
NDI: neck disability index

Table 2. Exercise program for improvements of the deep cervical flexors

	Items	Intensity & Repetitions
Warm up (10 min)	Stretching (the neck, shoulder and scapular muscles)	
Conventional DCF exercise	Supine position & Sidelying position • Neck curl with chin tucked • Neck lateral bending with chin tucked (right & left) Sitting position • Chin tuck • Head pushing against the palm with chin tucked (all directions) • Neck bending on the diagonal with chin tucked (right & left)	RPE 11–13
PBU exercise		20–30 mmHg

• Experimental group: stretching (10 min) + Conventional DCF exercise (15–20 min, 10–16 reps × 1–2 sets) + PBU exercise (5–10 min, 10–16 reps × 1–2 sets)
• Control group: stretching (10 min) + conventional DCF exercise (20–30 min, 10–16 reps × 1–4 sets)
DCF: deep cervical flexors, PBU: pressure biofeedback unit

group) and conventional DCF exercise (control group).

The exclusion criteria included: 1) a craniovertebral angle of > 53° when sitting, 2) a history of cervical trauma or surgery, 3) non-severe neck symptoms (neck disability index score > 15/50), and 4) non chronic neck pain or headaches occurring during the last six months (intensity, visual analogue scale < 3/10, frequency < 2 days/week, duration < 3 hours/day)[4, 9, 10].

All the subjects understood the purpose of the study and provided their written informed consent prior to participation. All measurements and assessments were repeated three times: before training, after six weeks of training, and following four weeks of detraining. This study complied with the ethical standards of the Declaration of Helsinki.

A lateral-view picture was taken of the craniovertebral angles of each subject. This angle was located between a horizontal line passing through C7 and a line extending from the tragus of the ear to C7[11, 12].

Neck mobility was assessed using a cervical range of motion (ROM) device (Myrin™ OB Goniometer, Kineman Enterprises, Norway), as in previous studies[10]. All movements (flexion, extension, lateral flexion and rotation) were performed and measured while the subject was seated on a static chair.

Muscular endurance measurement followed an established protocol using a PBU (Stabilizer™, Chattanooga Group Inc., USA)[13, 14]. Endurance of DCF was defined as the maximum time that subjects could maintain a base pushing pressure greater than 50 mmHg. The 50 mmHg threshold was established through pilot tests. Without dominantly using the superficial neck flexors, the subjects lifted their heads and time was measured until the each subject's chin was lifted in a supine position. The subjects bent their hip and knee joints to avoid lumbar lordosis. Contractions of the superficial neck flexors were carefully avoided by the subjects. These contractions were monitored by the examiner using palpation.

All exercise protocols and programs were taken from previously published studies[2, 4–7]. A conventional DCF exercise protocol was performed three times a week for six weeks in both groups. The duration of the conventional DCF exercise protocol was 20–30 minutes, once a day in the control group, and 15–20 minutes, once a day in the experimental group. The intensity of, conventional DCF exercise was conducted with rating of perceived exertion of 11–13 (RPE, Borg's 6–20 Scale). The craniocervical flexion exercise using a PBU was conducted for 5–10 minutes once a day, three times a week (Stabilizer™, Chattanooga Group Inc., USA) in the experimental group. This exercise was performed sequentially in order to reach 5 target pressures in 2 mmHg increments, from a starting baseline of 20 mmHg to a final level of 30 mmHg[4].

The subjects were advised to avoid regular exercise, except for activities of daily life, during the detraining period.

The exercise program was performed under the supervision of the researcher (Table 2).

The data were analyzed using SPSS software (Version 18.0). One-way ANOVA was performed to compare the three stages of the study within each group. The least significant difference (LSD) was used for post-hoc analyss.

The change values were calculated for the pre-training, post-training, and four-week follow-up after detraining stages of the study. These values were used, to compare two groups using independent-sample t-tests. Statistical signifi-

Table 3. Comparisons of the differences in the range of motion and endurance times within each group

	Pre (a)	Post (b)	After 4 weeks (c)	Post-hoc
Cervical flexion (°)				
Experimental	50.8±10.8	60.4±7.2*	60.7±5.9*	a < b, c
Control	52.8±13.2	62.3±10.2	56.5±12.7	
Cervical extension (°)				
Experimental	62.5±4.5	74.1±9.8*	75.2±10.9*	a < b, c
Control	59.5±11.0	72.0±9.7*	66.9±8.78	a < b
Left cervical rotation (°)				
Experimental	60.5±10.3	74.4±8.5*	74.9±8.7*	a < b, c
Control	61.8±8.9	77.2±9.5*	69.5±11.4	a < b
Right cervical rotation (°)				
Experimental	60.8±8.3	72.1±8.1*	72.3±8.8*	a < b, c
Control	65.3±6.2	74.3±5.6*	69.2±6.9	a < b
Craniovertebral angle (°)				
Experimental	48.9±7.2	53.5±6.3	54.6±5.3	
Control	47.0±7.1	50.7±5.2	51.2±5.4	
Muscular endurance of deep cervical flexors (sec)				
Experimental	16.9±3.8	29.6±6.0*	34.7±14.3*	a < b, c
Control	20.7±10.9	25.1±12.6	25.7±13.6	

Mean ± SD
*p < 0.05

Table 4. Comparisons in the range of motion and endurance times between two groups

	Pre-post (%)	Post-after 4 weeks (%)
Cervical flexion (°)		
Experimental	22.2±22.4	0.8±6.3**
Control	22.5±24.9	−9.8±10.4
Cervical extension (°)		
Experimental	19.3±19.1	1.3±5.8**
Control	22.7±15.1	−7.0±3.7
Left cervical rotation (°)		
Experimental	25.5±24.9	1.0±9.1*
Control	27.1±24.9	−9.8±9.7
Right cervical rotation (°)		
Experimental	20.1±18.8	0.5±7.5*
Control	14.4±17.4	−6.8±5.3
Cervical craniovertebral angle (°)		
Experimental	11.3±19.6	2.4±5.7
Control	9.6±16.7	1.0±5.5
Muscular endurance of deep cervical flexors (sec)		
Experimental	79.9±37.1***	18.4±47.9
Control	23.9±16.3	6.1±29.7

Mean± SD
*p < 0.05, **p < 0.01, ***p < 0.001

cance was set at $p < 0.05$.

RESULTS

The differences in craniovertebral angle, cervical ROM, and muscular endurance between the three different stages of the study were compared within each group.

The experimental group showed significant improvements in cervical ROM, and muscular endurance but not in craniovertebral angle at post-training and after the four-week detraining period, compared to pre-training ($p < 0.05$). In the control group, there were significant differences in cervical extension and both cervical rotations in post-training compared to pre-training ($p < 0.05$) (Table 3).

The changes in the three factors that occurred between pre-training and post-training, and between post-training and after the four-week detraining period, were compared between the two groups.

The experimental group showed a significantly greater increase in cervical ROM between post-training and the four-week detraining period, compared to the control group ($p < 0.05$, $p < 0.01$). Muscular endurance of DCF, showed a significantly greater increase between pre-training and post-training in the experimental group, compared to control group ($p < 0.001$) (Table 4).

DISCUSSION

FHP generally results in shortening of cervical extensors such as the splenii, upper trapezius and SCM muscle, and in lengthening and weakening of the cervical flexors[11]. An earlier research has suggested that when performance is impaired, the balance between the stabilizers on the posterior region of the neck and the DCF is damaged, resulting in a loss of proper alignment and posture. This loss of alignment, can then induce cervical impairment[2]. Therefore, using DCF training as a rehabilitation program for FHP is based on the rationale that DCF plays a major role in the stabilization of the head and on neck posture[3].

This study was designed to investigate whether the angular degrees of FHP, muscular endurance, and cervical mobility are affected by DCF training. It also aimed to find the effectiveness of DCF training with a PBU in comparison to conventional DCF training. The results of our study confirmed that six weeks of DCF training with a PBU improves the cervical mobility and muscular endurance of DCF in subjects with FHP even after four weeks of detraining. Moreover, DCF training with a PBU was more effective than DCF training without a PBU. As mentioned previously, until now, there has been little research regarding the ability of people with FHP to maintain the benefits of DCF training and there are insufficient data to suggest how much these benefits decrease over time. The lack of research in this area limited the possibility for direct comparison with other studies. Therefore, only a partial discussion of the comparisons of our work with other studies was possible.

The results of this study suggest that DCF training with a PBU improves muscular endurance by facilitating DCF contraction, and that stretching exercises induce increases mobility of shortened muscles in subjects with FHP. Consequently, the beneficial effects of this training lasted for up to four weeks following a six-week training program.

Muscular performance can also be increased with the use of PBU training. Craniocervical flexion is the basic action of DCF[2, 3] and craniocervical flexion exercises using a PBU aim to train the longus capitus and colli[5]. The results of our study are similar to earlier studies, which examined the direct application of massage to the longus colli and the results of this on increases of cervical ROM[14, 15]. In these studies, stretching seemed to improve cervical mobility. Stretching, was conducted with a conventional DCF exercise and consisted of stretches in the neck muscles, shoulders and scapular region. PBU training and stretching are beneficial because stretching the shortened muscles and strengthening the weak muscles are required to achieve these optimal length and strength of those muscles thereby improving muscular performance[6]. In this sense, the results of this study seems logical, as it is generally true that PBU training facilitates effective contraction of the longus colli and flattening of the cervical curve[5].

The results of this study have some potential limitations. As the endurance of the DCF increase, the degree of cervical lodorsis decreases. Therefore, cervical posture is related more closely to muscular endurance than to muscular strength of the DCF[13]. Unfortunately, no significant changes in craniovertebral angle were shown in this study following DCF training, even though the muscular endurance of the DCF increased significantly. This may have been influenced by musculoskeletal problems in the study's subjects. Additionally, the duration of the follow-up period was too short. Future studies should be designed to address these factors.

In conclusion, six weeks of DCF training with a PBU is a useful method for maintaining neck mobility and muscular endurance in people with FHP.

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