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Cervical Spondylosis: Deep Cervical Flexor Training

Effect of deep cervical flexors training on neck proprioception, pain, muscle strength and dizziness in patients with cervical spondylosis: A randomized controlled trial

Abstract

Background: Patients with cervical spondylosis are commonly suffering from neck pain and dizziness due to disturbance in cervical propriocetion. So, inhibiting the causes and improving proprioception might be a key for a positive treatment effect .

Purpose: This study aimed to evaluate the effect of deep cervical flexors (DCFs) training on neck proprioception, pain, muscle strength and dizziness in patients with cervical spondylosis.

Methods: Forty patients with cervical spondylosis suffering from neck pain and dizziness were chosen from Out-Patient Clinic, Faculty of Physical Therapy, Cairo University to participate in this study. They were randomly divided into two equal groups. The study group (A): received DCFs training plus traditional physical therapy (hot backs, TENS and cervical proprioceptive training). The control group (B): received traditional physical therapy only. Outcome measures included head repositioning accuracy (HRA), severity of pain, DCFs strength, severity of dizziness and dizziness handicap inventory (DHI). Measures were assessed for all patients in both groups before and after 6 weeks of treatment program (3 sessions/week).

Results: There was a significant improvement for all of the measured variables after treatment in each group, and there was a significant difference between the two groups in favor of the study group (A) for all of the measured variables including HRA for right rotation (p=0.001), HRA for left rotation (p=0.001), severity of pain (p=0.003), DCFs strength (p=0.001), severity of dizziness (p=0.01) and DHI (p=0.001).

Conclusions: The study findings indicate that DCFs training was more effective than traditional physical therapy for improving neck proprioception, pain, muscle strength and dizziness in patients with cervical spondylosis. Hence, it is recommended in the rehabilitation of patients with cervical spondylosis.

Keywords: Deep cervical flexors training, Neck Proprioception, Neck pain, Deep cervical flexors strength, Dizziness, Cervical spondylosis

Introduction

Cervical spondylosis is a common degenerative condition of the cervical spine in the general population, which occurs mostly in the fourth and fifth decades of life [1]. It is considered one of the most common causes of neck pain leading to decreased quality of life and socioeconomic damages such as medical expenses [2] and a major cause of poor balance and dizziness associated with spinal degeneration [3].

It has been reported that, patients with cervical spondylosis have demonstrated altered proprioception [4]. These impairment in cervical proprioceptive inputs have been attributed to neck pain and altered input from cervical afferents particularly muscle spindle. Muscle spindle are accepted as being the primary cervical receptors responsible for position sense and are coupled to supplementary afferent input from the cutaneous and joint receptors [4-6]. So, improvement of muscle spindle function is translated to improved cervical proprioception.

With regard to cervical muscles, the high density concentrations of muscle spindles have been identified in the suboccipital muscles and the deeper cervical muscles [4]. It has been theorized that when cervical muscle performance is impaired, the balance between the stabilizers on the posterior aspect of the neck and the Deep Cervical Flexors (DCFs) will be disrupted, resulting in loss of proper alignment and posture, which is then likely to contribute to cervical impairment and neck pain [7]. So, for controlling neck posture and relieving pain which in turn leads to improvement of prorioception and dizziness, typically specific proprioceptive training regimes are designed to target the deep suboccipital muscles, such programs include gaze stability exercises, eye–head coordination and/or practice of relocation of the head on the trunk [8,9].

Also, DCFs training which aims to enhance activation of the DCFs and restore coordination between the deep and superficial cervical flexors, is one form of exercise that has been advocated for addressing impaired neuromuscular control of the cervical flexors [10]. Clinical trials examining the effectiveness of this exercise regime have demonstrated positive outcomes in terms of decrease in neck pain and disability, improvement in sitting posture, enhanced neuromuscular

control of the cervical flexors in patients with chronic neck pain [10-14], and also improved proprioceptive acuity of the neck, indicating that proprioception can be enhanced with specific exercise [11].

On the light of the previous research studies, sensorimotor proprioceptive disturbances in the cervical spine might be an important factor in the maintenance, recurrence, or progression of various symptoms in patients with neck pain. Thus, addressing these deficits are likely to be an important step towards better management of patients with cervical spondylosis. So, the current randomized controlled study which is first of its kind was conducting to investigate the effect of DCFs training on neck proprioception, pain, muscle strength and dizziness in patients with cervical spondylosis.

Materials and methods

This randomized experimental trial was conducted at the Out-Patient Clinic of Faculty of Physical Therapy, Cairo University from January to April 2018. The study protocol was explained in details for each patient before the initial assessment and enrollment in the study and all patients signed an institutionally approved informed consent form which was approved by the Ethics Committee of the Faculty of Physical Therapy, Cairo University (P.T.REC/012/001900).

Participants

A total of 54 patients with cervical spondylosis based on careful clinical assessment and radiological investigations by X rays were initially screened, and after the screening process 40 patients were eligible to participate in this study as shown in **Figure 1**. Patients were eligible to participate in this study

Figure 1. Flow chart of study participants.
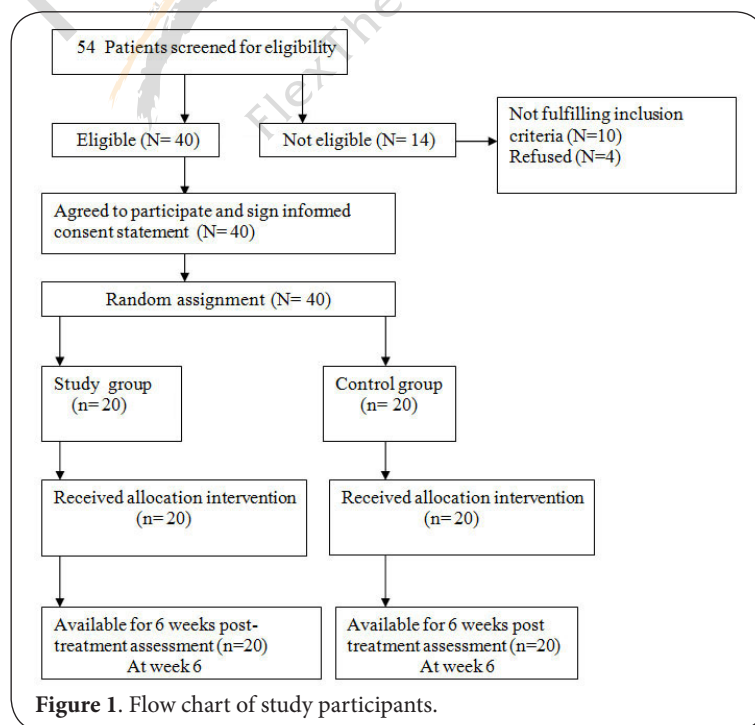
if they had age ranging from 45 to 55 years, concurrent neck pain and dizziness for more than six months, dizziness related to either position or movement of the neck, dizziness described as imbalance or unsteadiness (not rotatory vertigo) and moderate disability score on the Dizziness Handicap Inventory (DHI) (31-60 points) [15]. While patients were excluded if they had cervical myelopathy or radiculopathy, tumor or infection involving cervical spine, history of cervical injury or trauma, poor hearing or vision, congenital anomalies involving the cervical spine, any neurologic disease (e.g, cerebellar disorders, multiple sclerosis, Parkinson's disease, syringomyelia), benign positional vertigo, Meniere's diseases, acute peripheral vestibulopathy, chronic sinusitis or pain and dizziness due to whiplash injury.

Patients were randomly assigned to the study group A (n=20) or the control group B (n=20) by an independent person who picked one of the sealed envelopes, which contained numbers chosen by random number generator. Randomization was restricted to permuted blocks of different size to ensure that equal numbers were allocated to each group. Each random permuted block was of consecutively numbered, sealed, opaque envelopes and these were stored in a locked drawer until required. As each participant formally entered the trial, the researcher opened the next envelope in the sequence in the presence of the patient.

Patients in both groups received the same traditional physical therapy treatment including hot backs, Trancutaneous Electrical Nerve Stimulation (TENS) and cervical proprioceptive training, 3 days per week for six weeks. The study group additionally received DCFs training using Pressure Biofeedback Unit (PBU).

Examination
All of the following assessments were done to all patients in both groups (A) and (B) before and after 6 weeks of treatment program by outcome assessor who was not masked during the study.

Measurement of cervical proprioception
Cervicocephalic kinesthetic sensibility was assessed by measuring the Head Repositioning Accuracy (HRA) using the Cervical Range of Motion (CROM) device. The CROM device is a type of goniometer designed specifically for the cervical spine and was used to measure cervical ROM [16]. It consists of a plastic frame that is mounted over the subject's nose bridge and ears and secured to the head by a felcro strap. Three independent inclinometers attached to the frame and arranged orthogonally to one another indicate the subject's cervical ROM. The CROM device has good criterion validity (r = 0.89 – 0.99) and reliability (ICC= 0.92 - 0.96) [17]. For testing, the subjects were asked to sit upright in a comfortable position, their feet flat on the ground and their head in a neutral position. The participants (blindfolded) started with their head in the Neutral Head Position (NHP) and were asked to actively move to the midpoint of their maximum rotation range, which

was called the "target position". After 5 sec, the patients return their head to NHP, then they were asked to rotate their head to the target position. The difference between the target position and the achieved position was recorded 3 times for both right and left rotation and the average taken for each direction of rotation movement according to Reid et al. [18].

Measurement of pain intensity
Severity of cervical pain was measured using Visual Analogue Scale (VAS). The VAS is a horizontal continuous scale,10 cm in length, ended with two verbal pain descriptors on either end one is "no pain" (score of 0) and "pain as bad as it could be" or "worst imaginable pain"(score of 10) on other end [19]. The patients were asked to point the suitable score on the line that represent their pain intensity. Visual analogue scale is reliable and valid to measure pain intensity in neck pain [20].

Measurement of deep cervical flexors strength
Strength of DCFs were measured using PBU during the Cranio-Cervical Flexion Test (CCFT). The PBU provides the feedback and direction to the patient to perform the required five stages of the test. The CCFT is performed with the patient in crock lying with the cervical spine was kept in a neutral position as described by Chiu et al. [21]. The PBU was inflated to a baseline of 20 mmHg after placing it between the plinth and the posterior aspect of the neck just below the occiput. Subjects were given practice sessions to learn the CCFT with the PBU, and they were instructed to relax the neck musculature and to concentrate on permitting a gentle and slowly head nodding movement, and to avoid head lift for reducing the recruitment of superficial flexors. During the practice phase of the CCFT, the examiner observed and corrected any substitutions to ensure performance of a correct test and any recruitment of superficial neck flexor muscles is discouraged by the examiner by verbal feedback. Each patient had to perform the neck Cranio-Cervical Flexion (CCF) movement at 5 different pressure levels (22, 24, 26, 28 and 30 mmHg) with 10 sec hold at each level and 30 sec rest between each level. The testing procedure was terminated if subject could not hold 10 sec at specific pressure level or if the maximum level of 30 mmHg was achieved. The maximum pressure level achieved (activation score) with 10 sec hold was recorded for analysis purpose.

Measurement of dizziness intensity
The severity of dizziness (an average level over the previous week) was measured with a 100 mm horizontal VAS, which has been used successfully to measure dizziness in a previous study [22].

Measurement of disabilities caused by dizziness
Disability caused by dizziness was measured with DHI. This is a health status measure questionnaire composed of 25 questions specifically designed to assess the quality of life

using three subscales evaluating the impact of dizziness on the functional (nine), emotional (nine) and physical aspects (seven) of everyday life. For each question, patients respond "yes," "sometimes," or "no," corresponding to four, two, or zero points, respectively. The highest possible score is 100, indicating maximum self-perceived handicap [23]. The DHI has been shown to be a highly reliable and responsive tool [23-25].

Treatment

The patients in both groups received the same traditional physical therapy treatment including hot packs, TENS and cervical proprioceptive training 3 times a week for six weeks. The patient was instructed to lie prone and hot packs were applied on the neck for 15 minutes. Then, TENS was administered at a frequency of 80 Hz with 10-30 mA intensity for 20 minutes. Four surface electrodes, 5x5 cm each, were placed over the painful area in the neck region [26]. TENS was delivered using Intelect Advanced (REF2773MS; Chattanooga: Mexico).

Cervical proprioceptive training

Patients trained cervical proprioception following the protocol described by Revel et al. [8]. Exercises included oculomotor exercises and eye-head coordination exercises. Oculomotor exercises were progressed through several stages. First, eye movement following a target located at a comfortable distance was practiced with the head stationary, progressing to movements of the head with visual fixation on a target (gaze stability). Eye-head coordination exercises started with rotation of the eyes and head to the same side, in both left and right directions. Subsequently, the patient practiced following a target with the eyes first, followed by the head, ensuring that they maintained focus on the target. As a further progression, the eyes moved first, and then the head, to look between 2 targets positioned horizontally or vertically, and finally, the eyes and head rotated in opposite directions, both left and right. All these exercises were further progressed by increasing the speed and range of movements and/or alteration of the visual target.

The study group received the same program of the control group in addition to DCFs training 3 times a week for six weeks.

Deep cervical flexors training

Low load training of the CCFs followed the protocol described by Jull et al. [27]. This exercise specifically targets the DCFs (longus capitis and longus colli), while aiming to minimize the activation of the superficial cervical flexors (sternocleidomastoid and anterior scalene). Initially, from a supine lying position the patients were taught to perform the CCF movement slowly and in a controlled manner, with the head and neck in a neutral position. Once the correct CCF motion was achieved, patients began to hold progressively increasing ranges of CCF using PBU (Stabilizer TM Chattanooga Group Inc., Tennessee, USA), which placed behind the neck just next to the occiput and was inflated up to a baseline pressure of

20 mmHg. The patients performed CCF to sequentially reach 5 pressure targets in 2 mmHg increments from a baseline of 20 mmHg to the final level of 30 mmHg. For each target level, the patients were instructed to maintain the contraction for 10 sec for 10 repetitions with brief rest periods between each contraction (~3–5 sec). Once a set of 10 repetitions of 10 sec was achieved at one target level, the exercise was progressed to train at the next target level up to the final target level at 30 mmHg.

Data analysis

Descriptive analysis, including mean and standard deviation, were performed for all variables. t-test were conducted for comparison of subject characteristics between both groups. Chi-squared test was used for comparison of sex distribution between groups. Normal distribution of data was checked using the Shapiro-Wilk test for all variables. Unpaired t-test was conducted to compare the mean values of HRA, pain intensity, DCFs strength, severity of dizziness and DHI between the study and control groups. Paired t test was conducted for comparison before and after treatment in each group. The level of significance for all statistical tests was set at p<0.05. Statistical analysis was conducted through the statistical package for social studies (SPSS) version 19 for windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics

As shown in Table 1, there was no significant difference between both groups in the mean age, weight, height and body mass index (p<0.05). Also, There was no significant difference between both groups in the duration of dizziness (p=0.59), and sex distribution (p=0.51).

Comparison of pre and post treatment for both study and control groups

As shown in Tables 2 and 3, there were significant differences between pre and post treatment in all measured variables in both study and control groups. As, right and left HRA, pain intensity, severity of dizziness and DHI showed significant decrease post treatment compared with pre treatment (p=0.001). Also, there was a significant increase in the DCFs strength post treatment compared with pre treatment (p=0.001).

Comparison of pre and post treatment between study and control groups

As shown in Table 4, there was no significant difference between the study and control groups in all measured variables pre-treatment (p>0.05). While, Post treatment there was a significant decrease in right and left HRA, pain intensity, severity of dizziness and DHI of the study group compared with that of control group (p>0.01). Also, there was a significant increase in the DCFs strength of the study group compared with that of control group (p=0.001).

Table 1. Comparison of the mean age, weight, height, BMI, duration of dizziness and sex distribution between study and control groups.

	Study group (n=20)	Control group (n=20)	t- value[#]	p- value	Significance
Age (yrs.)	47.9± 2.77	48.65± 2.73	-0.86	0.39	NS
Weight (kg)	73.85± 8.96	76.1± 9.07	-0.78	0.43	NS
Height (cm)	164.1± 6.52	167.45± 7.1	-1.55	0.12	NS
BMI (kg/m²)	27.46± 3.25	27.11± 2.42	0.37	0.7	NS
Duration of dizziness (weeks)	17.55± 4.68	16.75± 4.75	0.53	0.59	NS
Males/Females	7/13	9/11	(χ^2= 0.41)	0.51	NS

Data are expressed as mean ± SD; #=unpaired t-test; χ2, Chi squared value; NS=p>0.05=non-significant; BMI: Body Mass Index

Table 2. Comparison between mean values of each measured variable before and after treatment for the study group.

	Before treatment	After treatment	Mean difference	% change	t-value[#]	p-value	Significance
Right HRA	9.53 ± 0.98	3.95 ± 0.7	5.58	↓58.55	26.37	0.001	S
Left HRA	8.96 ± 1.11	3.59 ± 0.89	5.37	↓59.93	16.55	0.001	S
VAS Pain (cm)	6.15 ± 1.13	2.15 ± 1.08	4	↓65.04	15.91	0.001	S
DCFs strength (mmHg)	25.2 ± 1.64	29.15 ± 2.27	-3.95	↑15.67	-7.66	0.001	S
VAS Dizziness (mm)	61 ± 10.78	42.35 ± 8.44	18.65	↓30.57	17.36	0.001	S
DHI	41.15 ± 7.09	19.3 ± 6.79	21.85	↓53.09	19.07	0.001	S

Data are expressed as mean ± SD; #=paired t-test; S=p>0.05= significant; HRA: Head Repositioning Accuracy; VAS: Visual Analogue Scale; DCFs: Deep Cervical Flexors; DHI: Dizziness Handicap Inventory

Table 3. Comparison between mean values of each measured variable before and after treatment for the control group.

	Before treatment	After treatment	Mean difference	% change	t-value[#]	p-value	Significance
Right HRA	9.1± 1.25	6.75± 0.81	2.35	↓25.82	7.71	0.001	S
Left HRA	9.21± 0.58	7.65± 0.8	1.56	↓16.93	7.91	0.001	S
VAS Pain (cm)	6± 1.25	3.35± 1.3	2.65	↓44.16	8.78	0.001	S
DCFs strength (mmHg)	25 ± 1.89	26.6± 2.06	-1.6	↑6.4	-6.83	0.001	S
VAS Dizziness (mm)	61.05± 11.29	48.8± 7.88	12.25	↓20.06	7.03	0.001	S
DHI	41.3± 9.25	33.55± 6.71	7.75	↓18.76	4.96	0.001	S

Data are expressed as mean ± SD; #=paired t-test; S=p>0.05= significant; HRA: Head Repositioning Accuracy; VAS: Visual Analogue Scale; DCFs: Deep Cervical Flexors; DHI: Dizziness Handicap Inventory

Discussion

Disturbance of afferent input from proprioceptors of the neck in patients with cervical spondylosis, leads to a sensory mis-match between cervical, visual and vestibular inputs to the sensorimotor control system and has been associated with objective deficits in proprioception [4,28]. Because improving

Table 4. Comparison between study and control groups on each measured variable before and after treatment.

	Study group (n=20)	Control group (n=20)	t- value [#]	p- value	Significance
Before treatment					
Right HRA	9.53 ± 0.98	9.1 ± 1.25	1.21	0.23	NS
Left HRA	8.96 ± 1.11	9.21 ± 0.58	-0.88	0.38	NS
VAS Pain (cm)	6.15 ± 1.13	6 ± 1.25	0.39	0.69	NS
DCFs strength (mmHg)	25.2 ± 1.64	25 ± 1.89	0.35	0.72	NS
VAS Dizziness (mm)	61 ± 10.78	61.05 ± 11.29	-0.01	0.98	NS
DHI	41.15 ± 7.09	41.3 ± 9.25	-0.05	0.95	NS
After treatment					
Right HRA	3.95 ± 0.7	6.75± 0.81	-11.6	0.001	S
Left HRA	3.59 ± 0.89	7.65± 0.8	-15.08	0.001	S
VAS Pain (cm)	2.15 ± 1.08	3.35± 1.3	-3.15	0.003	S
DCFs strength (mmHg)	29.15 ± 2.27	26.6± 2.06	3.71	0.001	S
VAS Dizziness (mm)	42.35 ± 8.44	48.8± 7.88	-2.49	0.01	S
DHI	19.3 ± 6.79	33.55± 6.71	-6.66	0.001	S

Data are expressed as mean ± SD; #=unpaired t-test; NS=p>0.05=non-significant; S=p>0.05= significant; HRA: Head Repositioning Accuracy; DCFs: Deep Cervical Flexors; VAS: Visual Analogue Scale; DHI: Dizziness Handicap Inventory

proprioception might be a key for a positive treatment effect [28], and high density concentrations of muscle spindles have been identified in the suboccipital muscles and the deep cervical muscles [6], so the purpose of this study was to evaluate the effect of DCFs training on neck proprioception, pain, muscle strength and dizziness in patients with cervical spondylosis.

The results of the current study showed that, DCFs training group had a significant improvement in proprioception than the group received traditional physical therapy. These findings are in agreement with the findings of Jull et al. [11] who mentioned that DCFs training is effective approach for improving proprioception in patients with chronic neck pain. These findings might be explained by several mechanisms. First, The DCFs training directly activates the DCFs [29], and this justification is supported by the findings of O'Leary et al. [30] and Rezasoltani et al. [31] who found that, retraining the DCFs increase the activation of the DCFs during performance of the clinical test of CCF. These DCFs have a relatively high density of muscle spindles, which generally accepted as being the primary cervical receptors responsible for position sense [4,6]. Thus, the repeated contractions of DCFs during DCFs training may improve muscle spindle function which translating to improved cervical proprioception.

It has been suggested that abnormal joint stress in patients with cervical spondylosis may alter firing of cervical afferents with resultant changes in proprioceptive function [32]. Thus, the second explanation for the significant improvement of proprioception in study group than control group in the current study might be attributed to improvement of cervical neuromuscular control gained after DCFs training which lead to decrease stresses placed on the joints and other structures of the cervical region [33,34].

The third explanation is using of PBU during DCFs training for the study group. As the PBU provides patients with constant feedback during each repetition of the exercises that encourages patients to perform exercises correctly and gets them more involved in the treatment which augment the patient's sensory feedback mechanisms through precise information about body processes [35].

It has been reported by Jull et al. [10] that, sternocleidomastoid muscle activity is reduced and DCFs activity is increased following DCFs training, as measured with electromyography. So, the fourth explanation may be related to this changes in activity of the deep and superficial muscles, which may alter cervical inter segmental kinematics leading to improved acuity for cervical movement and responsible for changes in

proprioception. This explanation is supported by the opinion of Proske et al. [36] who mentioned that changes in activity of the deep and superficial muscles may be responsible for changes in proprioception.

Regard to pain intensity, there is a significant improvement in pain intensity level in DCFs groups than control group. This result comes in agreement with the findings of Iqbal et al. [35] and Gupta et al. [37] who mentioned that DCFs training improved chronic neck pain more significantly than conventional physical therapy. While, the result disagrees with the findings of Izquirdo et al. [38] who found that there was no significant difference between DCFs training and conventional proprioceptive training in improving chronic neck pain. This significant decrease in the reported pain is another explanation for the significant improvement of proprioception in DCFs group than traditional physical therapy group. This explanation based on that, pain induces changes in muscle spindle discharge and the proprioceptive properties of brainstem neurons [4].

This significant improvement of pain in DCFs group might be attributed to more significant improvement of DCFs strength as evaluated by the CCFT. This explanation is supported by the opinion of Ylinen et al. [39] who mentioned that weakness of DCFs tend to cause neck pain. Also, it can be confirmed by Javanshir et al. [40] who mentioned that, there is relationship between reduction in strength and endurance capacity of the DCFs and neck pain. Moreover, DCFs training might directly influence pain sensitive structures of upper cervical region more than conventional training [41].

The significant improvement in the strength of DCFs in the study group than the control group in the current study come in agreement with previous observations by Jull et al. [10] who conducted a study to compare between the effect of DCFs training and another therapeutic exercise on activation of DCFs in people with chronic neck pain and they reported that, activation of the DCFs was significantly increased at each of the five levels of the CCFT after CCFs training.

Regarding the severity of dizziness and DHI, the results revealed statistically significant changes favoring the study group. This might be attributed to the reported significant improvement of proprioception and severity of pain in the study group than the control group. This explanation is based on the fact that, neck pain is a cause of dizziness, unsteadiness and altered cervical proprioception [28,42], and also supported by Clark et al. [43] who stated that, there is a connection between neck pain, cervical proprioceptors and dizziness.

Limitations

This study has some limitations, however, each of which points toward directions of future study. The primary limitation was the lack of following up the long term effects of DCFs training on proprioception, pain, muscle strength and dizziness in patients with cervical spondylosis, as, the study considered only the immediate effects. In addition, it was not be pos-

sible to blind the physiotherapist due to the nature of the interventions which need the direct communication between the physiotherapist and the patients. Furthermore, the initial selection of the patients was represented as a convenient sample rather than a random sample of the whole population.

Conclusions

The study findings indicate that, DCFs training was more effective, comfortable and safe for improving neck proprioception, severity of pain, DCFs strength, severity of dizziness, and DHI scores. These observed effects should be of value to clinicians and health professionals involved in the treatment of patient with cervical spondylosis.