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Correlation between Deep Neck Flexors Strength and Dynamic Balance Indices in Patients with Cervical Spondylosis

[1]*Mohamed Nabil ElBahrawy,* [2]*Ebtesam M. Fahmy,*
[1]*Yousra S. Ahmmed and* [1]*Nagwa I. Rehab*

[1]Department of Physical Therapy for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt
[2]Neurology Department, Faculty of Medicine, Cairo University, Cairo, Egypt

Abstract: *Background*: Patients with cervical spondylosis commonly suffer from neck pain that may lead to decline in deep neck flexors (DNFs) strength. Deep neck flexors strength is critical in the maintenance of the stability of cervical spine, so its assessment has gained importance in recent clinical practice. *Objective*: This study aimed to investigate the relationship between DNFs strength and dynamic balance indices in patients with cervical spondylosis. *Methodology*: Forty five subjects from both sex with age ranged from 45-55 years participated in this study. Subjects were assigned into two groups ; study and control groups. The study group included thirty patients with cervical spondylosis suffering fron neck pain and the control group included fifteen age matched healthy subjects. Deep neck flexors strength was assessed using pressure biofeedback unit and dynamic balance indices were assessed using biodex balance system in both groups. *Results*: There was a statistically significant decrease in the median value of DNFs strength and a statistically significant increase in the median value of overall stability index (OSI), antroposterior stability index (APSI) in patients with cervical spondylosis compared to age matched healthy subjects, however there was no statistically significant difference in the median values of mediolateral stability index (MLSI) in both groups. There was a non-significant correlation between DNFs strength and dynamic balance indices (OSI, APSI and MLSI) in both groups (p>.05). *Conclusion*: It was concluded that patients with cervical spondylosis have deficits in DNFs strength and dynamic balance indices. So, Balance and DNFs strength exercises are an essential elements in management of patients with cervical spondylosis. Also, it was concluded that DNFs dysfunction may not affect balance in these patients.

Key words: Deep Neck Flexors · Cervical Spondylosis · Dynamic Balance · Pressure Biofeedback · Craniocervical Flexion Test · Neck Pain

INTRODUCTION

Cervical spondylosis is a common progressive degenerative disorder of the human spine often caused by the natural aging process or secondary to degenerative disc disease [1]. Twenty five to fifty percent of people develop cervical spondylosis by the age of 50. By the age of 75 years, it would be present in at least 70% of people [2]. The majority of people with spondylosis are asymptomatic[3]. When osteophytic development compromise the canal diameter, myelopathic and/or radicular symptoms often develop. These symptoms are the result of increased pressure on the spinal cord producing neurological and vascular changes [4].

The cervical facet joints contain nerve endings known as mechanoreceptors which respond to stimuli such as tension in the muscles or pressure being placed on the joints; injury to the joint negatively influences the body's proprioception [5].

Corresponding Author: Yousra S. Ahmmed, Department of Physical Therapy for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt.

Fifty percent of all cervical proprioceptors were in the joint capsules of the first to the third cervical vertebra. In addition, there is an abundance of mechanoreceptors in the γ-muscle spindles of the deep segmental upper cervical muscles. This mechanoreceptors' function can be altered by direct trauma, muscular fatigue, degenerative changes, or direct effect of pain [6]. Sensory information from mechanoreceptors in the skin, muscles, tendons and joint structures plays an important role in joint stability. The reason for the more altered proprioceptive inputs in patients of cervical spondylosis might be the involvement of muscles, capsules and the intervertebral disc in the degeneration [7].

The cervical spine is surrounded by a complex arrangement of muscles that contribute to control of the head and neck. Among the most important part of this system is the deep vertebral muscles [8]. The deep neck flexors (Longus capitis, longus coli, rectus capitis anterior and latrealis) are small stabilizing muscles located on the anterior and anterolateral surfaces of the cervical spine deep to the sternocleidomastoid (SCM) muscle [9]. The location of the DNFs suggest that they potentially play an important role in stabilizing the cervical spine [10].

Neck muscles have an important role in maintaining the stability of cervical vertebrae and it has been suggested that dysfunction of these muscles is closely associated with neck pain. For instance, weakness of the anterior cervical neck flexor muscles is thought to contribute to persistent neck pain [11].

This study designed to investigate the relationship between DNFs strength and dynamic balance indices in patients with cervical spondylosis in Egypt.

MATERIAL AND METHODS

Subjects: Forty five subjects from both sex participated in this study with age ranged from 45-55 years old and body mass index<30 kg\m2 (BMI). Subjects were assigned into two groups (study and control groups). Study group included thirty patients with cervical spondylosis suffering from neck pain from six to twelve months diagnosed and referred from a neurosurgen. Diagnosis was confirmed radiologically by plain-X Rays of the cervical spine. Patients were chosen from Out-Patient Clinic, Faculty of Physical Therapy, Cairo University. Patients were excluded from this study if they had any disorders that affect balance as cervical myelopathy, chronic sinusitis, labyrinthitis, Ménière's disease, whiplash injuries, benign paroxysmal position vertigo, poor hearing and vision, polyneuropathy and chronic cardiovascular disease. Control group included fifteen age matched healthy subjects. This study was conducted at the balance lab of Faculty of Physical Therapy, Cairo University in the period from March 2017 to June 2018 (No: P.T.REC/ 012/001332).

Instruments:

The Pressure Biofeedback Unit (PBU) (Stabilizer, Chattanooga, USA): Was used to assess DNFs strength, consists of a non-elastic three-chambered bag, a catheter and a manometer gauge ranging from 0mmHg to 200mmHg, with an accuracy of +_3mmHg [12]. Pressure-biofeedback device is a reliable and valid [13].

Biodex Balance System: (Model 945-302, Software version 3.12, Shirley New York, United States) at the balance unit of the Faculty of Physical Therapy, Cairo University. The Biodex Balance system was used to measure and train balance and postural stability under dynamic stress**.** The biodex balance system uses a circular platform that is free to move in the anterior-posterior and medial - lateral axes simultaneously. Biodex balance system has been reported high test-retest reliability when using high resistance levels [14].

Procedures: Prior to participation in this study, the aim and procedures were explained to the participants. Patients were subjected to complete clinical assessment (Including careful history taking, motor, sensory, balance assessment). All the subjects signed an informed consent.

Assessment of Deep Neck Flexors Strength: The participant was positioned in crocklying with pressure biofeedback unit under the back of his/her head and was handed the dial end to guide the performance of the test. The cranial cervical flexion test (CCFT) was composed of five progressive stages based on the amount of the pressure the participant could exert at a neutral head position by the back of his head (22,24,26,28 and 30 mmHg). The therapist elevated the pressure to 20mmHg. The participant was asked to slowly perform a head nod action to elevate the cuff pressure from 20mmHg to 22mmHg and hold for three seconds. This process was repeated through 2mmHg increments until 30mmHg was reached. Baseline assessment was taken as the amount of pressure that the participant could achieve and hold for three seconds with the correct craniocervical flexion action. The tester palpated the superficial flexors to ensure that no substitution occurred throughtout the test [15].

Assessment of Dynamic Balance Indices: Assessment of dynamic balance indices {antroposterior stability index (APSI), mediolateral stability index (MLSI) and overall stability index (OSI)} were done using the dynamic balance test. The participant was asked to stand with bare feet on the center of the locked platform with double leg stance with eyes open then enter patient weight and height. To assess the foot position coordinates and establish the subjects' ideal foot positioning for testing, the stability platform was unlocked to allow motion. Participants were instructed to adjust the position of the foot until they found a position at which they could maintain platform stability. The platform was then locked. Foot position coordinates were constant throughout the test. The time of test was adjusted to be 20 seconds. Stability level of the test was adjusted to start test from level 8(the most stable level of platform). The platform was advanced to an unstable state.

The participant was instructed to maintain the cursor in the middle of a concentric circle that appeared on the screen. The instrument recorded the actual postural sway and calculated the variance from the center which was expressed as a balance index. More postural sway was reflected as a large variance that was quantified as a greater score of the balance index.

The test consisted of three trials, each of which were 20 seconds in duration with a 25-second inter-trial rest period. After each trial, the platform automatically returned to the locked position. The average value of the three trials was displayed and taken as the final balance index which reflected the participant's overall performance. The data generated from the test were printed in a comprehensive report that included:

Overall Stability Index: Represented the participant's ability to control balance in all directions. High values indicated balance disturbance (increase rate of body swaying during the test).

Anterior /Posterior Stability Index: Represented the participant's ability to control balance in front to back direction.

Medial /Lateral Stability Index: Represented the participant's ability to maintain balance from side to side.

Statistical Analysis:

- Results are expressed as mean±standard deviation, median, range and number (percent).
- Comparison between categorical data [number (%)] was performed using Chi square test.
- Test of normality, Kolmogorov-Smirnov test, was used to measure the distribution of data measured at pre-treatment.
- Accordingly, comparison between normally distributed variables in both two groups was performed using unpaired t test.
- In not normally distributed data, comparison between variables in both groups was performed using Mann Whitney test. Correlation between different variables was performed using Spearman Rank correlation coefficient.
- Statistical Package for Social Sciences (SPSS) computer program (version 19 windows) was used for data analysis. P value $\leq$ 0.05 was considered significant.

RESULTS

General Characteristics of Subjects: No statistically significant difference was found between both groups regarding mean of age (p= 0.578), weight (p= 0.209), height (p= 0.284) and BMI (p= 0.529) and no significance difference was found between both groups regarding sex distribution (Chi square value= 1.296; p= 0.255) (Table 1).

Comparison Between Groups: There was a statistically significant difference between study and control groups as regards the median value of DNFs strength (24 versus 26) being lower in the study group (p value = 0.001) (Table 2).

There was a statistically significant difference between study and control groups as regards the median value of OSI and APSI being higher in the study group (p value = 0.036, p= 0.045 respectively) and there was no statistically significant difference in the median value of MLSI between both groups (p value = 0.256), (Table 3).

There was no significant correlation between dynamic balance indices (OSI, APSI and MLSI) and DNFs strength in the study and control groups (p>0.05) (Table 4).

Table 1: Demographic characteristics and sex distributions of subjects in both groups.

	Study group (n= 15)	Control group (n= 15)	t value	P value
Age (yrs.)	47.70±2.89	48.20±2.68	0.560	0.578 (NS)
Sex				
Female	11 (36.7%)	3 (20.0%)	x^2= 1.296	0.255 (NS)
Male	19 (63.3%)	12 (80.0%)		
Weight (kg.)	73.73±4.99	77.07±9.25	1.304	0.209 (NS)
Height (cm)	166.00±6.42	168.33±7.51	1.086	0.284 (NS)
BMI (kg/m^2)	26.79±1.68	27.11±1.55	0.634	0.529 (NS)

Data are expressed as mean±SD. *X*2 value= Chi square test. NS= p> 0.05= not significant.

BMI: body mass index

Table 2: Comparison of median values of the deep neck flexors strength between both groups.

	Study group Median (range)	Control group Median (range)	Z value	p value
DNFs strength (mmHg)	24.0 (21.0-28.0)	26.0 (24.0-30.0)	-3.254	0.001(S)

S: Significant at p≤ 0.05. DNFs: Deep neck flexors

Table 3: Comparison of median values of dynamic balance indices between both groups

	Study group Median (range)	Control group Median (range)	Z value	p value
OSI	2.0 (0.8-7.4)	1.6 (0.8-2.4)	-2.100	0.036 (S)
APSI	1.6 (0.3-4.3)	1.2 (0.4-1.7)	-2.006	0.045 (S)
MLSI	1.4 (0.6-6.3)	1.4 (0.7-1.9)	-1.137	0.256 (NS)

NS= Not significant at p> 0.05. S: Significant at p≤ 0.05. OSI: Overall stability index.

APSI: Antroposterior stability index. MLSI: Mediolateral stability index

Table 4: Correlation between dynamic balance indices and deep neck flexors strength in both groups:

	DNFs strength			
	Study group		Control group	
Dynamic balance indices	R	p value	R	p value
OSI	0.056	0.770 (NS)	0.072	0.799 (NS)
APSI	-0.010	0.959 (NS)	0.191	0.495 (NS)
MLSI	0.161	0.396 (NS)	-0.159	0.571 (NS)

r= Spearman's Rank Correlation Coefficient NS= p> 0.05= Not significant

DISCUSSION

The results of the current study showed that study group had a statistically significant lower median value of DNFs strength compared to the control group. The results come in agreement with the findings of Chiu *et al.* [16] who conducted a study to compare the performance of the deep cervical flexor muscle by CCFT in subjects with or without neck pain and demonstrated that patients with chronic neck pain had a poorer ability to perform the CCFT when compared with asymptomatic subjects. Also, Olson *et al.* [17] found that subjects without neck pain showed good cervical flexor endurance than in subjects with neck pain. The results showed that the neck pain caused muscle weakness which in turn resulted in reduction of muscle endurance. Decreased DNFs strength in the study group might be attributed to the presence of neck pain. Ylinen *et al.* [18] showed that there was an association between reduction in the strength and endurance capacity of the cervical muscles and neck pain. Also, Falla *et al.* [19] found impaired activation of the deep cervical flexor muscles, the longus colli and longus capitis, in people with neck pain.

The results of the current study showed that patients of the study group had a statistically significant increase in the median value of OSI, APSI when compared to the control group. These findings come in agreement with Treleaven *et al.* [20] who mentioned that chronic neck pain may be linked to reduced cervicocephalic kinesthetic sensibility and postural balance. In contradistinction, Palmgren *et al.* [21] found no evidence of impaired static postural balance in patient with nontraumatic chronic neck pain. Impaired balance in patients with cervical spondylosis might be attributed to impaired proprioception which might be related to the involvement of muscles, capsules and intervertebral disc in process of degeneration [7]. Pain from different neck-structures may cause disturbed afferent input by altering muscle spindle sensitivity, central modulation of proprioceptive input and sensorimotor control [22, 23]. Cervical proprioceptive reposition errors are increased in patient with cervical spondylosis in comparison with age and gender matched normal individuals [7]. This explanation was based on the fact that imbalance may originate from altered proprioceptive signals due to degenerative cervical disorders. Cervical proprioception contributes to the perception of head motion and converges with vestibular and visual information for spatial orientation and balance [24].

The results of the current study showed that patients with cervical spondylosis had no statistically significant difference in the median value of MLSI compared to the control group. This might be explained in view that DNFs responsible for balance between anterior aspect and posterior aspect of neck not side to side. Iqbal *et al.* [25] theorized that DNFs are considered to be an important stabilizer of the head-on-neck posture. When muscle performance was impaired, the balance between the stabilizers on the posterior aspect of the neck and the deep neck flexors would be disrupted, resulting in loss of proper alignment and posture.

The non significant correlation between dynamic balance indices and DNFs strength in both groups might be attributed to that balance was measured in this study using BBS which depend mainly on lower extremity proprioception not on neck proprioception. Neck proprioception affect functional balance tasks requiring head stability such as maintaining balance during picking up object, reaching object, washing face and turning to look behind while sitting.

CONCLUSION

It could be concluded that patients with cervical spondylosis have deficits in DNFs strength and dynamic balance indices but there is no correlation between DNFs deficit and balance deficit in these patients. This study indicates that DNFs strength may not play a major role in balance.

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