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RESEARCH ARTICLE

INVESTIGATION OF LATERAL TRUNK FLEXOR MUSCLE PERFORMANCE IN INDIVIDUALS WITH CHRONIC NECK PAIN: A CASE-CONTROL STUDY

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ABSTRACT

Purpose: To investigate lateral trunk flexor muscle performance and thoracolumbar mobility in individuals with chronic neck pain (CNP) compared to asymptomatic controls.
Materials and Methods: This case-control study included 20 participants with CNP and 20 asymptomatic controls. Pain and disability variables in the CNP group were assessed via Visual Analogue Scale (VAS) and Neck Disability Index. Lateral trunk flexor muscle performance was evaluated on endurance, strength, and thoracolumbar rotation range basis using the side-bridge lateral trunk flexor endurance test, hand-held dynamometer, and bubble inclinometer, respectively. Group differences were analyzed using the Independent Sample's t-test.
Results: The individuals with CNP reported pain intensity scores of 6.32 at rest and 6.63 during activity, on the VAS. Additionally, their neck disability index value was found to be 45.6%, indicating a moderate disability level. Compared to the asymptomatic controls, the CNP group demonstrated significantly lower lateral trunk flexor endurance, strength, and thoracolumbar rotation, with large effect sizes ($p<0.05$, Cohen's $d>0.71$).
Conclusion: Individuals with CNP exhibit reduced lateral trunk flexor muscle performance and thoracolumbar mobility compared to asymptomatic individuals. These observations suggest that interventions focused on improving trunk muscle strength, endurance, and mobility may be advantageous in managing CNP.

Keywords: chronic neck pain; lateral trunk muscle performance; thoracolumbar rotation.

INTRODUCTION

Chronic neck pain (CNP) is a prevalent musculoskeletal disorder that significantly impacts individuals' daily lives and socioeconomic factors (1). The underlying causes of CNP are multifactorial including muscle strength imbalances between superficial and deep layers of the cervical musculature, poor posture, and psychosocial factors (1,2). While these factors emphasize the localized impact of CNP, emerging research suggests that its effects may extend beyond the cervical region (3–5).

Trunk muscle performance plays a crucial role in maintaining spinal stability and controlling head and neck movements (6). Weakness or dysfunction in these muscles can lead to altered biomechanics, increased spinal loading, and ultimately, the development and persistence of neck pain (6). Schweigart et al. explained their experimental model for determining head rotation perception in space, attributing head perception to two main factors: head-on-trunk rotation and stationary trunk biomechanics (7). From a clinical perspective, Falla et al. reported that individuals with CNP walk with increased stiffness in the trunk region (8). Also, Christensen et al. showed alterations in axio-scapular muscle activity during the acute phase of neck pain (9). In addition to this evidence, regional interdependence theory describes the human body as an interconnected system with compensation mechanisms that are neurological, fascial, and biomechanical in nature (10,11). The theory supports the idea that muscle strength imbalances and pain may arise in compensating body parts, regardless of their proximity to the painful area (10). Ghamkar et al. provided findings supporting the theory, revealing altered muscle strength in pain-free regions, such as the shoulder, trunk, and scapulothoracic area, in individuals with neck pain (11). Moreover, growing evidence from systematic review and meta-analysis suggests that a combined therapeutic approach targeting both the cervical and thoracic regions may be more effective for managing CNP than focusing on the neck alone (12). This approach recognizes the interconnectedness of the cervical and thoracic spine and the potential for muscular alteration of the trunk to contribute to neck pain.

Overall, this research highlights that CNP is not just a localized issue; it has broader implications for movement control, muscle function, and potentially spinal health. However, the specific performance of the lateral trunk muscles, which are critical for maintaining spinal alignment, postural control, and daily functional activities, has not been extensively studied in this population.

The aim of this study was to compare lateral trunk flexor muscle strength and endurance and thoracic rotation between individuals with and without CNP. We hypothesized that individuals with CNP would exhibit decreased lateral trunk flexor strength and endurance as well as reduced trunk rotation range of motion compared to asymptomatic individuals.

MATERIALS AND METHODS

Design

This case-control study was conducted at Dokuz Eylul University. Ethical approval was obtained from the Dokuz Eylul University Non-invasive Research Ethics Committee (Number: 2023/04-01, Date: 15.02.2023), and all procedures adhered to the Declaration of Helsinki. Participants provided informed consent before participating in the study.

Participants

The total sample size was calculated using the pilot data set (The CNP group n=9, mean age=37.44±13.22 years, mean body mass index (BMI)=24.96±4.54 kg/m2; the control group n=9, mean age=41.66±6.87 years, mean BMI=26.87±3.53 kg/m2). The total sample size was 38, with an effect size of 1.22, a power of 0.95, and two tails, using G*Power for Windows (v3.1.9.4, Düsseldorf University, Germany). In the pilot sample, we evaluated all independent variables of thoracolumbar range of motion, lateral trunk endurance, and lateral trunk flexor strength. However, the reference value for the sample size calculation was based on the right lateral trunk strength, which represents the variable with the smallest difference between the pilot groups (13).

The study recruited participants from the Neurosurgery Outpatient Clinic at Dokuz Eylul University. Individuals experiencing neck pain lasting over six months were included in the CNP group. Exclusion criteria for this group included previous or current spinal pain (except neck pain), neurological deficits related to neck disorders, any history of spinal trauma or surgery, and diagnoses of neurological or musculoskeletal conditions that could affect trunk muscle performance. The control group consisted of asymptomatic individuals with no current or history of spinal pain, as well as no history of trauma, surgery, or diagnosed conditions that could impact trunk muscle function.

A total of forty-seven participants were assessed for eligibility, two participants from the CNP group were excluded regarding the criteria of current low back pain (n=2), and five participants from the control group were excluded regarding the criteria of low back pain (n=4), and history of spinal trauma (n=1). Forty participants were enrolled in the study, comprising twenty in the CNP group and twenty in the control group.

Measurements

The Visual Analog Scale (VAS) was used to assess participants' neck pain severity at rest and during activity. Participants were asked to indicate their pain intensity on a 100-mm visual analog scale, where 0 represented no pain and 100 indicated the worst imaginable pain (14). Additionally, the Neck Disability Index (NDI) was used to evaluate self-reported neck pain-related disability. The NDI scores range from 0 to 100, with higher values indicating greater functional impairment (15).

The side-bridge lateral trunk flexor endurance test

The participant was positioned in a side-lying posture on their dominant side, with their legs extended and resting on their forearm and elbow. The shoulder was abducted to a 90-degree angle, and the elbow was flexed at a 90-degree angle. The test instruction was to 'lift your hip off the bed and maintain a straight line between your shoulder, hip, and feet while placing the hand of your free arm on the contralateral shoulder (16). Throughout the assessment, the examiner monitored the participant's alignment to ensure their entire body remained straight. If the participant deviated from the test position, verbal commands were provided to correct their posture and continue the trial. The test concluded if the participant was unable to maintain a straight posture for more than three seconds or if they experienced excessive fatigue or discomfort, at which point the time was recorded (16) (Figure 1).

Figure 1. The side-bridge lateral trunk flexor endurance test

The muscle strength of lateral trunk flexors

The lateral trunk flexor muscle strength of each side was evaluated using a handheld dynamometer (Lafayette Instrument, UK), positioned at the mid-trunk by the examiner. Participants were securely positioned on a plinth using straps, with their knees and hips flexed at 90 degrees and their hands crossed over their chest. The examiner stood perpendicular to the participant and provided resistance to lateral trunk flexion using the handheld dynamometer to minimize actual trunk movement. Participants were instructed to exert maximal effort to bring their shoulder towards the ipsilateral iliac crest and sustain that position for 5 seconds. Trials exhibiting excessive movement were excluded, with excessive movement defined as any detectable movement or rotation in the transverse plane. Adequate rest periods (minimum 30 seconds) were provided between trials. Three trials were conducted, and the average strength value was recorded in kilograms for each side. The measurement procedure demonstrated excellent inter-rater reliability, with an intraclass correlation coefficient (ICC) of 0.88 reported (17) (Figure 2).

Figure 2. The muscle strength of lateral flexors

The side-lying thoracolumbar rotation measurement

The trunk rotation measurements were performed as outlined by Iveson et al. Participants were positioned in a side-lying posture with their hips and knees flexed to 90 degrees (18). They then rotated their trunk posteriorly toward the treatment table, attempting to approximate their scapulae to the surface. Measurements were obtained using a bubble inclinometer (Baseline, USA) placed across the medial clavicles, and the average of three trials was used for analysis. The intra-rater reliability for the measurements was consistent for both right and left side rotation, reported as ICC=0.95 for the right side and ICC=0.94 for the left side (18) (Figure 3).

Figure 3. The side-lying thoracolumbar rotation measurement

Statistical Analyses

Statistical analyses were performed using IBM® SPSS Statistics 25 with data from 40 participants. The Shapiro-Wilk test and descriptive statistics confirmed that the data were normally distributed. Demographic characteristics were compared between groups using the Independent Samples t-test, and descriptive variables were presented as means and standard deviations.

The Independent Samples t-test was performed to compare trunk muscle performance variables (lateral trunk flexor endurance and strength, thoracolumbar rotation angle) between the CNP and asymptomatic groups. The statistical significance level was set at p<0.05. Effect sizes were calculated according to the Cohen's d and were interpreted as follows: 0 to 0.40, small effect; 0.41 to 0.70, moderate effect; and 0.71 or higher, large effect (13,19).

RESULTS

The demographic variables of the groups, as well as the pain intensity and disability level variables for the neck pain group, are presented in Table 1. The age, weight, and BMI values of the neck pain group were higher (p<0.05), while there was no significant difference between the groups in terms of height (p>0.05). The individuals with CNP reported pain intensity scores of 6.32 at rest and 6.63 during activity, on the VAS. Additionally, their neck disability index value was found to be 45.6%, indicating a moderate disability level (Table 1).

The comparison of lateral trunk flexor muscle performance between the chronic neck pain and asymptomatic groups was presented in Table 2. Lateral trunk flexor endurance, lateral trunk flexor strength, and thoracolumbar rotation degrees were lower in the CNP group compared to the asymptomatic group (p<0.05) for both sides. The effect size was large for all differences (d> 0.71) (Table 2).

DISCUSSION

This study demonstrated that individuals with chronic neck pain exhibited significantly reduced performance in several key areas related to trunk function compared to asymptomatic controls. Specifically, individuals with CNP had lower endurance and strength in their lateral trunk flexors, as well as decreased thoracolumbar rotation. These findings align with existing research suggesting that CNP is often associated with impaired neuromuscular function, not only in the neck region but also affecting the trunk with a new perspective in terms of lateral trunk flexor muscle performance.

The findings of altered lateral trunk muscle endurance and strength in the CNP group are consistent with previous studies that have reported impairments in trunk flexor endurance in individuals with CNP (3,20). Previous research has predominantly focused on trunk flexor endurance rather than isometric muscle strength (3,20). Additionally, our study reveals that both endurance and strength measures of the lateral

Table 1. Demographic and pain-related variables of the groups

Variables	The CNP Group (n=20)	The Asymptomatic Group (n=20)	
	Mean (SD)	Mean (SD)	p[a]
Age, year	43.2 (6.19)	37.25 (9.86)	0.028*
Weight, kg	69.95 (8.47)	62.88 (11.36)	0.032*
Height, cm	162.75 (4.64)	161.2 (5.23)	0.328
BMI, kg/m²	26.44 (3.21)	24.15 (3.74)	0.045*
The pain intensity at rest, cm on VAS	6.32 (1.54)	-	-
The pain intensity at activity, cm on VAS	6.63 (1.65)	-	-
Neck Disability Index, %	45.6 (8.98)	-	-

Abbreviations: CNP, Chronic Neck Pain; [a], Independent Samples t-Test; SD, Standard Deviation; BMI, Body Mass Index; *,p<0.05

Table 2. Comparison of lateral trunk flexor muscle performance between the chronic neck pain and asymptomatic groups

Variables		The CNP Group (n=20)	The Asymptomatic Group (n=20)		
		Mean (SD)	Mean (SD)	p	Cohen's d
Endurance of lateral trunk flexors, second	right	12.40 (5.24)	34.57 (16.01)	<0.001*	1.861
	left	11.71 (3.03)	33.42 (15.18)	<0.001*	1.983
The strength of lateral trunk flexors, kg	right	10.71 (2.03)	14.54 (2.86)	<0.001*	1.544
	left	10.71 (2.77)	14.39 (2.55)	<0.001*	1.382
The range of motion of thoracolumbar rotation º	right	50.46 (8.59)	66.35 (10.38)	<0.001*	1.667
	left	50.94 (8.78)	65.10 (9.83)	<0.001*	1.519

Abbreviations: CNP, Chronic Neck Pain; SD, Standard Deviation; *, p<0.05 in Independent Samples t-test.

trunk flexors were lower in individuals with CNP compared to asymptomatic controls. The underlying reasons remain unclear, but these alterations could be attributed to neurophysiological adaptations. Elgueta-Cancino et al. demonstrated that the motor cortex representation of the deep neck flexors is directly connected to the trunk, face, and neck regions in the motor homunculus (21). If we accept the involvement of deep neck flexors in our CNP group, we can speculate that this involvement initiates a change in the neurophysiological patterns of the trunk muscles due to their connection through the motor cortex. Yalcinkaya et al. also reported that lumbar motor control could be affected in individuals with CNP through changes in the contractile properties of the transversus abdominis (4). If we consider the role of transversus abdominus during trunk rotation and lumbopelvic control (22), we can hypothesize that impairment of the lateral trunk flexor muscles may lead to a decrease in thoracolumbar rotation observed in our study.

The trunk musculature provides proximal stability, enabling the transfer of force and angular momentum between the limbs (23). As a result, the trunk is often characterized as a critical 'powerhouse' due to its ability to transmit, absorb, and redirect kinetic energy during functional tasks (24). Moghaddas et al. showed that individuals with CNP exhibited reduced thoracolumbar rotation during functional tasks such as overhead reaching (25). In parallel, we found that a decreased active range of motion in thoracolumbar rotation was present in the CNP group compared to the asymptomatic group. Joshi et al. showed that thoracic mobility was reduced in the neck pain population and revealed an association between thoracic kyphosis and postural alterations in the cervical spine (26). More specifically, Falla et al. reported that individuals with CNP exhibit decreased thoracic rotational movement during walking (8). These findings indicate the importance of adequate thoracolumbar rotation for optimal movement. The reduction in trunk mobility may be linked to compensatory protective mechanisms employed to minimize spinal loading and pain, as suggested by Van Der Hoorn et al., who found reduced trunk residual rotation in individuals with low back pain (27). Further research is needed to explore the long-term consequences of these adaptations and to develop targeted interventions that address both trunk muscle function and thoracolumbar mobility in individuals with CNP. Also, the lateral trunk muscles facilitate the force transfer between the upper and lower extremities (23). Our findings of decreased endurance and strength could point out superficial muscles of the trunk region may compensate for the current pain and this overuse frame of CNP leads to muscle imbalance, coordination, and poor postural stability through the axis of the lateral trunk region. Research that further explores the mechanical coupling between the thorax, neck region, and upper extremities might expand the knowledge of disabilities or functional movement alterations due to CNP.

Several limitations should be considered when interpreting the findings. Firstly, the small sample size may have limited statistical power of our findings due to the limited (n=18) number of participants in the pilot findings. To reach a larger sample size estimation would have been preferable to impact the generalizability of the findings. Future studies with larger and more diverse samples are needed to confirm and expand upon our findings. Secondly, while our study focused on lateral trunk muscle performance, other muscle groups contributing to trunk stability and movement, such as the anterior and posterior trunk muscles, were not assessed. A comprehensive evaluation of trunk muscle function would provide a more complete understanding of the co-occurring mechanisms employed in neck pain conditions. Also, using novel instruments such as electromyography or ultrasonography could have provided a more detailed edge of the underlying neuromuscular alterations. In addition, the measurement of thoracolumbar rotation angle may obscure distinct contributions of thoracic, lumbar, and even neck mobility to the observed findings due to the biomechanical coupling mechanism of the spine and the rib cage. Therefore, future research could examine the long-term results of data isolating the thoracic region, such as a 3D motion analysis system. Finally, the cross-sectional design of this study limits our ability to draw definitive conclusions about the cause-effect relationships between CNP, trunk muscle function, and thoracolumbar mobility. Longitudinal studies are necessary to investigate the long-term effects of CNP on these variables. Additionally, exploring the potential influence of other factors, such as pain duration, psychosocial factors, and physical activity levels, would provide a more comprehensive understanding of CNP's impact on trunk function.

CONCLUSION

This study provides evidence of reduced lateral trunk flexor muscle performance and thoracolumbar mobility in individuals with chronic neck pain compared to asymptomatic individuals. These findings highlight the potential importance of addressing trunk muscle function and thoracolumbar mobility in the management of CNP.

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