

## Investigation of the Relationship Between the Endurance of Cervical Flexor and Extensor Muscles and Pain, Disability, and Range of Motion in Individuals with Neck Pain

Boyun Ağrısı Olan Bireylerde Servikal Fleksör ve Ekstansör Kasların Dayanıklılığı ile Ağrı, Disabilite ve Hareket Açıklığı Arasındaki İlişkinin Araştırılması

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### ABSTRACT

**Aim:** Individuals experiencing chronic neck pain often present with heightened pain levels, functional disability, restricted cervical range of motion, and diminished muscular endurance. Despite the prevalence of these symptoms, the interrelationships among them remain insufficiently explored in the literature. Therefore, the present study aimed to examine the associations between cervical flexor and extensor muscle endurance and key clinical outcomes, including pain intensity, disability, and cervical range of motion, in individuals with chronic neck pain.

**Methods:** This study included 120 female participants with a mean age of  $39.7 \pm 9.8$  years. Flexor and extensor muscle endurance was assessed using cervical endurance tests. Pain intensity at rest and during activity was measured using the Visual Analog Scale (VAS). Functional disability related to neck pain was assessed with the Neck Disability Index (NDI). Cervical range of motion (ROM) was measured using a universal goniometer. Statistical analyses were conducted using Pearson correlation coefficients to examine relationships between variables. The significance level was determined as  $p < 0.05$ .

**Results:** In this study, a statistically significant relationship was found between the endurance of cervical flexors and the VAS parameter regarding pain at rest ( $r = -0.18$ ,  $p = 0.04$ ); and between the endurance of cervical extensors and VAS [rest VAS ( $r = -0.24$ ,  $p = 0.006$ ) and activity VAS ( $r = -0.34$ ,  $p < 0.001$ )], the NDI ( $r = -0.33$ ,  $p < 0.001$ ) and ROM [only flexion ( $r = 0.19$ ,  $p = 0.03$ ) and left rotation ( $r = 0.17$ ,  $p = 0.05$ )] ( $p < 0.05$ ).

**Conclusion:** These findings suggest that variations in cervical muscle endurance may significantly influence neck pain, functional disability, and cervical mobility.

**Keywords:** Disability, endurance, neck pain, pain, range of motion.

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## ÖZET

**Amaç:** Boyun ağrısı olan bireylerde artmış ağrı, disabilite, hareket açıklığı ve kas dayanıklılığında azalma bildirilmiştir. Ancak bu semptomlar arasındaki ilişkiyi inceleyen yeterli çalışma bulunmamaktadır. Bu çalışmanın amacı, kronik boyun ağrısı olan bireylerde servikal fleksör ve ekstansör kasların dayanıklılığı ile ağrı, disabilite ve servikal eklem hareket açıklığı arasındaki ilişkiyi araştırmaktır.

**Metod:** Çalışmaya yaş ortalaması  $39,7 \pm 9,8$  yıl olan toplam 120 kadın katılımcı dahil edilmiştir. Fleksör ve ekstansör kas dayanıklılığı, servikal dayanıklılık testleri ile değerlendirilmiştir. İstirahat halindeki ve aktivite sırasındaki ağrı düzeyini değerlendirmek için Görsel Analog Skalası (VAS) kullanılmıştır. Boyun ağrısına bağlı olarak günlük yaşam aktivitelerinde oluşan disabilite düzeyini değerlendirmek için Boyun Disabilite İndeksi (NDI) kullanılmıştır. Servikal bölgenin eklem hareket açıklığı (ROM) ise evrensel gonyometre ile ölçülmüştür. Verilerin istatistiksel analizi Pearson korelasyon analizi ile yapılmıştır. Anlamlılık düzeyi  $p < 0,05$  olarak belirlenmiştir.

**Bulgular:** Bu çalışmada, servikal fleksör kasların dayanıklılığı ile istirahatteki ağrıya ilişkin VAS arasında ( $r = -0,18$ ,  $p = 0,04$ ); servikal ekstansör kasların dayanıklılığı ile NDI ( $r = -0,33$ ,  $p < 0,001$ ), VAS [dinlenme VAS ( $r = -0,24$ ,  $p = 0,006$ ) ve aktivite VAS ( $r = -0,34$ ,  $p < 0,001$ )] ve ROM [yalnızca fleksiyon ( $r = 0,19$ ,  $p = 0,03$ ) ve sol rotasyon ( $r = 0,17$ ,  $p = 0,05$ )] arasında istatistiksel olarak anlamlı bir ilişki bulunmuştur ( $p < 0,05$ ).

**Sonuç:** Bu çalışmanın sonuçları, servikal kasların dayanıklılığındaki azalma veya artışın boyun ağrısı, servikal disabilite ve servikal eklem hareketliliğinde önemli bir rol oynayabileceğini göstermektedir.

**Anahtar Kelimeler:** Dayanıklılık, disabilite, boyun ağrısı, ağrı, hareket açıklığı.

## INTRODUCTION

Chronic neck pain is a common and disabling condition, with approximately two-thirds of adults experiencing neck pain at some point in their lives (Fejer et al., 2006). Individuals with recurrent neck pain often report chronic and episodic symptoms that negatively affect daily activities and quality of life (O'Leary et al., 2009). Previous studies have demonstrated that neck pain is associated with impairments in neuromuscular coordination, reduced cervical range of motion, decreased muscle strength and endurance, postural instability, and altered oculomotor control (Brotzman & Manske, 2011; Falla, 2008; Kim et al., 2015; Medeni et al., 2025).

A decline in cervical muscle performance may occur rapidly following the onset of neck pain and may persist even after symptom resolution or tissue healing (Sterling et al., 2003). Reductions in cervical muscle strength and endurance have been consistently reported in individuals with neck pain (O'Leary et al., 2007; Lee et al., 2005). Frouzian et al. (2025) highlighted the importance of type I muscle fibers for spinal stabilization and demonstrated that individuals with neck pain exhibit a reduced proportion of slow-twitch fibers in deep spinal muscles, such as the multifidus and erector spinae, suggesting impaired muscular endurance. Moreover, altered activation patterns have been observed in this population, with increased activity of superficial cervical muscles compensating for inhibited deep cervical flexors, leading to early fatigue and reduced endurance capacity (Dere & Alemdaroğlu-Gürbüz, 2024). Consistent with these findings, individuals with chronic mechanical neck pain have been shown to exhibit significantly lower cervical muscular endurance compared to asymptomatic controls (Yazar & Altun, 2007).

Although pain intensity, functional disability, limited cervical range of motion, and decreased muscular endurance are well-documented clinical features of neck pain (Brotzman & Manske, 2011; Falla, 2008; Kim et al., 2015; O'Leary et al., 2007; Sterling et al., 2003), the interrelationships among these parameters remain insufficiently explored. In particular, there is a lack of comprehensive studies simultaneously examining cervical flexor and extensor muscle endurance in relation to pain severity, functional disability, and cervical range of motion within the same cohort. Addressing this gap may contribute to a more integrated understanding of the neuromuscular and functional impairments associated with neck pain and inform more targeted rehabilitation strategies.

Therefore, the primary aim of the present study was to investigate the associations between cervical flexor and extensor muscle endurance and key clinical parameters, including pain intensity, functional disability, and cervical range of motion, in individuals with chronic neck

pain. It was hypothesized that reduced cervical muscle endurance would be significantly associated with higher pain intensity, greater functional disability, and decreased cervical range of motion.

## **MATERIALS AND METHODS**

This cross-sectional study included a total of 120 female participants with neck pain, recruited using a convenience sampling method. A total of 120 female participants with neck pain were enrolled in this study, which aimed to examine the associations between cervical flexor and extensor muscle endurance and pain, disability, and cervical range of motion. Participants were between the ages of 18 and 65. They had been experiencing neck pain for at least three months, and had no neurological, rheumatological, or musculoskeletal disorders. Exclusion criteria included a history of cervical spine surgery, engagement in a physical therapy or rehabilitation program for neck pain within the previous six months, or a diagnosis of vertebrasilar artery insufficiency. Ethical approval for the study was obtained from the Clinical Research Ethics Committee prior to data collection (Decision No: 2021-03/31).

Demographic data of the participants were recorded. Pain intensity was assessed using the Visual Analog Scale (VAS), while functional disability was measured via the Neck Disability Index (NDI). Cervical range of motion was measured through goniometric assessment and endurance of the cervical flexor and extensor muscles was determined using standardized endurance tests specific to these muscle groups.

### **Endurance Assessment of Cervical**

To assess the endurance of the cervical flexor and extensor muscles, specific endurance tests targeting these muscle groups were employed. Each measurement was performed twice, and the better result was recorded. A 3-minute rest interval was given between tests to allow recovery. The duration that the participant was able to maintain the test position was recorded in seconds (Büyükturan et al., 2021). The tests we used to assess the endurance of the neck flexor and extensor muscles in our study have been shown in previous studies to have high reliability and validity (Edmondston et al., 2008). Measurements were taken by a single evaluator.

### **Neck Flexor Endurance Test**

The participant was positioned in a supine hook-lying position with the arms resting at the sides. The physiotherapist placed one hand beneath the participant's head to provide support. Participants were instructed to perform a chin tuck by gently drawing the chin toward the

chest, followed by lifting the head approximately 2.5 cm off the surface. They were asked to maintain this position for as long as possible. The duration for which the position was sustained was recorded in seconds. The test was terminated if the participant was unable to maintain the position due to pain or fatigue, or if the head made contact with the physiotherapist's hand (Büyükturan et al., 2021).

### **Neck Extensor Endurance Test**

For this assessment, the participant was instructed to lie in a prone position on the examination table, with the arms resting alongside the body and the head extending beyond the edge of the table at chest level. A 2 kg sandbag was placed over the ear level to provide resistance during the test (Edmondston et al., 2008). The participant was instructed to lift their head, along with the attached weight, to a neutral position and maintain that posture. The time during which the position was sustained was recorded in seconds. The test was discontinued if the participant reported pain or fatigue, or if a deviation of 5° from the neutral head position was observed.

### **Neck Disability Index**

The Neck Disability Index (NDI) is a widely used instrument for evaluating the degree of disability in daily activities associated with neck pain. It comprises 10 items, of which 4 assess subjective symptoms—namely pain intensity, headache, concentration, and sleep—while the remaining 6 evaluate functional activities such as personal care, lifting, reading, work, driving, and recreational engagement. Based on the total score, disability severity is categorized as follows: 0–4 points indicate no disability, 5–14 points mild disability, 15–24 points moderate disability, 25–34 points severe disability, and scores above 35 indicate complete disability (Bicer et al., 2004). Aslan et al. found that the Turkish version of the NDI is a valid and reliable measurement method for assessing disability resulting from problems in the neck region (Aslan et al. 2008).

### **Pain**

Pain intensity during rest and activity was evaluated using the Visual Analog Scale (VAS). This valid and reliable scale developed by Price and colleagues measures the intensity of pain (Güçlü et al., 2013). Participants were asked to indicate their average pain intensity over the past four weeks by marking a point on a 10-centimeter horizontal line, with 0 representing “no pain” and 10 indicating “unbearable pain”. (Cagnie et al., 2009). The results were recorded in centimetres.

## Range of Motion

Cervical range of motion (ROM) was assessed using a universal goniometer. Measurements were taken for cervical flexion, extension, right and left lateral flexion, and right and left rotation. Each movement was measured three times actively. The average value of the measurements was recorded as ROM (Büyükturan et al., 2021) (Table 1). The maximum pain-free range for each movement was measured in degrees (Büyükturan et al., 2018). This method has demonstrated good reliability (Whitcroft et al., 2010).

**Table 1.** Description of Cervical Range of Motion Measurements Obtained by Goniometer.

<b>Range of motion</b>	Description of cervical range of motion measurements obtained by goniometer. Range of Motion Description of goniometer for cervical range of motion (Participants were instructed to sit upright with their spine resting against the back of a chair, looking forwards, with their arms relaxed and their hands resting on the thighs)
<b>Flexion/ Extension</b>	Goniometer axis was positioned at the level of the acromion, with the stable arm parallel to the floor and, at the end of the movement, the moving arm was aligned with the middle line of the ear.
<b>Lateral Flexion</b>	Goniometer axis was placed on the spinous process of the seventh cervical vertebra, with the stable arm parallel to the floor and the moving arm aligned with the midline of the cervical spine.
<b>Rotation</b>	Goniometer axis was positioned at the center of the head, with the stable arm positioned at the center of the head, at the sagittal suture, and at the end of the movement, the moving arm was aligned with a pencil introduced in the mouth of the participant.

## Statistical Analysis

Statistical analyses were performed using appropriate statistical software. The normality of data distribution was assessed using the Kolmogorov–Smirnov test in combination with skewness and kurtosis values. Skewness and kurtosis values between  $-1$  and  $+1$  were accepted as indicative of normal distribution. As all continuous variables demonstrated normal distribution, parametric statistical methods were applied. The relationships between VAS, NDI, ROM, and cervical flexor and extensor endurance test results were examined using the Pearson Correlation Test. A p-value of less than 0.05 was considered statistically significant.

The Sample size was calculated using G\*Power software 3.1 (Universities, Dusseldorf, Germany) (Faul et al., 2009). The Pearson's *r* between cervical endurance and NDI was used to estimate the study's sample size (Dere & Alemdaroğlu-Gürbüz, 2024). The alpha level was set at 0.05, and a statistical power of at least 0.80 was targeted, resulting in a total sample size of 120 participants.

## RESULTS

A total of 120 individuals with neck pain, with a mean age of  $39.7 \pm 9.8$  years, were included in the study. The demographic characteristics of the participants are summarized in Table 2, while the means and standard deviations of the assessed parameters are provided in Table 3. In this study, which investigates the relationship between the endurance of cervical flexors and extensors and pain, disability, and range of motion in individuals with neck pain, a statistically significant relationship was found between the endurance of cervical flexors and the VAS parameter regarding pain at rest; and between the endurance of cervical extensors and NDI, VAS scale, and ROM (only flexion and left rotation) (Table 4).

**Table 2.** Demographic Characteristics of Individuals Participating in the Study

Variables	Minimum	Maximum	Mean	Standard Deviation
Age (years)	19	65	39.7	9.8
Height (cm)	145	187	164.3	8.03
Weight (kg)	46	108	69.9	11.5

The correlation analysis revealed several statistically significant associations between cervical muscle endurance and clinical parameters (Table 3). Cervical flexor endurance demonstrated a weak negative correlation with pain intensity at rest measured by the VAS ( $r = -0.18$ ,  $p = 0.04$ ), indicating that lower flexor endurance was associated with slightly higher resting pain levels. No significant correlations were observed between cervical flexor endurance and disability, pain during activity, or cervical range of motion.

In contrast, cervical extensor endurance showed moderate negative correlations with functional disability (NDI;  $r = -0.33$ ,  $p < 0.001$ ), pain at rest ( $r = -0.24$ ,  $p = 0.006$ ), and pain during activity ( $r = -0.34$ ,  $p < 0.001$ ). These findings suggest that reduced extensor endurance

is moderately associated with increased disability and pain severity. Additionally, cervical extensor endurance exhibited weak to moderate positive correlations with cervical flexion ROM ( $r = 0.19$ ,  $p = 0.03$ ) and left rotation ROM ( $r = 0.17$ ,  $p = 0.05$ ), indicating a limited but significant association between extensor endurance and specific cervical mobility components.

**Table 3.** Means and Standard Deviations of the Evaluated Parameters

		Mean	Standard deviation
<b>Cervical endurance (sec)</b>	Flexion	62.4	30.9
	Extension	109.5	124.6
<b>NDI (0–35 point)</b>		16.4	7.7
<b>VAS (0–10)</b>	Rest	4.3	2.6
	Activity	5.9	2.7
<b>ROM (Degree)</b>	Flexion	43.3	9.6
	Extension	35.4	10.3
	Right lateral flexion	32.7	9.3
	Left lateral flexion	33.5	9.5
	Right rotation	45.6	9.3
	Left rotation	46.7	9.2

NDI: Neck Disability Index, VAS: Visual Analog Scale, ROM: Range of Motion

**Table 4.** Relationship Between Evaluation Parameters

		Cervical Endurance (sec)			
		Flexion		Extension	
		r	p	r	p
<b>NDI</b>		-0.02	0.82	-0.33	<0.001*
<b>VAS</b>	Rest	-0.18	0.04*	-0.24	0.006*
	Activity	-0.08	0.36	-0.34	<0.001*
<b>ROM</b>	Flexion	-0.04	0.65	0.19	0.03*
	Extension	0.05	0.54	0.12	0.18
	Right lateral flexion	0.11	0.21	0.13	0.13
	Left lateral flexion	-0.04	0.60	0.14	0.10

Right rotation	0.10	0.25	0.17	Büyükturan et al. 0.06
Left rotation	0.11	0.21	0.17	0.05*

\*p<0,05, NDI: Neck Disability Index, VAS: Visual Analog Scale, ROM: Range of Motion

## DISCUSSION

The present study investigated the relationships between cervical flexor and extensor muscle endurance and pain intensity, functional disability, and cervical range of motion (ROM) in individuals with chronic neck pain. The main findings indicated that cervical flexor muscle endurance was significantly associated only with pain intensity at rest, whereas cervical extensor muscle endurance demonstrated significant associations with disability, pain intensity both at rest and during activity, and specific components of cervical ROM, namely flexion and left rotation.

These findings are largely consistent with previous studies reporting reduced cervical muscle endurance in individuals with chronic neck pain (De Pauw et al., 2016; Kahlaee et al., 2017; Lee et al., 2005; Schomacher & Falla, 2013). Several authors have emphasized that impairments in cervical muscle endurance, particularly in the extensor muscle group, are common in this population and may contribute to pain persistence and functional limitations. In line with this evidence, our results suggest that cervical extensor endurance may be more closely related to clinical outcomes than flexor endurance.

The limited association observed between cervical flexor endurance and only resting pain may be explained by the differential functional roles of cervical flexor and extensor muscles. Cervical extensors play a critical role in postural control, head stabilization, and resistance to gravitational forces during daily activities. Previous research has suggested that chronic neck pain may exert a greater detrimental effect on extensor muscle performance compared to flexors, potentially due to sustained postural loading and prolonged low-level activation (Edmondston et al., 2008). This may explain why extensor endurance was associated with multiple clinical parameters, including disability, pain severity, and ROM, whereas flexor endurance showed a more limited relationship.

Pain-induced neuromuscular inhibition has been proposed as a key mechanism underlying reduced muscle endurance in individuals with chronic pain conditions (Reddy et al., 2012). Persistent pain may lead to altered motor control strategies, reduced recruitment of deep cervical muscles, and early fatigue. Additionally, structural and functional changes in muscle fiber composition, such as a shift from type I to type II fibers, have been reported in

individuals with neck pain and may contribute to diminished endurance capacity (Falla et al., 2004). Furthermore, the vicious cycle of pain, muscle guarding, reduced flexibility, and declining strength and endurance may exacerbate functional impairment and limit cervical mobility over time (Mukesh, 2017).

Consistent with previous findings, this study also demonstrated significant associations between cervical muscle endurance, functional disability, and ROM. Reduced endurance was associated with higher disability scores and decreased cervical mobility, supporting the notion that impaired muscle performance may play a role in functional limitations observed in individuals with neck pain. The observed relationships between extensor endurance and cervical flexion and rotation ROM suggest that endurance deficits may influence not only pain perception but also movement capacity and motor control.

From a clinical perspective, these findings highlight the importance of assessing cervical muscle endurance—particularly extensor muscle endurance—during the evaluation of individuals with neck pain. Incorporating endurance-based interventions targeting cervical extensor muscles may be beneficial in reducing pain, improving functional ability, and enhancing cervical mobility.

### **Limitations**

Several limitations of this study should be acknowledged. First, the study sample consisted exclusively of female participants, which limits the generalizability of the findings to male populations. Sex-related differences in muscle characteristics and pain perception may influence cervical muscle endurance and clinical outcomes. Second, the cross-sectional design of the study precludes causal inferences regarding the relationships between muscle endurance and clinical parameters. Longitudinal or interventional studies are needed to determine whether improvements in cervical muscle endurance lead to reductions in pain and disability. Additionally, muscle endurance was assessed using clinical endurance tests rather than electromyographic or imaging techniques, which may provide more detailed information regarding muscle activation patterns and structural changes. Despite these limitations, the present study contributes to the existing literature by providing a comprehensive evaluation of the relationships between cervical muscle endurance and key clinical features of chronic neck pain within a single cohort.

### **CONCLUSION**

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Büyükturan et al.

The relationship between cervical flexor and extensor muscle endurance and pain, disability, and cervical ROM in individuals with neck pain was evaluated. The findings revealed that cervical flexor endurance was significantly associated only with resting pain, whereas cervical extensor endurance showed significant associations with disability, pain (both at rest and during activity), and certain ROM components (flexion and left rotation).

## REFERENCES

- Aslan, E., Karaduman, A., Yakut, Y., Aras, B., Simsek, I. E., & Yaglı, N. (2008). The cultural adaptation, reliability and validity of neck disability index in patients with neck pain: a Turkish version study. *Spine*, 33(11), E362-E365.
- Bicer, A., Yazici, A., Camdeviren, H., & Erdogan, C. (2004). Assessment of pain and disability in patients with chronic neck pain: reliability and construct validity of the Turkish version of the neck pain and disability scale. *Disability and Rehabilitation*, 26(16), 959-962. <https://doi.org/10.1080/09638280410001696755>
- Brotzman, S. B., & Manske, R. C. (2011). *Clinical orthopaedic rehabilitation e-book: An evidence-based approach-expert consult (3rd Edition)*. Elsevier Health Sciences.
- Büyükturan, B., Şaş, S., Karartı, C., & Büyükturan, Ö. (2021). The effects of combined sternocleidomastoid muscle stretching and massage on pain, disability, endurance, kinesiophobia, and range of motion in individuals with chronic neck pain: A randomized, single-blind study. *Musculoskeletal Science and Practice*, 55, 102417. <https://doi.org/https://doi.org/10.1016/j.msksp.2021.102417>
- Büyükturan, Ö., Büyükturan, B., Şaş, S., Karartı, C., & Ceylan, İ. (2018). The effect of mulligan mobilization technique in older adults with neck pain: A randomized controlled, double-blind study. *Pain Research and Management*, 2018(1), 2856375. <https://doi.org/https://doi.org/10.1155/2018/2856375>
- Cagnie, B., Derese, E., Vandamme, L., Verstraete, K., Cambier, D., & Danneels, L. (2009). Validity and reliability of ultrasonography for the longus colli in asymptomatic subjects. *Manual therapy*, 14(4), 421-426. <https://doi.org/https://doi.org/10.1016/j.math.2008.07.007>
- De Pauw, R., Coppieters, I., Kregel, J., De Meulemeester, K., Danneels, L., & Cagnie, B. (2016). Does muscle morphology change in chronic neck pain patients? – A systematic review. *Manual therapy*, 22, 42-49. <https://doi.org/https://doi.org/10.1016/j.math.2015.11.006>
- Dere, T., & Alemdaroğlu-Gürbüz, İ. (2024). Muscular endurance and its association with neck pain, disability, neck awareness, and kinesiophobia in patients with chronic neck pain. *Somatosensory & Motor Research*, 41(3), 134-141. <https://doi.org/10.1080/08990220.2023.2186390>
- Edmondston, S. J., Wallumrød, M. E., MacLéid, F., Kvamme, L. S., Joebges, S., & Brabham, G. C. (2008). Reliability of isometric muscle endurance tests in subjects with postural neck pain. *Journal of manipulative and physiological therapeutics*, 31(5), 348-354.
- Falla, D., Bilenkij, G., & Jull, G. (2004). Patients With Chronic Neck Pain Demonstrate Altered Patterns of Muscle Activation During Performance of a Functional Upper Limb Task. *Spine*, 29(13), 1436-1440. <https://doi.org/10.1097/01.Brs.0000128759.02487.Bf>
- Falla, D. L. (2008). Neuromuscular control of the cervical spine in neck pain disorders. In *Fundamentals of musculoskeletal pain* (pp. 417-430). IASP Press.
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G\*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41(4), 1149-1160. <https://doi.org/10.3758/BRM.41.4.1149>
- Fejer, R., Kyvik, K. O., & Hartvigsen, J. (2006). The prevalence of neck pain in the world population: a systematic critical review of the literature. *European spine journal*, 15(6), 834-848.
- Frouzaniyan, M., Shirdel, S. S., Meskar, H., Shahrezaee, M., Chamanara, M., Ghanbarpour Juybari, A., & Abdollahi, A. (2025). Muscle Morphology and Its Role in Chronic Neck Pain: A Review Article. *Translational Health Reports*, 1(1), 1-11.
- Güçlü, D. G., Şenormancı, A. Ö., Gönüllü, B. O., Çırak, B. M., Konkan, A. R. ve Erkıran, M. B. (2013). Kronik Boyun Ağrılı Hastalarda Psikopatolojinin Yaşam Kalitesi ve Yetim Yitimine Etkisi. *Türkiye Klinikleri Journal of Medical Sciences*, 33(3), 702-10.
- Kahlaee, A. H., Rezasoltani, A., & Ghamkhar, L. (2017). Is the clinical cervical extensor endurance test capable of differentiating the local and global muscles? *The Spine Journal*, 17(7), 913-921. <https://doi.org/https://doi.org/10.1016/j.spinee.2017.01.014>
- Kim, J. H., Lee, H. S., & Park, S. W. (2015). Effects of the active release technique on pain and range of motion of patients with chronic neck pain. *Journal of physical therapy science*, 27(8), 2461-2464. <https://doi.org/10.1589/jpts.27.2461>
- Lee, H., Nicholson, L. L., & Adams, R. D. (2005). Neck Muscle Endurance, Self-Report, and Range of Motion Data From Subjects With Treated and Untreated Neck Pain. *Journal of manipulative and physiological therapeutics*, 28(1), 25-32. <https://doi.org/https://doi.org/10.1016/j.jmpt.2004.12.005>
- Medeni, İ., Medeni, V., Yıldız, E. T., & İlhan, M. N. (2025). Musculoskeletal pains, eye symptoms and associated factors among office workers: a cross-sectional study from Turkey. *International Journal of Occupational Safety and Ergonomics*, 31(1), 337-344.
- Mukesh, P. A. (2017). Cervical Flexor Endurance, ROM, and Disability in Subjects with Neck Pain: A Correlative Study. *Website: www.ijpot.com*, 11(3), 156.

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Büyükturan et al.

- O'Leary, S., Falla, D., Elliott, J. M., & Jull, G. (2009). Muscle Dysfunction in Cervical Spine Pain: Implications for Assessment and Management. *Journal of Orthopaedic & Sports Physical Therapy*, 39(5), 324-333. <https://doi.org/10.2519/jospt.2009.2872>
- O'Leary, S., Jull, G., Kim, M., & Vicenzino, B. (2007). Cranio-cervical flexor muscle impairment at maximal, moderate, and low loads is a feature of neck pain. *Manual therapy*, 12(1), 34-39. <https://doi.org/https://doi.org/10.1016/j.math.2006.02.010>
- Reddy, R. S., Maiya, A. G., & Rao, S. K. (2012). Effect of dorsal neck muscle fatigue on cervicocephalic kinaesthetic sensibility. *Hong Kong Physiotherapy Journal*, 30(2), 105-109. <https://doi.org/https://doi.org/10.1016/j.hkpj.2012.06.002>
- Schomacher, J., & Falla, D. (2013). Function and structure of the deep cervical extensor muscles in patients with neck pain. *Manual therapy*, 18(5), 360-366. <https://doi.org/https://doi.org/10.1016/j.math.2013.05.009>
- Sterling, M., Jull, G., Vicenzino, B., Kenardy, J., & Darnell, R. (2003). Development of motor system dysfunction following whiplash injury. *Pain*, 103(1), 65-73. [https://doi.org/10.1016/s0304-3959\(02\)00420-7](https://doi.org/10.1016/s0304-3959(02)00420-7)
- Whitcroft, K. L., Massouh, L., Amirfeyz, R., & Bannister, G. (2010). Comparison of methods of measuring active cervical range of motion. *Spine*, 35(19), E976-E980.
- Yazar, T., & Altun, N. (2007). *Dejeneratif omurga hastalıkları (1. Baskı)*. Türk Omurga Derneği Yayınları -2.