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The Cervical Muscle System In Health And Disease: Structural And Functional Alterations

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Abstract: The purpose of this review is to analyze the anatomical structure of the cervical musculature and to describe the main morphological and functional changes occurring in neck muscles under various pathological conditions. A narrative review of scientific publications from 2015–2025 was conducted using PubMed, Scopus, ScienceDirect, and Google Scholar databases. The neck muscles form a complex anatomical system responsible for stability, mobility, and proprioception of the cervical spine. Pathological processes such as degenerative, postural, or traumatic disorders cause atrophy, fatty infiltration, and altered neuromuscular activation, especially in the deep stabilizing muscles. Understanding the anatomy and pathological remodeling of neck muscles provides the foundation for accurate diagnosis, rehabilitation, and prevention of cervical disorders.

Keywords: Neck muscles, cervical anatomy, muscle pathology, degenerative changes, whiplash, cervical dystonia, posture disorders, muscle morphology, electromyography, rehabilitation.

Introduction: The cervical region is one of the most anatomically and functionally complex structures of the human body. It contains multiple layers of muscles that maintain the balance of the head, ensure cervical stability, and protect vital neurovascular elements. Neck muscles participate in flexion, extension, rotation, and lateral bending of the head and neck, while also contributing to respiration, phonation, and posture control [1,2]. Because of their structural complexity and constant mechanical loading, these muscles are prone to various pathological conditions. Chronic strain, degenerative spine changes, trauma, or prolonged static posture can lead to anatomical remodeling manifested by muscular atrophy, fatty degeneration, and dysfunction [3–6]. From the anatomical viewpoint, the cervical musculature is divided into anterior, lateral, and posterior groups. The anterior muscles, including the sternocleidomastoid, longus colli, and infrahyoid muscles, act as primary flexors and stabilizers. The lateral compartment is represented by the scalene group, which assists in lateral flexion and respiration. Posteriorly, the splenius, semispinalis, multifidus, and suboccipital groups maintain extension and fine control of motion [2,3]. Of particular anatomical interest is the myodural bridge, which links the suboccipital muscles to the spinal dura mater and may play a role in cervicogenic headaches [6].

The aim of the present study is to summarize and systematize current knowledge about the anatomy and pathology of the neck musculature, integrating morphological, radiological, and functional perspectives to highlight its clinical significance.

METHODS

A comprehensive narrative literature review was performed according to the IMRAD structure. Electronic searches were conducted in PubMed, Scopus, and Google Scholar databases for English-language papers published between 2015 and 2025. Search terms included “neck muscles anatomy,” “cervical muscle pathology,” “muscle morphology MRI,” “whiplash,” “cervical dystonia,” and “postural neck pain.” Additional sources included classical anatomical reviews and recent clinical studies. Preference was given to works providing imaging data, morphological quantification, or neuromuscular analysis. Data extraction focused on identifying recurrent anatomical patterns and pathological mechanisms. Relevant related studies in medical and rehabilitation sciences were also included to ensure a multidisciplinary perspective [7,10–12].

RESULTS

The neck muscles demonstrate a complex layered organization with clearly differentiated biomechanical functions. Deep cervical muscles such as the longus colli, longus capitis, semispinalis cervicis, and multifidus serve as dynamic stabilizers of the cervical spine. Superficial muscles, including the sternocleidomastoid, trapezius, and splenius, provide larger movement arcs and postural support [1,3,4]. Imaging and morphological studies have confirmed that pathological conditions lead to measurable alterations in muscle architecture. Elliott et al. [3] described the regional organization of cervical musculature based on MRI segmentation, which allows objective quantification of cross-sectional area (CSA) and muscle fat infiltration (MFI). Peolsson et al. [4] demonstrated significant MFI increase and CSA reduction in the deep anterior muscles of patients with chronic whiplash-associated disorders. These findings indicate that deep muscles are more susceptible to degenerative remodeling than superficial ones, possibly due to their stabilizing function and high spindle density.

In chronic neck pain, EMG and ultrasound studies have revealed delayed activation of deep flexors and hyperactivity of superficial extensors, leading to impaired load distribution and persistent discomfort [7,9,11]. Cervical dystonia represents another pathology where involuntary contractions of the sternocleidomastoid and splenius muscles cause asymmetric hypertrophy and secondary degenerative changes [13]. Degenerative cervical spine diseases, including spondylosis and disc herniation, result in compensatory hypertrophy or atrophy of adjacent musculature, contributing to spinal imbalance and proprioceptive impairment [8,9]. Moreover, modern lifestyle factors such as prolonged smartphone use have produced a growing prevalence of forward head posture ("text neck"), which chronically overloads the posterior muscles and weakens the deep flexors [14,15].

Recent technological advances, including wearable posture sensors and biomechanical modeling, have introduced new methods to evaluate cervical strain dynamically. Studies using systems like "NeckCheck" demonstrated that sustained flexion angles above 45° significantly increase cervical extensor tension and fatigue, providing new evidence for preventive ergonomics [15]. Collectively, these results emphasize the anatomical vulnerability of deep cervical muscles and the need for early detection and rehabilitation.

DISCUSSION

The analysis of the reviewed data reveals that pathological transformations of the neck muscles share several common anatomical features. The most consistent findings across various disorders include reduction of CSA, fatty infiltration, asymmetry, and altered activation patterns [3,4,7]. These changes are especially evident in deep stabilizing muscles, confirming their key role in maintaining segmental control and proprioception [5]. Chronic dysfunction of deep flexors and extensors leads to biomechanical imbalance, secondary strain of superficial muscles, and eventual progression to chronic pain syndromes [9,11].

The myodural bridge, linking suboccipital muscles to the spinal dura mater, provides an anatomical substrate for cervicogenic headaches and neck-related dizziness, as its tension can influence dural dynamics and pain perception [6]. In cervical dystonia, anatomical remodeling manifests as selective hypertrophy and fibrosis, while degenerative spinal diseases trigger adaptive hypertrophy and subsequent fatigue of extensor groups [8,13]. Postural syndromes such as forward head posture represent an emerging public health issue that demonstrates the interplay between habitual behavior and anatomical adaptation. Despite advances in imaging, standardization of measurement protocols for cervical muscle morphology remains insufficient. Differences in slice positioning, ROI delineation, and normalization methods limit interstudy comparability. Future studies should integrate imaging biomarkers (CSA, MFI) with biomechanical modeling and functional outcomes to establish reliable anatomical indicators of muscle health. Rehabilitation protocols should focus on reactivation and strengthening of deep stabilizing muscles, correction of posture, and controlled dynamic loading. Multimodal approaches combining manual therapy, sensorimotor retraining, and ergonomic modification have shown the best outcomes in restoring muscle balance and reducing pain [9,15].

CONCLUSION

The neck musculature exhibits a highly specialized and multilayered anatomy essential for cervical stability, head mobility, and neuromuscular control. Pathological conditions, whether traumatic, degenerative, or postural, induce characteristic anatomical and morphological changes, primarily in the deep stabilizing muscles. Recognition of these structural transformations is critical for accurate diagnosis and targeted rehabilitation. A comprehensive anatomical understanding of neck muscle pathology bridges the gap between clinical symptoms and biomechanical function, contributing to more effective therapeutic strategies. Further longitudinal and multidisciplinary studies are needed to elucidate the temporal dynamics of cervical muscle remodeling and to develop preventive measures against posture-related disorders [3–15].

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