

Anatomical Variations of the Trapezius Muscle: Biomechanical and Functional Implications

Anna Puchalska-Sarna¹, Ewa Lenart-Domka², Jadwiga Trzeciak³, Grzegorz Domino⁴, Michał Sarna⁵, Katarzyna Walicka-Cupryś⁶

¹ *University of Rzeszów, Medical College, Faculty of Health Sciences and Psychology, Institute of Physiotherapy, Poland*

² *University of Rzeszów, Medical College, Faculty of Medicine, Department of Pediatrics, Poland*

³ *University of Rzeszów, Medical College, Faculty of Medicine, Department of Pediatrics, Poland*

⁴ *University of Rzeszów, Faculty of Physical Culture Sciences, Study of Physical Education and Recreation, Rzeszów, Poland*

⁵ *University of Rzeszów, Faculty of Physical Culture Sciences, Study of Physical Education and Recreation, Rzeszów, Poland*

⁶ *University of Rzeszów, Medical College, Faculty of Health Sciences and Psychology, Institute of Physiotherapy, Poland*

Introduction

Trapezius dorsi muscle (*musculus The trapezius*) plays a key role in the mobility and stabilization of the scapula and shoulder girdle. The scapula is the attachment site for many muscles that cooperate to enable precise movements of the upper limb. The literature lacks consideration of a situation in which the trapezius muscle completely covers the scapula, taking over its functions. The aim of this article is to consider the biomechanical and functional consequences of such a hypothetical situation. The analysis indicates that complete coverage of the scapula by the trapezius muscle would result in significant limitation of arm rotation and stabilization, as well as muscle overload. Further research is proposed to explore the possibilities of muscle compensation within the shoulder girdle.

This article presents theoretical considerations regarding the biomechanical and functional consequences of a situation in which the trapezius muscle completely covered the scapula, taking over its functions and limiting the action of the remaining muscles.

Anatomy of the trapezius muscle

Structure:

The trapezius muscle is a large, flat, diamond-shaped muscle that resembles a hood.

Starting trailers:

- external occipital protuberance and superior nuchal line (medial part),
- nuchal ligament,
- spinous processes of the C7 vertebra and all thoracic vertebrae,
- parts of the supraspinous ligament.

The initial tendon expands in three places:

1. in the area of the external occipital protuberance (often fuses with the sternocleidomastoid tendon),
2. at the level of C7 and the upper thoracic vertebrae,
3. at the height of Th11–Th12 (triangular area).

End trailers:

- upper fibers → shoulder end of the clavicle,
- middle fibers → acromion and scapular crest,
- lower fibers → medial part of the upper edge of the scapular crest.

Action:

- Upper part: raises the shoulder by approximately 10 cm, supports weight on the shoulder joint; with the shoulder fixed, flexes the head backward.
- Middle section: pulls the shoulder blade towards the spine.
- Lower part: lowers the shoulder or – with a fixed shoulder girdle – lifts the torso upwards.

The joint action of the upper and lower parts causes the rotation of the scapula:

- the upper angle approaches the spine,
- the lower angle moves forward and laterally,
- the joint socket is directed upwards → allowing the arm to be raised above the horizontal.

Overall action:

The trapezius muscle retracts the shoulder and pulls and presses the scapula toward the rib cage. The effect of lifting and rotating the scapula is dominant over lowering it.

Damage:

When the muscle is paralyzed, the shoulder drops, moves forward, and the medial edge of the scapula becomes oblique – from above downwards and inwards [1,2].

Trapezius muscle variations described in the literature

1. Anatomical abnormalities in the posterior triangle of the neck are rare and are estimated to affect approximately 2% of the population [3, 4]. They include, among others, a different location, range or extent of the origin of the trapezius muscle (*musculus trapezius*), as well as changes in the course of the neurovascular structures in this area. The posterior part of the neck triangle, bounded by the posterior border of the sternocleidomastoid muscle, the anterior border of the trapezius muscle, and the clavicle, is an important area both functionally and surgically.

Variations in the attachment of the trapezius muscle can affect the biomechanics of the shoulder girdle and cervical spine. This muscle plays a key role in scapular stabilization and movement, including elevation, retraction, and external rotation. Abnormalities in its structure can lead to limited range of motion in the upper limbs, particularly in elevation and abduction, as well as reduced head and neck mobility. This can result in secondary scapular dyskinesia, muscle overload, and pain in the shoulder girdle and cervical spine.

From a surgical perspective, these anomalies have significant practical implications. The trapezius muscle is sometimes used as a muscle flap in soft tissue reconstructions of the head and neck. Abnormal structure, altered vascularization, or altered innervation (particularly with respect to the accessory nerve – *n. accessorius*) may constitute a relative or absolute contraindication to performing a trapezius flap [5, 6].

2. The trapezius muscle exhibits a wide morphological variability, including anomalous origins or partial/complete absence of the muscle. Mehra et al. [7] described a rare case of bilateral absence of the cervical spine in which each side of the muscle was shaped like a right triangle from C5 to Th10, forming an isosceles triangle instead of the typical trapezius muscle, termed the dorsoscapular triangle.

Trapezius muscle (*musculus trapezius*) is characterized by significant morphological variability, both in terms of the range of attachments and the structure of individual parts (descending, transverse, and ascending). Cases of abnormal fiber origin, asymmetry, additional muscle bands, and partial or complete absence of one of the muscle parts have been described. These variations can be unilateral or bilateral and are often detected incidentally during anatomical dissections or imaging studies.

Mehra S. et al. [7] presented a particularly rare case of bilateral absence of the cervical segment of the trapezius muscle. In their specimen, each side of the muscle assumed the shape of a right triangle, extending from the C5 to Th10 level. The two triangular muscle bands together formed a structure resembling an isosceles triangle, instead of the typical trapezoidal shape of the muscle. The authors termed this variant a "dorso-scapular triangle."

This type of anomaly significantly alters the topography of the posterior neck and upper back. The absence of the cervical spine, which physiologically controls scapular elevation and contributes to

extension and lateral flexion of the cervical spine, can lead to impaired shoulder girdle stabilization. Potential consequences include weakened shoulder elevation, reduced control of scapular rotation, and increased strain on other stabilizing muscles, such as the levator scapulae and rhomboids [7].

3. Congenital absence of skeletal muscle (agenesia or aplasia) is a rare developmental anomaly, estimated to occur in approximately 0.3–1.9% of the population. It may affect a single muscle, parts of it, or, less frequently, entire muscle groups. These disorders most often result from abnormalities in the development of the paraxial mesoderm and somites during embryogenesis, leading to impaired myoblast differentiation and the formation of primitive muscle buds.

In the case of the trapezius muscle, the causes of its congenital absence may be:

- inflammatory – associated with intrauterine inflammatory processes that disrupt tissue development,
- vascular – resulting from vascularization disorders in the prenatal period (e.g. transient ischemia),
- neuropathic – associated with abnormal development or damage to the accessory nerve (n. accessorius), which determines the proper differentiation and function of the muscle,
- myopathic – a consequence of primary disorders of muscle tissue development.

Trapezius agenesis may also be part of a broader clinical picture of congenital defects. It has been reported in Poland syndrome, which is characterized by unilateral absence or underdevelopment of the chest muscles (most often the pectoralis major), often accompanied by upper limb deformities. Another example is Klippel-Feil syndrome, which involves congenital fusion of the cervical vertebrae, which may be accompanied by impaired development of the neck and shoulder muscles.

Clinically, congenital absence of the trapezius muscle can lead to shoulder girdle asymmetry, shoulder depression on the affected side, weakened scapular elevation and rotation, and secondary postural abnormalities. Compensatory hypertrophy of other scapular stabilizing muscles, such as the levator scapulae and rhomboids, often occurs. However, in some cases, the defect remains asymptomatic and is diagnosed incidentally during imaging studies or surgical procedures [8].

4. Emsley J. et al. [12] presented a case report of an 89-year-old man with marked asymmetry of the trapezius muscle. The left muscle was significantly smaller than the right, and the differences were most visible in the caudal (lower) part. Even on macroscopic examination, the fibers on the left side were lighter in color, which may suggest an altered histological structure, lower muscle mass, or a predominance of fibers of a different metabolic type.

Morphometric analysis revealed that the fiber thickness of the left muscle below the scapula was only one-third to two-thirds that of the right. Furthermore, the vertebral insertion of the lower fibers on the left side was higher, shortening the vertical range of the muscle and altering its geometry. The total surface area of the left muscle was approximately 50% of the surface area of the right, confirming significant unilateral hypoplasia. Additionally, a different fiber orientation was noted, which could influence the direction of force generation and the effectiveness of scapular stabilization.

From a functional perspective, such asymmetry can lead to muscular imbalances in the shoulder girdle. The inferior portion of the trapezius plays a key role in scapular depression and external rotation, and its underdevelopment can contribute to shoulder elevation, scapulohumeral rhythm disturbances, and secondary overload of the rotator cuff structures. However, in elderly individuals, it is difficult to definitively determine whether the observed changes are congenital or the result of long-term denervation, degenerative changes, or age-related involution [9].

5. Allouch H. et al. [13] described an exceptionally rare case of complete agenesis of the left trapezius muscle in an 87-year-old man. Autopsy revealed a complete absence of muscle structures on the left side – from the occipital and nuchal attachments to the lower part, including the spinous processes of the thoracic spine and the attachments to the scapula and clavicle.

Importantly, muscle agenesis was also accompanied by unilateral absence of the left accessory nerve (nervus accessorius) and the absence of a vascular pedicle supplying the muscle. The coexistence of these abnormalities suggests a primary developmental disorder involving both muscular and neurovascular components. The lack of innervation may have prevented proper differentiation and development of myoblasts during the embryonic period, leading to complete muscle aplasia.

Anatomically, the absence of the trapezius muscle significantly alters the topography of the posterior triangle of the neck. Structures typically covered by the muscle—including the cervical plexus, brachial plexus, and subclavian vessels—may be more superficial and less protected. This has clinical implications for surgical procedures, lymph node biopsies, and nerve blocks in this area.

Functionally, complete absence of the trapezius muscle can lead to marked asymmetry of the shoulder girdle, shoulder depression on the affected side, difficulty with scapular elevation and retraction, and disturbances in the scapulohumeral rhythm. In the described case, however, due to the patient's advanced age, partial compensation of function was possible through compensatory mechanisms – primarily through increased activity of the levator scapulae, rhomboids, and serratus anterior [10].

6. Hug et al. [14] described a 48-year-old patient with chronic right upper extremity pain who had an accessory portion of the trapezius muscle crossing the upper portion of the brachial plexus. Resection of the abnormal muscle and release of the clavicular portion of the sternocleidomastoid muscle alleviated the symptoms [11].

7. Kwak et al. [12] described a case of anatomical variation of the trapezius muscle in a Korean woman in whom the lateral 3/4 of the descending part was separated from the rest of the muscle and attached to the clavicle by a tendon.

8. Newman et al. [13] reported a case of a 5-year-old child and his father. The child had bilateral trapezius aplasia with myopathy and camptodactyly. The father had partial, unilateral trapezius hypoplasia without functional impairment, accompanied by lateral displacement of the right scapula and mild bilateral camptodactyly.

9. Garbelotti et al. [14] described a partial, unilateral absence of the trapezius muscle in an adult black man. The ascending and descending fibers of the middle portion were replaced by a wide, 2 mm fascia, in which histology showed the presence of sparse muscle fibers.

10. Nooij et al. [15] described the complete absence of the descending and transverse parts of the trapezius muscle, with the preservation of a few fibers in the ascending part.

11. Gross- Kieselstein et al. [16] reported cases of siblings with complete absence of the trapezius muscle. The 17-year-old patient had no trapezius muscle on the back and no pectoralis major muscle anteriorly. His older brother, aged 28, had absent trapezius muscle and unilateral absence of the pectoralis major muscle on the right side.

12. Stacey et al. [17] reported a case in which the trapezius muscle was innervated solely by the cervical plexus, without any branches of the accessory nerve. The results confirm that complete paralysis of the trapezius muscle does not always occur after loss of the accessory nerve during radical neck dissection.

13. Beaton et al. [18] described numerous deviations of trapezius muscle attachments, including anomalies of attachment to the vertebrae or nuchal ligament, asymmetry between sides, and abnormal muscle size.

14. According to Bing [19], The trapezius muscle, alongside the pectoralis major, often exhibits morphological abnormalities, although this is poorly documented in the literature. Located in the upper back, it rarely reveals abnormalities that may be noticeable clinically, intraoperatively, or at autopsy. These changes have functional significance and should be addressed before harvesting a trapezius flap.

15. Anatomical deviations of the trapezius muscle may have a genetic basis [16, 20] or embryological [21,3]

16. The trapezius muscle develops from the branchial musculature. In the 7 mm embryo, it develops ventral to the two caudal occipital myotomes and the two anterior cervical myotomes, and in the 9 mm embryo, it divides into the sternocleidomastoid and trapezius portions. In the 11 mm embryo, the trapezius extends to the 6th pair of cervical nerves, remaining unattached to the shoulder skeleton and separated by the cervical fascia. In the 16 mm embryo, the muscle attaches to the scapular spine and clavicle, and only in the 20 mm embryo does it reach its final configuration [22].

After 2017, there has been a significant increase in the number of studies focusing on the anatomical variation of the accessory nerve (nervus accessorius, CN XI) and its relationship with the trapezius muscle (*musculus trapezius*). In contrast to earlier works, which focused mainly on the morphological variants of the muscle itself, more recent publications primarily analyze the differentiation of its innervation and the clinical implications of these variants.

In an anatomical study published in 2023 by Lin et al. in the journal *Scientific Reports* analyzed 15 cadaver preparations, covering a total of 24 accessory nerves. The authors assessed in detail the course of the accessory nerve branches innervating the trapezius muscle. Four distinct patterns of nerve branch

course were identified in relation to the sternocleidomastoid muscle (*musculus sternocleidomastoideus*). In most cases, the branch to the trapezius muscle entered its parenchyma as a single nerve trunk; however, in approximately 21% of cases, the presence of two separate branches innervating the muscle was observed, indicating significant anatomical variability. Furthermore, a variable number of cervical root contributions (from 0 to 3) to the branches destined for the trapezius muscle was demonstrated. These results emphasize that the variability in the course of the accessory nerve may partially explain the varying degrees of muscle dysfunction after neck surgery, especially during *neck surgery. dissection* [23].

Significant clinical data were presented by Anehosur et al. (2021) in a prospective study published in *the Journal of Maxillofacial and Oral Surgery*. The analysis included 50 patients undergoing neck surgery between 2016 and 2018. The authors demonstrated that the accessory nerve presents diverse topographic relationships to the internal jugular vein and the sternocleidomastoid muscle—running between, anterior to, or posterior to these structures. In many cases, variable contributions of cervical fibers (C2, C3) to the branches innervating the trapezius muscle were also observed. Based on these observations, new landmarks were proposed to facilitate nerve identification during surgical procedures. The authors emphasized that intraoperative recognition of accessory nerve variants is crucial for preventing functional complications, including weakened shoulder elevation and impaired scapular stabilization [24].

Roberts and Cardozo (2024) presented a comprehensive approach to this issue in a review published in *Anatomical Science International*. The authors systematized the current knowledge regarding the anatomy and variability of the accessory nerve, with particular emphasis on its relationship with the cervical plexus and its pathway to the trapezius muscle. They demonstrated significant variability in the nerve's course, the presence of anastomoses with branches of the cervical plexus, and the diversity of cervical root contributions. They emphasized that this variability has not only surgical but also diagnostic significance, particularly in the interpretation of imaging studies and neurophysiological analyses [25].

The literature also contains studies indirectly related to the function of the trapezius muscle. Melo et al. (2023) analyzed the H-reflex in the trapezius muscle in patients with shoulder pain, demonstrating potential differences in neural activation compared to healthy individuals [26]. Banerjee et al. (2022) described a rare case of a "star-shaped" branching pattern of the accessory nerve, which further supports the possibility of variability in its branching [27]. Quang et al. (2025), based on cadaver studies, indicated variation in the number and distribution of nerve branches within the muscle, which may be important when planning therapeutic injections, nerve blocks, and reconstructive procedures [28].

To date, there has been no reported case of the trapezius muscle completely covering the scapula. This observation broadens the spectrum of possible anomalies.

Description of the hypothetical variant:

The proposed anatomical variant is characterized by:

- expansion of muscle fibers beyond typical attachments,

- covering the entire dorsal surface of the scapula (supraspinatus fossa, infraspinatus fossa, inferior angle, medial border),
- covering the rotator cuff muscles (m. supraspinatus , m. infraspinatus) and part of the teres minor muscle.

Discussion:

This variant could have significant consequences:

- mechanical limitation of the rotator cuff function,
- the advantage of the trapezius in stabilizing the scapula,
- possibility of misinterpretation in imaging studies (MRI, CT) as a tumor or hypertrophy.
- The trapezius muscle, despite its size and strength, is not adapted to take over all the functions of the other muscles attached to the scapula. Overloading it can lead to chronic muscle tension, neck and back pain, as well as limited range of motion and impaired neuromuscular coordination.

Although this variant has not yet been described, it can be considered as a hypothetical extension of the spectrum of trapezius anomalies.

Conclusions:

A new, hypothetical variant of the trapezius muscle is proposed. Its eventual discovery in autopsy or imaging studies would expand our understanding of anatomical variability in the muscles of the upper limb girdle.

Conclusions and proposals for further research

This hypothetical situation, although unconfirmed by anatomical studies, is an interesting topic for further investigation into the biomechanics and functional anatomy of the shoulder girdle. Future studies should incorporate EMG analyses, MRI imaging, and computer models to help understand potential compensatory mechanisms and the role of the trapezius muscle in shoulder stabilization and movement.

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