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## Quantitative Anatomy of the Trapezius Muscle in the Human Fetus

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of article

### Abstract

**Background.** The trapezius muscle consists of three parts that are capable of functioning independently. Its superior part together with the levator scapulae and rhomboids elevate the shoulder, the middle part retracts the scapula, while the inferior part lowers the shoulder.

**Objectives.** The present study aimed to supplement numerical data and to provide growth dynamics of the trapezius in the human fetus.

**Material and Methods.** Using methods of anatomical dissection, digital image analysis (NIS Elements AR 3.0), and statistics (Student's t-test, regression analysis), we measured the length, the width and the surface area of the trapezius in 30 fetuses of both sexes (13♂, 17♀) aged 13–19 weeks.

**Results.** Neither sex nor laterality differences were found. All the studied parameters of the trapezius increased proportionately with age. The linear functions were computed as follows:  $y = -103.288 + 10.514 \times \text{age}$  ( $r = 0.957$ ) for total length of the trapezius muscle,  $y = -67.439 + 6.689 \times \text{age}$  ( $r = 0.856$ ) for length of its descending part,  $y = -8.493 + 1.033 \times \text{age}$  ( $r = 0.53$ ) for length of its transverse part,  $y = -27.545 + 2.802 \times \text{age}$  ( $r = 0.791$ ) for length of its ascending part,  $y = -19.970 + 2.505 \times \text{age}$  ( $r = 0.875$ ) for width of the trapezius muscle, and  $y = -2670.458 + 212.029 \times \text{age}$  ( $r = 0.915$ ) for its surface area.

**Conclusions.** Neither sex nor laterality differences exist in the numerical data of the trapezius muscle in the human fetus. The descending part of trapezius is the longest, while its transverse part is the shortest. The growth dynamics of the fetal trapezius muscle follows proportionately (*Adv Clin Exp Med* 2016, 25, 4, 605–609).

**Key words:** surface area, human fetuses, trapezius muscle, length, width.

The trapezius, the largest and the most superficial of the upper back and neck muscles, consists of three different but complementary anatomical and functional subdivisions: Descending, transverse and ascending [1, 2]. The trapezius originates from the medial third of the superior nuchal line and external occipital protuberance, the ligamentum nuchae, and spinous processes of C7–T12 vertebrae [2–5]. The insertions of every part of the trapezius refer to various aspects of the scapula and clavicle [6]. The upper third inserts onto the lateral superior aspect of the clavicle, the middle third inserts into the medial part of the acromion and the lower third ends on the spine of the scapula [2]. The descending, transverse and ascending parts of the

trapezius have been referred to as cleido-occipitalis, dorso-scapularis superior and dorso-scapularis inferior, respectively [5].

By voluntary command, each part of the trapezius is capable of functioning either independently or cooperatively [3, 7, 8]. With levator scapulae the trapezius elevates the scapula, with the serratus anterior it rotates the scapula upwards, and with the rhomboids it retracts the scapula. With the shoulder fixed [6, 9], it may flex both the head and the neck in the posterior-lateral direction. The trapezius also belongs to the main stabilizers of the shoulder girdle [2, 7]. It plays a substantial role in fixing and elevating the shoulder joint. Trapezius disorders are often considered to be involved

in shoulder rigidity [10]. As an auxiliary muscle in breathing, the trapezius facilitates respiration, and so may be overworked in individuals with breathing problems, such as asthma and pulmonary emphysema [6].

To date, however, little is known in the medical professional literature about the algebraic data for the trapezius muscle in the human fetus [11]. Thus, in the present study we sought to elucidate numerical information about the growth dynamics of the trapezius. Therefore, in the material under examination we set to examine:

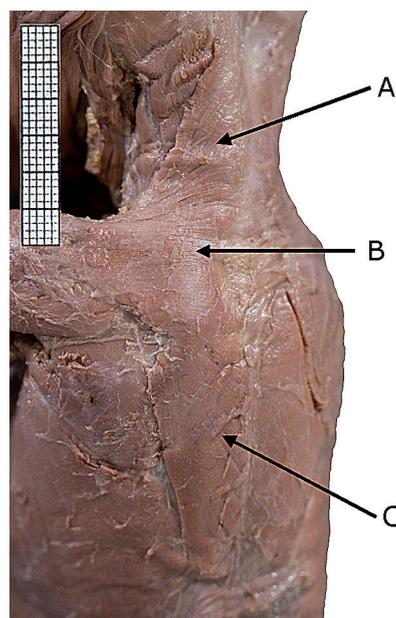
- normative values for its three parts in terms of length, width and surface area at varying gestational ages,
- the growth curves of best-fit for all the features studied, and
- the impact of sex and side on the values of the parameters examined.

## Material and Methods

The examinations were carried out on 30 human fetuses of both sexes (11 males, 19 females) from the age of 13–19 weeks. The fetuses were derived from spontaneous abortions and stillbirths. All fetuses were preserved by having been immersed in 10% neutral formalin solution. Since none of the subjects presented conspicuous malformations, the sample could be regarded as normal. Every trapezius muscle was visualized by anatomical dissection, recorded with a millimeter scale using a camera (SONY  $\alpha$ 330), and thereafter analyzed by the digital image analysis system of NIS Elements AR 3.0 (Fig. 1). The experiment was sanctioned by our University Ethics Committee (KB 72/2012). For each muscle the following 6 parameters were computed:

- 1) total length of the trapezius muscle, measured from its origin to its termination,
- 2) length of the descending part, measured from its origin to its termination,
- 3) length of the transverse part, measured from its origin to its termination,
- 4) length of the ascending part, measured from its origin to its termination,
- 5) width of the trapezius muscle, measured at its widest level, and
- 6) surface area ( $\text{mm}^2$ ) of the trapezius muscle.

Subsequently, in the present study the statistical program STATISTICA 12.5 was used. The statistical analysis was started by evaluating the probability of statistically significant differences appearing in values with relation to male-female (Student's t-test for unpaired variables) and right-left (Student's t-test for paired variables). Regres-



**Fig. 1.** The trapezius muscle in a male fetus aged 19 weeks: A – descending part; B – transverse part; C – ascending part

sion analysis was used to derive the curve of best-fit for the plot for each morphometric parameter vs. gestational age.

## Results

In all the studied individuals, the trapezius muscle extended typically. Neither laterality nor sex differences ( $p > 0.05$ ) between the parameters studied were found. These statistical findings have been precisely displayed in Table 1. Thus, for further analysis our numerical data has been aggregated for both sexes and sides.

Between 13 and 19 weeks of gestation, the values for total length of the trapezius muscle ranged from 38.95 to 99.98 mm respectively, with the mean of 67.04 mm. During the analyzed period, the length of the descending part of the trapezius gradually gained from 20.51 to 63.59 mm respectively, on average of 40.93 mm. The transverse part increased in length from 2.96 to 14.59 mm, averaging 8.25 mm. Between 13 and 19 gestational weeks, the values for the length of the ascending part of the trapezius alternated from 10.21 to 32.83 mm respectively, and averaged 17.84 mm. The values of the width of the trapezius varied from 12.15 to 27.62 mm, and averaged 20.61 mm. At the age range of 13–19 weeks of gestation, the surface area of the trapezius fluctuated from 209.96 to 1325.33  $\text{mm}^2$  respectively, so as to average 764.41  $\text{mm}^2$ .

The examined features revealed a proportionate increase in values when associated with ad-

**Table 1.** Statistical analysis of numerical data (mean  $\pm$  SD) of the trapezius muscle in relation to the side and sex

Muscle parameter	Side	Male fetuses (n = 11)	Female fetuses (n = 19)	p
Total length [mm]	left	64.02 $\pm$ 15.44	68.68 $\pm$ 18.62	0.489
	right	64.38 $\pm$ 15.37	68.65 $\pm$ 18.29	0.519
Width [mm]	left	20.66 $\pm$ 4.41	20.49 $\pm$ 4.71	0.924
	right	20.76 $\pm$ 4.38	20.62 $\pm$ 4.62	0.934
Surface area [mm <sup>2</sup> ]	left	732.40 $\pm$ 374.66	783.23 $\pm$ 371.93	0.721
	right	738.79 $\pm$ 368.43	778.94 $\pm$ 365.00	0.774

**Table 2.** Regression analysis for examined parameters of the trapezius with age

Trapezius	Parameter	Regression formulae related to age	R <sup>2</sup>	F	p
trapezius (as a whole)	total length [mm]	$y = -103.288 + 10.514 \times \text{age}$	0.916	639.0	0.000
	width [mm]	$y = -19.970 + 2.505 \times \text{age}$	0.766	189.6	0.000
	surface area [mm <sup>2</sup> ]	$y = -2670.458 + 212.029 \times \text{age}$	0.835	300.4	0.000
descending part	length [mm]	$y = -67.439 + 6.689 \times \text{age}$	0.732	159.0	0.000
transverse part	length [mm]	$y = -8.493 + 1.033 \times \text{age}$	0.280	22.7	0.000
ascending part	length [mm]	$y = -27.545 + 2.802 \times \text{age}$	0.627	97.5	0.000

vancing fetal age. This was displayed with the use of regression analysis, including regression formulae of best fit, statistics values (F), and coefficients of determination (R<sup>2</sup>) – (Table 2).

## Discussion

The trapezius muscle plays an essential double role in both posture and voluntary movements. The crucial function of the upper trapezius is to stabilize the head-neck complex *via* gait [6, 12]. Apart from this, it is considered to be the major suspensory muscle of the shoulder [13]. Like the sternocleidomastoid, the trapezius is a derivative of both the branchial mesoderm and adjacent myotomes that originate in the occipital region and expand as a thick common anlage. Thereafter, the common mass splits into two segments: The ventral one forms the sternocleidomastoid, the dorsal one develops the trapezius [5, 14].

The trapezius displays a sporadic anatomical variety. Once its anomalies occur they may result in restricted mobility at the glenohumeral joint. The literature review performed by Noussios [8] listed the subsequent anomalies of the trapezius: Accessory muscle slips, partial aplasia or complete agenesis, and even variations in its innervation. Emsley and Davis [3] reported a semi-absent

trapezius in a human cadaver, whose left muscle, its inferior third in particular, was extremely reduced in both surface area and thickness. As substantiated by these authors, the surface area and thickness of the left trapezius were only 50% and 1/3–1/6 respectively of those of its right partner. Nooij and Oostra [2] described a complete absence of the descending and transverse parts of trapezius with only a few scattered muscle fibers on the verge of its ascending part. Kwak et al. [14] described an anomalous muscle slip, springing from the descending part of the trapezius. This isolated muscle bundle inserted as an independent tendon into the clavicle exemplifies a variant of the cleido-occipitalis cervicalis. An excessive muscle slip may impede catheterization of the subclavian or internal jugular veins [5]. Agenesis of the trapezius may be either isolated or combined, in the latter with concomitant involvement of pectoralis major, sternocleidomastoid, supraspinatus, latissimus dorsi or serratus anterior muscles [2]. Furthermore, Poland's syndrome, characterized by thorax deformity and syndactyly, is associated with the absence of copious skeletal muscles, the pectoralis major in particular, muscles in the upper limb, and occasionally encompasses anomalies of the trapezius [2]. The isolated lack of the trapezius may result from an incomplete failure of occipital or cervical somites [3, 15, 16]. During embryogen-

esis both mechanical and inflammatory reasons are responsible for the absence of the trapezius. This may be exemplified by a local disturbance in the blood supply [2]. Like the sternocleidomastoid muscle, the trapezius has double motor innervation by way of the spinal accessory nerve and cervical plexus [2]. Soo et al. [17] and Nori et al. [18] meticulously identified motor innervation of the trapezius. Their data indicated that the trapezius was innervated by the ventral C2, C3 and C4 spinal nerves; however, this was a variable in each muscle part. Thus, the C3 and C4 ventral spinal nerves entered the trapezius in a direct manner, while the C2 ventral spinal nerve did so by anastomosing the spinal accessory nerve. The descending part of the trapezius was found to be mainly innervated by the spinal accessory nerve. Astonishingly enough, the transverse and ascending parts of trapezius were reported by Kierner et al. [19, 20] to receive their motor innervation mainly from the spinal accessory nerve, with only minor contributions from the cervical plexus. Noticeably, damage to the accessory nerve atrophies the trapezius [4, 16, 21]. Chronic tenderness and tightness (myalgia) of the descending part of the trapezius is the most mundane diagnosis in the adult with self-reported neck or shoulder pain [22].

Kędzia et al. [11] carried out meticulous research on the trapezius in 71 autopsied fetuses of both sexes aged 16–30 weeks of gravidity. They found no sex differences, which is in line with our current study. Furthermore, numerous morphometric studies on skeletal muscles in the human fetus, including triceps brachii [23], biceps brachii [24], deltoid [25], semitendinosus [26], semimembranosus [27], and biceps femoris [28] indubitably divulged no significant male-female differences. Not even once did we notice any laterality differences in the material under examination. On the contrary, Kędzia et al. [11] found the trapezius to be considerably wider on the right side. In addition to that, the surface area of the trapezius turned out to be significantly greater on the right (753 mm<sup>2</sup>) than on the left (680 mm<sup>2</sup>). With the use of MRI, Stemper et al. [12] gathered the numerical data of the neck muscles in adult male volunteers. In all

subjects the surface area of the trapezius was greatest at the C6–C7 level and was steadily diminishing in the cephalad direction. As a result, the surface area at the C5–C6 level proved to be significantly greater than that at the C2–C3 level. Incidentally, the surface area facilitates arriving at an estimation of the force produced by a contracting skeletal muscle [29]. As reported by Paraskevas et al. [5], the right trapezius was considerably more extensive at its origin and insertion. The trapezius may variably insert onto spinous processes: As superior as vertebra T8, and as inferior as vertebra L2. According to findings by Kędzia et al. [11], both the greatest length and width of the trapezius revealed proportionate increases, according to the following linear models:  $y = -16.7 + 3.95 \times \text{age}$  ( $r = 0.793$ ) and  $y = -11.06 + 2.54 \times \text{age}$  ( $r = 0.811$ ), respectively. This harmonizes with the present study, in which the length and the width of the trapezius ensued proportionately. In the material under examination the four studied lengths grew linearly, as follows:  $y = -103.288 + 10.514 \times \text{age}$  ( $r = 0.957$ ) for total length of the trapezius muscle,  $y = -67.439 + 6.689 \times \text{age}$  ( $r = 0.856$ ) for length of its descending part,  $y = -8.493 + 1.033 \times \text{age}$  ( $r = 0.53$ ) for length of its transverse part, and  $y = -27.545 + 2.802 \times \text{age}$  ( $r = 0.791$ ) for length of its ascending part. As far as the width and the surface area of the trapezius are concerned, both parameters computed the following linear functions:  $y = -19.970 + 2.505 \times \text{age}$  ( $r = 0.875$ ) and  $y = -2670.458 + 212.029 \times \text{age}$  ( $r = 0.915$ ), respectively.

The lack of numerical information in the medical literature concerning the studied parameters limits our debate on this subject. We believe that the normative data of the trapezius muscle in the fetus at varying ages obtained in this study will provide a conducive background for future autopsy studies.

The authors concluded that neither sex nor laterality differences exist in numerical data of the trapezius muscle in the human fetus. The descending part of trapezius is the longest, while its transverse part is the shortest. The growth dynamics of the fetal trapezius muscle follows proportionately.

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