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MORPHO-TOPOMETRIC VARIABILITY OF ANATOMICAL STRUCTURES IN THORACIC SPINE

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ABSTRACT — We studied the size-related features (body height, intervertebral discs, horizontal and vertical diameters of intervertebral foramina) on CT-grams of the thoracic spine in people whose age belongs to the first adulthood period (60 men aged 22–35 and 65 females aged 21–35) with no signs of the spine disease or any systemic and traumatic lesions. We have identified topographical variability, gender dimorphism as well as the interconnection of the parameters under study.

KEYWORDS — thoracic spine, vertebrae body, intervertebral discs, intervertebral foramen.

INTRODUCTION

Modern medical science can be described by rapid progress and clinical implementation of highly reliable advanced technological diagnostic methods, which feature their possible use in studying the normal anatomy and structure variability in human organs and systems [12–15].

The thoracic region is the longest part of the vertebral column and is relatively stable compared to the cervical and lumbar regions [1,2,5]. The typical thoracic vertebrae — from II to X (Th_{II}–Th_X) — join the ribs through combined costal-vertebral joints, while the rib head joint is complex (the rib head articulates with two adjacent vertebrae); the first vertebra (Th_I) articulates with the first atypical rib through two simple joints, and the XI and XII vertebrae (Th_{XI}–Th_{XII}) articulate with the respective oscillating ribs with simple non-combined joints. Given that, the thoracic vertebrae, the ribs, and the sternum make up a

relatively mobile, yet a strong structure. Besides, the articular processes that form facet joints are oriented within the frontal plane; the intervertebral discs are of low height, whereas the long spinous processes are tilted and overlap similar to tiles on the roof, which also reduces the thoracic spine mobility [4].

Adjacent vertebrae notches and the intervertebral disc limit the intervertebral foramen, which makes a passage for the spinal nerves and veins to exit, and for the segmental arteries to enter. Specific features of the thoracic vertebral bodies anatomy ensure the thoracic kyphosis [2]. The thoracic part is mainly involved in lateral (mostly lower-thoracic) and rotational (specifically upper-thoracic) movements [8]. When the spine is bent, it is only the thoracic part that bends, while the cervical and the lumbar parts straighten up; in case of extension, on the contrary, the cervical and the lumbar parts unbend, while the thoracic part straightens up [3, 7]. Compared to other parts of the column, the thoracic part gets affected less often, while it takes a larger factor to traumatize it [4].

Respective literature offers basically no detail on complex investigation into the laws of topographic, gender-related and individual-typological variability, as well as on the nature of the relationships and the ratio of the shape and the morpho-topometric features of the thoracic spine anatomical structures. The variability of the morpho-topometric patterns in the thoracic spine structure due to its complex kinematics and biomechanical properties is an urgent issue faced nowadays by functional anatomy, neurovertebrology, orthopedics and forensic studies [6,10]. These data are of important theoretical and applied value in practical health care in terms of diagnosing and correcting the thoracic spine lesions [9, 11].

Aim of the Study:

to identify the variability patterns of morpho-topometric features in the thoracic spine anatomical structures through the first adulthood period.

MATERIALS AND METHODS

We studied thoracic spine CT-grams obtained from people in their first adulthood period (60 men aged 22–35 and 65 females aged 21–35) who featured no sign of any spine disease, systemic or traumatic le-

sion, as well as we identified the size-related specifics of the thoracic spine anatomical features — the vertebrae body height, the intervertebral discs, as well as the horizontal and vertical diameters of the right intervertebral foramen.

The variation-statistical processing of the outcomes was done using descriptive statistics on the Statistica 10.0 platform; the median (Me), the upper and lower quartiles [25.0; 75.0%], as well as the variation coefficient (Cv%) were identified. At $Cv% < 10\%$, the samples were slightly variable; at $Cv%$ from 10 to 20% they revealed average variability, and at $Cv% > 20\%$ the variability was strong. To identify the link between the studied parameters, a correlation analysis (Pearson's criterion) was employed; the correlation was considered weak at $r < 0.25$; average — at r ranging from 0.25 to 0.5; significant — in case of r falling within 0.5 to 0.75, and strong — at $r > 0.75$. The normality test was performed using the Shapiro-Wilk test. The differences in the variables were considered statistically significant at $p < 0.05$; 0.01; 0.001 (Mann-Whitney test).

RESULTS

The height of the thoracic vertebrae bodies increases gradually towards the cervical-lumbar region from 13.7 mm [12.4; 15.2] to 22.2 mm [21.1; 23.1] in females (a significant relative increase was noted distal of vertebra Th_{VIII}) and from 16.5 mm [14.8; 18.0] at the Th_I level to 25.2 mm [23.5; 26.6] at the Th_{XII} level in men (the maximum relative increase was noted below the Th_X level). The gender-related differences, which are manifested in the predominance of the trait in males, are statistically significant at all levels of the thoracic spine with a 99% probability threshold ($p < 0.01$). In the female group, the trait variability is average, Cv% being within the range of 10.5 to 13.4%. In the male group, the variability of the vertebrae body height at the level of Th_I–Th_{VIII} is average (Cv% ranging from 10.0 to 13.5%), and distal of that, the variability is below average (Cv% varies from 8.9 to 9.5%).

The height of the thoracic spine intervertebral discs in females increases from disc Th_{I-II} to the thoraco-lumbar junction level (Th_{XI-XII}) from 4.1 mm [3.6; 5.0] to 6.5 mm [5.6; 7.1]; in males the disc height goes up from 4.6 mm [4.0; 5.2] in Th_{I-II} to 4.8 mm [3.9; 5.1] in Th_{II-III}, then decreases to the thoracic kyphosis apex level and ranges at the level from Th_{III-IV} to Th_{VII-VIII} between 4.3–4.6 mm, and distal of that it goes again up to 6.8 mm [5.9; 7.5] at the level of Th_{XI-XII}. The gender-related differences are statistically significant at all levels of the thoracic spine; at the levels of discs I-II–IV-V and I X-X-XI-XII, the parameter prevails in males, while at level of discs V-VI-VIII-IX — in females

($p < 0.01$). The trait variability is average and above average (Cv%, from 18.7 to 22.9%).

The vertical diameter of the I-II intervertebral foramen in females is 10.3 mm [9.2; 11.6], which decreases to 9.9 mm [8.8; 11.5] by foramina II-III, and then gradually goes up to 14.8 mm [13.1; 16.2] at the level of foramina XI-XII; in males, the foramen diameter decreases as well from 11.3 mm [10.3; 12.3] at foramina I-II to 10.6 mm [10.0; 11.5] at the II-III, and then gradually increases to 15.4 mm [13.4; 16.8]; the maximum relative increase is to be observed at the level of foramina X-XI and XI-XII, both in females and in males. Males have a slightly larger vertical foramen diameter than females, yet the differences do not reach statistical significance ($p > 0.05$). The trait variability is average both in females and in males (Cv% varies from 11.8 to 20.0%).

The horizontal diameter of the I-II intervertebral foramina in females is 5.9 mm [5.2; 6.7], in males — 5.5 mm [4.9; 6.4]; by foramina II-III, the parameter decreases down to 5.6 mm [5.0; 6.3] and to 5.3 mm [5.0; 6.3], to vary from 5.2 to 6.1 mm and from 5.1 to 5.6 mm in the respective gender groups; at the level of XI-XII, the foramina increases significantly to 6.8 mm [5.5; 7.6] in females and to 6.7 mm [5.2; 7.5] in males. In the female group, this parameter is somewhat prevalent compared to the male group, yet the differences do not come up to statistical significance ($p > 0.05$). The trait variability up to the level of foramina IX-X is average (Cv% ranges from 13.1 to 20.0%), while at the level of the last two thoracic intervertebral foramina, the variability goes beyond average (Cv% ranging from 22.0 to 25.6%).

A correlation analysis revealed no significant correlation between the height of the bodies and the height of the intervertebral discs in females; in males, the relationship between the height of the disc and the height of adjacent vertebrae does not exceed the inverse average correlation (r within the range of -0.4 to -0.5). There were significant direct connections detected between the height of the vertebral bodies and the vertical diameter of the intervertebral foramen below the level of the thoracic kyphosis apex (r ranging from 0.5 to 0.7).

CONCLUSION

In view of the above, the size-related features, the variability and the connections of anatomical parts of the thoracic spine have been analyzed here. The height of the vertebral bodies gradually increases towards the lumbar region; this feature increases through the thoracic spine — 1.6 times (by 38.3%) in females and 1.5 times (by 34.5%) in males. The height of the intervertebral discs, too, increases in females 1.6 times

(by 36.9%); in males the height of the discs decreases at the level of the thoracic kyphosis apex in relation to the upper (1.1 times, by 6.5%) and lower (1.6 times, by 36.8%) thoracic vertebrae. The vertical diameter of the intervertebral foramina first decreases 1.04 times (by 3.9%) from I-II to II-III in females and 1.07 times (by 6.2%) in males, then increases towards the lumbar region 1.6 times (by 33.1%) in females and 1.5 times (by 31.2%) in males. The foramina horizontal diameter varies up to the X-XI level falling within the range of 5.2–6.1 mm for females and 5.1–5.6 mm for males, and increases at foramina XI-XII level up to 6.8 mm for females and 6.7 mm for males. The gender differences reveal a statistically significant predominance of the vertebra height and the intervertebral disc in males; the foramen vertical diameter also prevails in males, while the horizontal diameter was found to be prevailing in females; however, the differences do not reach statistical significance. The studied parameters mostly feature average variability.

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