ORIGINAL RESEARCH PAPER

Volume - 10 | Issue - 09 | September - 2021 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

STUDY OF DIFFERENT AGE GROUP MORPHOMETRY OF LUMBAR VERTEBRAL BODY

Anatomy

Dr Ramanuj Singh Assistant Professor, Department Of Anatomy, ANM Medical College, Gaya.

Dr Randhir Kumar* Tutor, Department of Anatomy, ANM Medical College, Gaya. *Corresponding Author

ABSTRACT

Introduction: This study was designed to provide a large, accurate data of vertebral body size, focusing on age-related changes along the lumbar spine, and to look for size variations with relation to sex. **Methods:** All lumbar vertebrae (L1-L5) of 126 individuals (0-90 years) were dissected and analyzed by age and sex. A digital caliper was used to measure all vertebral body heights, lengths, and widths. **Result:** This study showed that the vertebral body size was independent of sex but correlated with the individuals' age. The most intensive growth of vertebral body sizes was found in children 1-7 year-old and the second peak of growth was observed in teenagers 13-16 year-old. The posterior vertebral body height was smaller than the anterior vertebral body height at L2 through L5 indicating posterior wedging with a peak at L3-L4 (except individuals of the 1st year of postnatal life). The superior vertebral body lengths constantly increased from L1 to L5 and inferior lengths - from L1 to L4, slightly decreased at L5. No significant difference was found between the superior and inferior vertebral body lengths of the same vertebra ($P > 0.05$). The superior vertebral body width typically was smaller than inferior widths of the same vertebra and superior width of adjacent inferior vertebra, resulting in a trapezoidal vertebral body shape in the lumbar spine.

Conclusion: As result of this research, a comprehensive database of vertebral body dimensions was generated from direct measurements of 630 lumbar vertebrae. These results are invaluable in establishing an anthropometric model of the human lumbar spine, and provide useful data for spinal surgery and spinal implants design. In addition this information has important implications for workspace specifications for a robot-assisted surgery system.

KEYWORDS

Vertebral body; Anatomical dimensions; Lumbar spine

INTRODUCTION

Present available data of vertebral and inter vertebral dimensions are not complete and has various limitations related to accuracy, study population or parameters recorded. The extensive knowledge of precise dimensions of the lumbar vertebrae is essential for the spinal implants design, lumbar decompression surgery and workspace definition for robot-assisted surgery [1].

In a older study , the author tried to established morphometry of vertebtal body in both normal and pathological conditions [2-5].

The aim of this study is to establish morphometry standards for all lumbar vertebrae for all age groups and found age-related changes in vertebral body shape and sizes.

MATERIAL AND METHODS:

Study Population

After observation of 126 lumbar spine total 630 vertebral body dimensions studied by digital caliper (66 male, 60 female) of individuals (0 - 90 years). All anatomic samples of lumbar spine had been collected in 2019-2020 from cadavers of Anatomy department of ANM Medical College, Gaya. The 11 age groups study was designated for study. (Table 1).

Measuring Methods

A total of 630 vertebrae from L1 through L5 were measured. The following seven parameters were directly taken for measurements from each vertebral body and their ratios were also analyzed: anterior andposterior VB heights in the midsagittal plane; superior and inferior VB anteroposterior (A-P) lengths; superior, middle and inferior VB widths (Figure 1).

Anterior (AVBH) and posterior (PVBH) vertebral body heights are distances in the sagittal plane between central borders of superior and inferior vertebral body, anteriorly and posteriorly, respectively.

Superior (SVBL) and inferior (IVBL) vertebral body lengths are distances in the sagittal plane between anterior and posterior borders of superior and inferior vertebral body, respectively.

Superior (SVBW), middle (MVBW) and inferior (IVBW) vertebral body widths are distances in the transverse plane between left and right borders of the superior, middle (1/2 of height), and inferior vertebral body, respectively. All measurements were taken from the external borders of the vertebral body rims, excluding any osteophytes.

Statistical Analysis

Statistical anaysis was done for all calculated measurements. The vertebral body growth rate was calculated as a % difference from a previous age group for all dimensions. The relation of vertebral body dimensions with age was calculated by ANOVA followed by orthogonal contrasts was used to compare the vertebral dimensions at different spinal levels. A significance level of $P < 0.05$ was used.

RESULT

Both the intra tester and inter tester reliability for all measurements were high. The intra class correlation coefficients varied from 0.93 to 0.97 for the intra tester reliability, and from 0.80 to 0.85 for the inter tester reliability. Validity was also very high ($r = 0.92$; $P < 0.001$).

Vertebral Body Heights And Sagittal Wedging

Table 2 summarizes data for the anterior and posterior vertebral body heights L1 - L5 for persons of different age groups. Anterior vertebral body heights were almost identical for all lumbar vertebrae in newborns (6.9 ± 0.3 mm - 7.2 ± 0.3 mm) and continuously increased through childhood, adolescence, and adulthood (in age group 8: 25.5 ± 2.7 mm for L1; 27.7 ± 2.5 mm for L2; 30.8 ± 3.3 mm for L3; 28.9 ± 4.6 mm for L4; 28.2 ± 2.4 mm for L5), then slightly decreased in senior persons due to osteopenia. Anterior vertebral body heights increased from L1 troughs L3 ($P < 0.05$) and decreased at L4 - L5 (for age groups 6 - 11). The most intensive rate of growth of anterior vertebral body heights (above of 40%) was found in children 3rd and 4th age groups (1-7 year-old) and the second peak of growth was observed in teenagers 13-16 year-old (age group 6). ANOVA shows a statistically significant correlation between the anterior vertebral body heights and person's age ($r=0.57$ in men and $r=0.69$ in women; $P < 0.0001$).

Average sizes of posterior vertebral body heights for L1 - L5 in newborns and infants of the first year of postnatal life were slightly above than anterior heights (7.2 - 7.3 mm and 8.6 - 8.7 mm, respectively). But starting from the 3rd age group on, the situation is quit opposite, anterior heights prevailed ($P < 0.05$).

Posterior vertebral body heights continuously increased with the age and reach their maximums in adults (25.9 ± 3.1 mm for L1, 27.1 ± 2.9 mm for L2, 27.0 ± 2.9 mm for L3, 25.8 ± 3.0 mm for L4 and 23.2 ± 2.9 mm for L5).

The correlation of this dimension with the age was also significant for both sexes ($r=0.66$ in men and $r=0.64$ in women ($P < 0.0001$). The posterior vertebral body height was smaller than the anterior vertebral body height at L2 through L5 indicating.

Vertebral Body Lengths

The superior vertebral body lengths were 7.6 ± 0.5 mm - 7.8 ± 0.3 mm in newborns (L1-L5) and drastically increased during the first 3 years of the postnatal life (age groups 1-3), reaching 17.2 ± 0.7 mm - 17.7 ± 0.6 mm (Table 3). Unlike vertical dimensions, that is the only peak of growth for vertebral body lengths with more than 80% rate (Figure 3). Even later, when the rate of growth is much less, this dimension was growing up until adulthood. The superior vertebral body lengths constantly increased from L1 (32.4 ± 4.3 mm) to L5 (37.0 ± 4.8 mm) in the lumbar spine (age group 10). The inferior vertebral body length increased from L1 (34.1 ± 4.2mm) to L4 (37.3 ± 4.9 mm) and then slightly decreased at L5 (34.7 ± 5.7 mm). No significant difference was found between the superior and inferior vertebral body lengths of the same vertebra (P >0.05). ANOVA shows a statistically significant correlation between the superior vertebral body lengths and person's age r=0.76 for men and r=0.71 for women (P<0.0001).

Vertebral Body Widths

The superior vertebral body widths slightly increased from L1 to L5 in newborns (14.5 ±0.9 mm - 14.8 ± 0.6 mm) and infants of the first year of postnatal life (17.3 ± 1.4 mm – 17.6 ± 1.6 mm). The middle vertebral body width was bigger than superior and inferior one in the first two age groups (P < 0.01) and was in the range 15.1 ± 0.6 mm - 15.4 ± 0.6 mm in newborns and 17.6 ± 1.2 mm - 18.0 ± 1.3 mm in 1st year infants. The most intensive vertebral body growth in coronal plane (more then 60%) was registered in the first three years of the postnatal life (age group 3). The second peak of growth (up to 30%) was found in teenagers (age group 6) and in this age middle vertebral body width became the same size or slightly below than the superior and inferior one and vertebral "waist" formation began. In adults (e.g. age group 10), superior vertebral body widths constantly increased from L1 to L5 (49.3 ± 7.0 mm - 56.0 ± 7.5 mm).

The superior vertebral body width typically was smaller than inferior widths of the same vertebra and superior width of adjacent inferior vertebra, resulting in a trapezoidal vertebral body shape in the lumbar spine. Also with age, the vertebral "waist" (middle width) became less thick compared with superior and inferior widths at the same vertebrae. ANOVA shows a statistically significant correlation between vertebral body widths and age (r=0.78 for men and r=0.72 for women; P < 0.

Table 1: Number Of Complete Lumbar Spine Specimens - Age Distribution 0001).

Age Group	Year-old	N
1	0	12
2	0-1	9
3	1-3	8
4	3-7	14
5	8-12	11
6	13-16	9
7	17-20	13
8	21-35	14
9	36-60	12
10	60-74	10
11	75-90	14
TOTAL		**126**

DISCUSSION

Information regarding the precise dimensions of the lumbar vertebral bodies is essential for spinal surgery and instrumentation, but we did not find longitudinal studies covering all age groups because of the extreme difficulty in obtaining such specimens. Even in the most comprehensive investigations like Masharawi et al., where dimensions were obtained from 240 normal complete spines of adult human skeletons (age range 20 - 80 years), or Wolf et al. (20 - 90 years old 55 patients), it is assumed that the vertebral body external shape is maintained with age [1,15].

Our finding challenges this concept and shows that a vertebral body is a dynamic structure, which grows constantly with different velocities until maturation. Shape of vertebral body is also different for different age groups.

In new borns and infants of the first year of the postnatal life, L1-L5 vertebral bodies are oval in shape and almost identical in size. They grow dramatically in childhood and become cylindrical in shape. We have registered 2 peaks of vertebral body grow: in children of 1-3 years old and teenagers 13-16 years old. In 17-20 years old individuals, lumbar vertebral bodies get a definite shape (middle vertebral body width is less than superior or inferior one).

Table 2: Material Of The Research: Number Of Complete Lumbar Spine Specimens - Age Distribution

Age group	Dimension	L1	L2	L3	L4	L5
(1) 0 yr	AVBH	6.9 ± 0.3	7.0 ± 0.2	7.2 ± 0.3	7.1 ± 0.3	7.0 ± 0.4
	PVBH	7.2 ± 0.6	7.2 ± 0.4	7.2 ± 0.4	7.3 ± 0.4	7.3 ± 0.3
(2) 0-1 yr	AVBH	8.4 ± 0.3	8.4 ± 0.2	8.5 ± 0.4	8.5 ± 0.4	8.4 ± 0.6
	PVBH	8.6 ± 0.7	8.6 ± 0.7	8.7 ± 0.7	8.7 ± 0.4	8.7 ± 0.9
(3) 1-3 yr	AVBH	11.7 ± 0.6	11.7 ± 0.8	12.1 ± 0.6	12.5 ± 1.0	12.5 ± 0.7
	PVBH	11.2 ± 0.5	11.1 ± 0.5	11.1 ± 0.7	11.3 ± 0.7	10.8 ± 0.6
(4) 3-7 yr	AVBH	16.1 ± 1.4	17.6 ± 2.2	18.5 ± 2.4	17.0 ± 1.7	16.7 ± 3.1
	PVBH	16.3 ± 0.9	15.9 ± 1.6	16.1 ± 1.8	14.7 ± 1.8	13.9 ± 1.3
(5) 8-12 yr	AVBH	18.9 ± 3.0	20.3 ± 4.7	23.0 ± 2.7	19.8 ± 3.4	20.3 ± 1.9
	PVBH	18.3 ± 3.6	19.9 ± 4.0	18.2 ± 3.4	16.5 ± 3.2	16.3 ± 3.2
6) 13-16 yr	AVBH	23.6 ± 1.4	25.4 ± 2.7	28.2 ± 2.8	25.5 ± 1.8	25.3 ± 3.5
	PVBH PVBH	22.1 ± 2.4	25.3 ± 3.7	24.9 ± 3.2	23.5 ± 3.0	19.9 ± 3.3
(7) 17-20 yr	AVBH	25.2 ± 3.1	27.6 ± 2.6	29.0 ± 3.5	28.3 ± 2.1	27.9 ± 2.7
	PVBH	25.0 ± 3.8	27.1 ± 3.4	27.1 ± 2.7	26.5 ± 3.7	23.3 ± 3.4
(8) 21-35 y	AVBH	25.5 ± 2.7	27.7 ± 2.5	30.8 ± 3.3	28.9 ± 4.6	28.2 ± 2.4
	PVBH	25.9 ± 3.1	27.1 ± 2.9	27.0 ± 2.9	25.8 ± 3.0	23.2 ± 2.9
(9) 36-60 yrs	AVBH	24.5 ± 3.2	26.9 ± 2.8	29.3 ± 3.2	27.6 ± 2.7	28.0 ± 2.7
	PVBH	25.5 ± 3.4	26.9 ± 2.8	27.3 ± 2.8	25.9 ± 3.0	23.2 ± 2.8
(10) 60-74 yr	AVBH	23.8 ± 2.6	25.8 ± 3.2	28.4 ± 3.2	27.1 ± 2.8	26.8 ± 3.2
	PVBH	25.7 ± 3.3	25.9 ± 3.3	26.1 ± 2.7	25.1 ± 3.7	22.4 ± 3.1
(11) 75-90 yr	AVBH	21.7 ± 2.2	24.4 ± 2.9	27.2 ± 3.4	26.2 ± 3.2	26.1 ± 2.6
	PVBH	23.9 ± 2.2	24.2 ± 2.8	24.7 ± 2.2	24.6 ± 2.8	21.7 ± 2.5

Measurements of vertebral body heights indicated a most rapid growth of anterior vertebral body height in L3 (compare with other lumbar vertebrae), one of the factors, as we believe, that contributes to the lumbar curve formation. Also our results shows decrease invertebral heights with advancing age and menopause that supports some earlier studies [2-6] and challenges another opinion that decreases in human height with aging, results from a decrease in the thickness of the inter vertebral discs only [7-11].

The current data indicate that vertebral body lengths and widths constantly increase with the age. There are the same two peaks of growth in kids and teenagers groups. Also, vertebral body lengths and widths rates of growth are different in L1 - L5 row: L1 growths the less intensively and L5 - the most This finding supports the prevalent concept about pyramidal structure of the vertebral column, in which the vertebral body dimensions continuously increase along the lumbar spine [12-16].

Our results show a statistically significant correlation between all vertebral body dimensions and age for both, men and women. This is in contrast with earlier studies that did not find such a correlation [16]. The contrasting findings are possibly due to the larger sample size and the age groups used in the current study (age range 0-90 years vs. 20-80 years). In addition, our results support the opinion that there is no sexual dimorphism (P > 0.05) in measurements of lumbar vertebral bodies [17-21].

Knowing the exact vertebral body size and shape is an important factor in the diagnostic and treatment processes of different spinal deformities.

CONCLUSION

The current study revealed to evaluate lumbar vertebral body anatomy of the Indian population in terms of morphometry measurements in healthy cases as well as giving data to the spinal surgeons for more precise operations planning, choosing an adequate inter body device or appropriate bone graft, and fixation plates or screws to the different vertebral levels. As result of this research, a comprehensive database of vertebral body dimensions was generated from direct measurements of 630 lumbar vertebrae. These results are invaluable in establishing an anthropometric model of the human lumbar spine, and provide useful data for spinal surgery and spinal implants design. In addition this information has important implications for workspace specifications for a robot-assisted surgery system. Further studies are needed with larger samples in order to support our data and biomechanical studies are required to validate these implications.

REFERENCES:

1. Mavrych V, Bolgova O, Ganguly P and Kashchenko S. Age- Related Changes of Lumbar Vertebral Body Morphometry. Austin J Anat. 2014;1(3): 1014.
2. Wolf A, Shoham M, Michael S, Moshe R. Morphometric study of the human lumbar spine for operation-workspace specifications. Spine (Phila Pa 1976). 2001; 26: 2472-2477.
3. Bruijne M, Michael MT, Tanko LB, Pettersen PS, Nielsen M. Quantitative vertebral morphometry using neighbor-conditional shape models. Medical Image Analysis. 2007; 11: 503-512.
4. Karabekir HS, Gocmen-Mas N, Edizer M, Ertekin T, Yazici C, Atamturk D. Lumbar vertebra morphometry and stereological assesment of intervertebral space volumetry: a methodological study. Ann Anat. 2011; 193: 231-236.
5. Scoles PV, Linton AE, Latimer B, Levy ME, Digiovanni BF. Vertebral body and posterior element morphology: the normal spine in middle life. Spine (Phila Pa 1976). 1988; 13: 1082-1086.
6. Parent S, Labelle H, Skalli W, Latimer B, de Guise J. Morphometric analysis of anatomic scoliotic specimens. Spine (Phila Pa 1976). 2002; 27: 2305-2311.
7. Panjabi MM, Goel V, Oxland T, Takata K, Duranceau J, Krag M, et al. Human lumbar vertebrae. Quantitative three-dimensional anatomy. Spine (Phila Pa 1976). 1992; 17: 299-306.
8. Berry JL, Moran JM, Berg WS, Steffee AD. A morphometric study of human lumbar and selected thoracic vertebrae. Spine (Phila Pa 1976). 1987; 12: 362-367.
9. Fang D, Cheung KM, Ruan D, Chan FL. Computed tomographic osteometry of the Asian lumbar spine. J Spinal Disord. 1994; 7: 307-316.
10. Aly T, Amin O. Geometrical dimensions and morphological study of the lumbar spinal canal in the normal Egyptian population. Orthopedics. 2013; 36: e229-234.
11. Zindrick MR, Wiltse LL, Doornik A, Widell EH, Knight GW, Patwardhan AG, et al. Analysis of the morphometric characteristics of the thoracic and lumbar pedicles. Spine (Phila Pa 1976). 1987; 12: 160-166.
12. Chawla K, Sharma M, Abhaya A, Kochhar S. Morphometry of the lumbar pedicle in North West India. Eur J Anat. 2011; 15: 155-161.
13. van Schaik JJ, Verbiest H, van Schaik FD. Morphometry of lower lumbar vertebrae as seen on CT scans: newly recognized characteristics. AJR Am J Roentgenol. 1985; 145: 327-335.
14. Gilad I, Nissan M. Sagittal evaluation of elemental geometrical dimensions of human vertebrae. J Anat. 1985; 143: 115-120.
15. Zhou SH, McCarthy ID, McGregor AH, Coombs RR, Hughes SP. Geometrical dimensions of the lower lumbar vertebrae--analysis of data from digitised CT images. Eur Spine J. 2000; 9: 242-248.
16. Masharawi Y, Salame K, Mirovsky Y, Peleg S, Dar G, Steinberg N, et al. Vertebral body shape variation in the thoracic and lumbar spine: characterization of its asymmetry and wedging. Clin Anat. 2008; 21: 46-54.
17. Kunkel ME, Schmidt H, Wilke HJ. Prediction equations for human thoracic and lumbar vertebral morphometry. J Anat. 2010; 216: 320-328.
18. Briggs AM, Greig AM, Wark JD, Fazzalari NL, Bennell KL. A review of anatomical and mechanical factors affecting vertebral body integrity. Int J Med Sci. 2004; 1: 170-180.
19. Guglielmi G, Diacinti D, van Kuijk C, Aparisi F, Krestan C, Adams JE, et al. Vertebral morphometry: current methods and recent advances. Eur Radiol. 2008; 18: 1484-1496.
20. Möller G, Andresen R, Banzer D. Shape model-based semi-automatic morphometric assessment of vertebral deformities in clinical practice. Osteologie. 2011; 20: 239-247.
21. Pouletaut P, Dalqamoni H, Marin F, Ho Ba Tho MC. Influence of age, gender and weight on spinal osteoarthritis in the elderly: An analysis of morphometric changes using X-ray images. IRBM. 2010; 31:141-147.