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Original Research

Vertebral morphometry in relation to understanding its functional and clinical importance

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ABSTRACT:
The study was conducted on random sample of 82 dried (13 cervical (excluding C1 & C2) + 46 thoracic + 23 lumbar) vertebrae. The data on the age, sex and built was not available. Using sliding caliper, vertebral body height anterior (VBHa), vertebral body height posterior (VBHp), vertebral body height central (VBHc), spinal canal depth (SCD), spinal canal width (SCW), spinous process length (SPL), upper end plate width (UEPW), upper end plate depth (UEPD), lower end plate width (LEPW) and lower end plate depth (LEPD) were measured. Mean vertebral body height (VBH) and spinal canal depth (SCD) appears to be maximum in lumbar vertebrae (VBHa 2.26cm, VBHp 2.27, VBHc 2.29, SCD 1.37cm) whereas mean spinal canal width (SCW) is maximum in cervical (2.18cm) and mean spinous process length (SPL) is found to be maximum in thoracic (3.60cm). Mean UEPW (3.85cm) , UEPD (2.90 cm), LEPW (4.06cm) and LEPD (2.87cm) are maximum in lumbar vertebrae. Differences for all the vertebral measurements except spinal canal depth (SCD) are statistically highly significant among cervical, thoracic and lumbar vertebrae.
Key words: Vertebrae, Cervical, Thoracic, Lumbar, Morphometry, Clinical aspect, Functional aspect

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INTRODUCTION

While living in digital world we are very much affectionate towards our electronic gadgets. Starting from the day till its end our body is fully under their control and moreover COVID-19 era has made them our necessary addiction as from school to office, from home to market everything has gone online. So, maximum hours of the day we are spending either lying on the bed or sitting on the chair following different body postures, physical body movements got restricted to much extent and as result chronic pain in the neck, back and lower back is getting prominent.

Vertebral column formed from the articulation of 33 vertebrae connected by ligaments and intervertebral discs and categorized into cervical (07), thoracic (12), lumbar (05), sacrum (05) and coccygeal (04). Although its function is to protect spinal cord passing through the spinal canal but additionally it transmits body weight in walking and standing. Structural anatomy of vertebral components in humans can be affected severely by incorrect body postures that leads to abnormal spinal curvatures, degenerative disorders, spinal tuberculosis etc.[1].

Typical features of different types of vertebrae such that presence of vertebral body having upper and lower end plates that holds the intervertebral discs with opposed surfaces of adjacent vertebral bodies, vertebral foramen that encloses the spinal cord along with meningeal layers and their related vessels and nerves, spinous process act as supporting structure for the attachment of various muscles of the back directly or indirectly [2] .

Morphometric analysis of cervical spinous process is of remarkable significant in understanding the pathology and planning of the treatment of various clinical conditions and the measurements recorded can be taken as reference values which could be used as a diagnostic tool for spine pathology [3-7]. Also shape and size of the upper and lower end plates of the lumbar vertebrae helps in correlating clinically with the complications generated due to disc arthroplasty surgery [8]. While literature on the various dimensions of vertebral body, spinal canal, spinous process and upper and lower endplates in typical cervical, thoracic and lumbar vertebrae is still lacking.

The purpose of the present study was to understand and relate the vertebral morphometry with special reference to its clinical and functional importance.

MATERIAL AND METHODS

A total of 82 dried (13 cervical (excluding C1 & C2) + 46 thoracic + 23 lumbar) vertebrae without determine of age and sex from the Department of Anatomy, Desh Bhagat Dental College and Hospital were included in the study and measured for the vertebral body height anterior (VBHa), vertebral body height posterior (VBHp),vertebral body height central (VBHc), spinal canal depth (SCD), spinal canal width (SCW), spinous process length (SPL), upper end plate width (UEPW), upper end plate depth (UEPD), lower end plate width (LEPW) and lower end plate depth (LEPD) using the sliding caliper (Fig.1 to Fig.10) . Vertebrae who are broken were excluded from the study.

Fig. 1: VBHa

Fig. 2: VBHp

Fig. 3: VBHc

Fig. 4: SCD

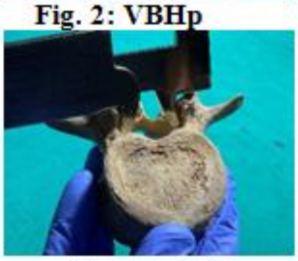

Fig. 5: SCW

Fig.6: SPL

Fig.7: UEPD

Fig.8: UEPW

Fig.9: LEPD

Fig.10: LEPW

After recording the measurements, data is analyzed using the software version SPSS 16.

RESULTS

Table 1 to 3 indicates the descriptive statistics of cervical (Table 1), thoracic (Table 2) and lumbar (Table 3) vertebrae for various parameters. It has been observed that mean vertebral body height (VBH) appears to be maximum in lumbar vertebrae (VBHa 2.26cm, VBHp 2.27, VBHc 2.29) followed by thoracic (VBHa 1.75cm, VBHp 1.74, VBHc 1.77) and cervical (VBHa 1.26cm, VBHp 1.22, VBHc 1.45) vertebrae in all directions i.e. anterior, posterior and central. Centrally mean vertebral body height (VBHc) is more in all the three types of vertebrae in comparison to their mean vertebral body height anteriorly (VBHa) and posteriorly (VBHp).

Mean spinal canal depth (SCD) is found to be maximum in lumbar vertebrae (1.37cm) followed by cervical (1.33cm) and thoracic (1.31cm) vertebrae whereas mean spinal canal width (SCW) is maximum in cervical (2.18cm) followed by lumbar (1.91cm) and thoracic (1.45cm) vertebrae. Mean spinous process length (SPL) is found to be maximum in thoracic (3.60cm) and is minimum in cervical (1.83cm) vertebrae.

Further it has been observed that mean values for upper end plate width (UEPW) are more in comparison to lower end plate width (LEPW) in all three types of vertebrae. Inter-comparison trend shows that mean values for UEPW are maximum in lumbar vertebrae (3.85cm) followed by thoracic (2.48cm) and cervical (2.25cm) whereas same trend has been observed for UEPD mean values i.e. lumbar (2.90cm), thoracic (1.98cm) and cervical (1.52cm).

Similarly, maximum mean values for LEPW is found in lumbar vertebrae (4.06cm) followed by thoracic (2.66cm) and cervical (2.03cm) vertebrae whereas LEPD mean value is also maximum in lumbar

(2.87cm) followed by thoracic (2.08cm) and cervical (1.48cm) vertebrae.

Table 1: Descriptive Statistics of Cervical Vertebrae.

Statistics										
Cervical	**VBHa**	**VBHp**	**VBHc**	**SCD**	**SCW**	**SPL**	**UEPW**	**UEPD**	**LEPW**	**LEPD**
N	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
MEAN (cms)	**1.25**	**1.22**	**1.45**	**1.33**	**2.18**	**1.83**	**2.25**	**1.52**	**2.03**	**1.48**
SEM	**0.03**	**0.03**	**0.06**	**0.03**	**0.05**	**0.18**	**0.08**	**0.10**	**0.07**	**0.05**
Median	1.20	1.20	1.50	1.30	2.20	1.60	2.30	1.40	2.00	1.50
SD	**0.10**	**0.10**	**0.22**	**0.12**	**0.19**	**0.64**	**0.29**	**0.37**	**0.26**	**0.16**
Minimum	1.10	1.00	1.00	1.20	1.90	1.20	1.80	1.20	1.70	1.30
Maximum	1.40	1.40	1.80	1.50	2.50	3.10	2.90	2.60	2.50	1.80

Table 2: Descriptive Statistics of Thoracic Vertebrae.

Thoracic	**VBHa**	**VBHp**	**VBHc**	**SCD**	**SCW**	**SPL**	**UEPW**	**UEPD**	**LEPW**	**LEPD**
N	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00
MEAN (cms)	**1.75**	**1.74**	**1.77**	**1.31**	**1.45**	**3.60**	**2.48**	**1.98**	**2.66**	**2.08**
SEM	**0.03**	**0.03**	**0.03**	**0.02**	**0.03**	**0.08**	**0.03**	**0.05**	**0.05**	**0.05**
Median	1.70	1.70	1.80	1.30	1.40	3.50	2.50	2.00	2.60	2.10
SD	**0.22**	**0.21**	**0.19**	**0.15**	**0.20**	**0.57**	**0.22**	**0.34**	**0.31**	**0.37**
Minimum	1.40	1.40	1.40	1.00	1.10	2.70	2.00	1.40	2.10	1.40
Maximum	2.30	2.70	2.40	1.70	1.90	5.10	2.90	2.70	3.50	2.80

Table 3: Descriptive Statistics of Lumber Vertebrae.

Lumbar	**VBHa**	**VBHp**	**VBHc**	**SCD**	**SCW**	**SPL**	**UEPW**	**UEPD**	**LEPW**	**LEPD**
N	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
MEAN (cms)	**2.26**	**2.27**	**2.29**	**1.37**	**1.91**	**2.49**	**3.85**	**2.90**	**4.06**	**2.87**
SEM	**0.07**	**0.06**	**0.05**	**0.04**	**0.08**	**0.11**	**0.13**	**0.10**	**0.13**	**0.08**
Median	2.20	2.30	2.30	1.40	1.80	2.50	3.70	2.80	4.20	2.90
SD	**0.33**	**0.28**	**0.25**	**0.20**	**0.39**	**0.52**	**0.61**	**0.49**	**0.61**	**0.38**
Minimum	1.50	1.70	1.70	1.10	1.30	1.40	2.90	2.00	2.80	2.20
Maximum	3.00	2.80	2.70	1.80	2.80	3.50	5.10	3.80	4.90	3.50

Analyzing the comparative difference, t-vlaues have been calculated among cervical vs thoracic (Table 4), cervical vs lumbar (Table 5) and thoracic vs lumbar (Table 6) for vertebral measurements.

It has been observed that differences for all the vertebral measurements except spinal canal depth (SCD) are statistically highly significant among cervical, thoracic and lumbar vertebrae.

Table 4: Mean difference and t-test between Cervical and Thoracic Vertebrae.

Cervical Vs Thoracic			**95% Confidence Interval of the Difference**			
	Mean Difference	**Std. Error Diff.**	**Lower**	**Upper**	**t-value**	**Sig. (2-tailed)**
VBHa	-0.50	0.06	-0.63	-0.38	-7.84	.000***
VBHp	-0.53	0.06	-0.65	-0.40	-8.58	.000***
VBHc	-0.31	0.06	-0.44	-0.19	-5.07	.000***
SCD	0.02	0.05	-0.07	0.12	0.54	0.59
SCW	0.73	0.06	0.60	0.85	11.86	.000***
SPL	-1.77	0.18	-2.14	-1.41	-9.70	.000***
UEPW	-0.23	0.08	-0.39	-0.08	-3.12	.003**
UEPD	-0.46	0.11	-0.68	-0.24	-4.23	.000***
LEPW	-0.63	0.09	-0.81	-0.44	-6.67	.000***
LEPD	-0.61	0.11	-0.82	-0.39	-5.68	.000***

*p<0.05 ** p<0.001 ***p<0.001

Table 5: Mean difference and t-test between thoracic and lumbar vertebrae.

Thoracic Vs Lumbar	Mean Difference	Std. Error Diff.	95% Confidence Interval of the Difference		t-value	Sig. (2-tailed)
			Lower	Upper		
VBHa	-0.51	0.07	-0.64	-0.37	-7.51	.000***
VBHp	-0.52	0.06	-0.65	-0.40	-8.59	.000***
VBHc	-0.52	0.05	-0.63	-0.42	-9.73	.000***
SCD	-0.07	0.04	-0.15	0.02	-1.59	0.12
SCW	-0.46	0.07	-0.60	-0.32	-6.52	.000***
SPL	1.12	0.14	0.83	1.40	7.90	.000***
UEPW	-1.37	0.10	-1.57	-1.17	-13.51	.000***
UEPD	-0.92	0.10	-1.12	-0.71	-9.00	.000***
LEPW	-1.40	0.11	-1.62	-1.18	-12.77	.000***
LEPD	-0.79	0.10	-0.98	-0.60	-8.19	.000***

*p<0.05 ** p<0.001 ***p<0.001

Table 6: Mean difference and t-test between Cervical and Lumbar Vertebrae.

Cervical Vs Lumbar	Mean Difference	Std. Error Diff.	95% Confidence Interval of the Difference		t-value	Sig. (2-tailed)
			Lower	Upper		
VBHa	-1.01	0.09	-1.20	-0.82	-10.72	.000***
VBHp	-1.05	0.08	-1.22	-0.88	-12.84	.000***
VBHc	-0.84	0.08	-1.01	-0.67	-10.08	.000***
SCD	-0.04	0.06	-0.17	0.08	-0.72	0.48
SCW	0.26	0.12	0.03	0.50	2.25	.031*
SPL	-0.66	0.20	-1.06	-0.26	-3.34	.002**
UEPW	-1.60	0.18	-1.97	-1.23	-8.81	.000***
UEPD	-1.38	0.16	-1.70	-1.06	-8.76	.000***
LEPW	-2.03	0.18	-2.39	-1.66	-11.40	.000***
LEPD	-1.39	0.11	-1.62	-1.17	-12.42	.000***

*p<0.05 ** p<0.001 ***p<0.001

DISSCUSION

The present study shows **(Tables 1 – 3)** that vertebral body height central (VBHc), is greater than that of anterior and posterior vertebral heights among all three types of vertebrae similarly trend has been observed for the spinal canal width (SCW).

Vertebral body height is found to increase after vertebroplasty in which bone cement is injected into the vertebral body for stabilizing or supporting the compression fractures in the spine but its clinical significance is still unknown [9]. Vertebral body heights are found to be highly similar in humans and because of upright position, end-plates width and depth increases more caudally in the human spine as it demands relatively larger vertebral bodies to balance the higher axial loads and thus shows the larger intervertebral disc heights [10] .

On the other hand, upper end plate width (UEPW) is greater than lower end plate width (LEPW) in cervical vertebrae only as in case of thoracic and lumbar vertebrae it is lesser than that of LEPW whereas upper end plate depth (UEPD) is greater than lower end plate depth (LEPD) in both cervical as well as lumbar vertebrae than that of thoracic where it is found to be lesser than LEPD. Upper and lower end plates of adjacent vertebrae can be used to measure Cobb's angle [11].

Thoracic spinous process is found to be larger than that of lumbar and cervical vertebrae **(Tables 1 – 3)** because of postural muscles which are more pronounced as also noticed by **Busscher et al**.[10]

Our results **(Table 1)** for spinal canal depth (SCD) of cervical vertebrae (Mean 1.33cm) were almost equal to the findings of the studies conducted by **Lee et al**.[12] on Korean population (SCD mean range 1.28 – 1.34

cm) and **Castro et al**.[13] on Japanese population (SCD mean range 1.24 – 1.33 cm) and further it is suggested that cervical canal measurements are quite helpful in preoperative planning of cervical surgeries [14]. Variations in the dimensions of spinal canal may also attribute to difficulties during neuroaxial anesthesia in Lumbar Disc Herniation (LDH) patients [15].

Thus, measurements at different sides and positions of the vertebrae at different levels of vertebral column plays a significant role in various clinical aspects. Variations observed indicates the adaptations to a greater range of flexion-extension . Even racial differences can be monitored for sagittal diameter of the lumbar vertebral canal [02].

Ageing and bone loss is common process, which increase the frequency of developing osteoporosis and its common complication is vertebral compression fractures. It has been also observed that vertebral height loss of >50% resulted in vertebral body instability [16-18]. Two important parameters that help in its prognosis and treatment are vertebral body height and kyphotic angle [19]. Further anterior and posterior vertebral heights can be used for estimating kyphotic angle and it is found that this angle (kyphotic angle) may be increased by 1% when the height difference of 7mm is observed between posterior and anterior vertebral heights [20].

Summarizing, one way or the other morphometric dimensions plays a remarkable role in understanding various vertebral anomalies and for planning or managing the related treatment or surgeries and for designing surgical appliances or prosthesis. Increased bone size at any level in the vertebral column might resist the normal movement of the body which could further compress the nerves or blood vessels lying internally or crossing nearby. Moreover, baseline data of various vertebral measurements also helpful in studying the racial or ethnic differences.

CONCLUSION

The morphometric analysis of various vertebral dimensions of cervical, thoracic and lumbar vertebrae are of great clinical significance in planning and managing surgical treatments and also serve as a useful guide in designing surgical instrumentation and prosthesis.

REFERENCES

1. Rogers K (2020) Vertebral Column. Encyclopaedia Britannica URL: http//www.britannica.com/science/vertebral- column 27th May,2020.
2. Gray H. (2000) *Grays Anatomy*. 38th Edition, Churchill Livingstone Publishing; pages 510-537.
3. Pavlov H, Torg JS, Robie B, Jahre C (1987) Cervical spinal stenosis: determination with vertebral body ratio method. Radiology.164(3):771-5. 3.
4. Ladd AL, Scranton PE (1986) Congenital cervical stenosis presenting as transient quadriplegia in athletes. Report of two cases. J Bone Joint Surg Am. 68(9):1371-4. 5.
5. Yue WM, Tan SB, Tan MH, Koh DC, Tan CT (2001) The Torg--Pavlov ratio in cervical spondylotic myelopathy: a comparative study between patients with cervical spondylotic myelopathy and a nonspondylotic, nonmyelopathic population. Spine.26(16):1760
6. Hukuda S, Kojima Y (2002) Sex discrepancy in the canal/body ratio of the cervical spine implicating the prevalence of cervical myelopathy in men. Spine. 27(3):250-3. 2.
7. Song KJ, Choi BW, Kim SJ, Kim GH, Kim YS, Song JH (2009) The relationship between spinal stenosis and neurological outcome in traumatic cervical spine injury: an analysis using Pavlov's ratio, spinal cord area, and spinal canal area. Clin Orthop Surg.1(1):11-8. 4.
8. Yue Wang,Michele C,Battie,Tapio Videman (2012). A morphological study of lumbar vertebral endplates: radiographic,visual and digital measurements. Eur Spine J; 21: 2316-2323.
9. Akio Hiwatashi , Toshio Moritani, Yuji Numaguchi, Per-Lennart Westesson (2003) Increase in vertebral body height after vertebroplasty. AJNR Am J Neuroradiol.24(2):185-9.
10. Busscher I, Ploegmakers JJW, Verkerke GJ, Veldhuizen AG (2010) Comparative anatomical dimensions of the complete human and porcine spine.Eur Spine J;19 : 1104 -1114.
11. Kuklo TR, Polly Jr DW,Owens BD , Zeidman SM, Chang AS, Klemme WR (2001) "Measurement of thoracic and lumbar fracture kyphosis: evaluation of intraobserver, interobserver, and technique variability," Spine, vol. 26, no. 1, pp. 61– 66 .
12. Lee HM, Kim NH, Kim HJ, Chung IH (1994) Mid-sagittal canal diameter and vertebral body/canal ratio of the cervical spine in Koreans. Yonsei Med J. 35(4):446-52. 16.
13. Castro FP (2003) Stingers, cervical cord neuropraxia and stenosis. Clin Sports Med. 22:483-92.
14. Chaurasiya AK, Dawar A, Gour R, Vaidya K (2021) Morphological study of cervical spinal body and vertebral body anatomy: CT scan based. Int Surg J. 8(5) : 1540-1544.
15. Kaydu A, Andan I, Akif DM, Bilge H, Başol O (2021) Examination of Spinal Canal Anatomy with MRI Measurements in Lomber Disc Herniation Patients: An Anesthesiologist Viewpoint. Anesth Essays Res. Jan-Mar; 15(1): 38–44.
16. M. Chadha and R. Bahadur (1998) "Steffee variable screw placement system in the management of unstable thoracolumbar fractures: a third world experience," Injury, vol. 29, no. 10, pp. 737–742.
17. McAfee PC,Yuan HA, Fredrickson BE, Lubicky JP (1983) The value of computed tomography in thoracolumbar fractures. An analysis of one hundred consecutive cases and a new classification," The Journal of Bone and Joint Surgery, vol. 65, no. 4, pp. 461–473.
18. Mikles MR, Stchur RP, and Graziano GP (2004) Posterior instrumentation for thoracolumbar fractures," Journal of the American Academy of Orthopaedic Surgeons, vol. 12, no. 6, pp. 424–435.
19. Ensrud KE and Schousboe JT (2011) "Vertebral fractures," New England Journal of Medicine, vol. 364, no. 17, pp. 1634–1642 .
20. Wei-En Hsu , Kuo-Chih Su ,Kun-Hui Chen , Chien-Chou Pan , Wen-Hsien Lu and Cheng-Hung Lee (2019) The Evaluation of Different Radiological

Measurement Parameters of the Degree of Collapse of the Vertebral Body in Vertebral Compression Fractures. Applied Bionics and Biomechanics Volume 2019, Article ID 4021640, 5 pages.