

ANTEROPOSTERIOR AND TRANSVERSE DIAMETERS OF VERTEBRAL BODIES OF ADULT THORACOLUMBAR VERTEBRAL COLUMN OF NORTH INDIAN POPULATION: A MORPHOMETRIC STUDY

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ABSTRACT

Background: The thoracolumbar vertebral column comprising of 17 vertebrae (thoracic:12; lumbar:5) is designed to support the combined weight of the head, upper limb and torso in erect position and also the weight of the burdens born upon these parts of the body. These weights subject the vertebral column mainly to the vertical compression forces, the magnitude of which increases in craniocaudal direction i.e. from T1-L5, thus the size of vertebral bodies also increase craniocaudally.

Purpose of study: The present study has been conducted upon vertebral bodies of 510 vertebrae (thoracic: 360; lumbar: 150) with the aim to provide a baseline data for mathematical modeling and biomechanical studies of human spine. The anteroposterior and transverse diameters of the vertebral body along its upper and lower surfaces were measured with vernier calipers.

Results: All the linear dimensions increased from T1-L5 with few exceptions. The anteroposterior diameter on lower surface decreased slightly at L5 which showed that comparatively less compressive force is exerted upon L5 as compared with L4 or L3. On comparing on both surfaces, it was more at lower surface by 1mm from T1-L1 and almost same from L2-L5. Similarly, transverse diameter of vertebral body along upper surface was less in the centre than the maximum transverse diameter by 4-5mm in thoracic region and 2-3mm in lumbar region. Further it was more as compared to anteroposterior diameter at all levels on both surfaces.

Conclusion: In humans, the thoracolumbar vertebral column supports the combined weight of the head, upper limb and torso in erect position which subject it to vertical compression forces. The magnitude of these forces increase from T1-L5, increasing the size of vertebral bodies in same pattern.

KEY WORDS: Anteroposterior Diameter, Transverse Diameter, Vertebral Body, Weight Bearing.

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INTRODUCTION

The thoracolumbar vertebral column is functionally a complex structure. The 17 vertebrae connected by intervertebral discs, ligaments and muscles are designed to support the combined weight of the head, upper limb and torso in erect position[1]. The elasticity of vertebral column is due to its four curves. The dorsal and sacral curves are primary as they appear in the fetal life and permanent owing to the shape of vertebral bodies. The cervical and lumbar curves are secondary curves which appear after birth following assumption of the erect posture. Weight bearing and mechanical factors appear to play important roles in morphological and functional adaptation of the vertebral column to the changing demands associated with growth[2].

Morphology of Body (Corpus Vertebrae) of typical thoracic vertebra: When viewed from above or below, it is heart shaped, being broad and hollowed out behind, and narrow and rounded off in front. The posterior height of the body exceeds the anterior in adaptation to the backward curve of the vertebral column in the thoracic region. The superior and inferior surfaces present a raised rim round the circumference and this renders the whole of the each surface slightly concave from the periphery towards centre. The anterior and lateral surfaces merge gradually into each other and are concave from above downward. The entire anterolateral surface is convex from side to side and pierced by numerous vascular foramina. Each lateral surface presents two semicircular articular demifacets, superior and inferior. The posterior surface of the body is concave from side to side and presents vascular foramina. The superior and inferior surfaces are related to the intervertebral discs. The anterior and posterior surfaces are related to the anterior and posterior longitudinal ligaments[3].

Morphology of Body (Corpus Vertebrae) of typical lumbar vertebra: When viewed from above or below, it is kidney shaped, being flattened from above downward, convex transversely over its anterolateral surface and slightly concave transversely on its posterior surface. It is wider transversely. The anterior

depth is slightly greater than the posterior, in adaptation to the forward curve of the vertebral column in the lumbar region. There is no facet on either side of the body[4].

AIMS AND OBJECTIVES

1. To compile the results, analyse these and provide a baseline data for all the parameters studied which may be useful for mathematical modeling and biomechanical studies of human spine.
2. To compare the results and explain the variations observed on the basis of anthropometric studies already available in accessible literature.

MATERIALS AND METHODS

The present study was conducted in the Department of Anatomy, Govt. Medical College, Amritsar after getting approval from Institutional ethical committee. The material comprised of 30 human adult male thoracolumbar vertebral columns i.e. a total of 510 vertebrae (thoracic 360; lumbar 150) obtained from the Department of Anatomy, Govt. Medical College, Amritsar. The vertebrae were thoroughly cleaned and boiled. All the vertebrae were without any gross abnormality. These were labeled from T1 to L5 depending upon the vertebra and bound in a wire in the correct sequence. Any particular set of vertebral column was belonging to the same body. Following parameters were measured with vernier calipers with least count of 0.02mm.

Fig. 1: Typical Thoracic Vertebra – Superior View.



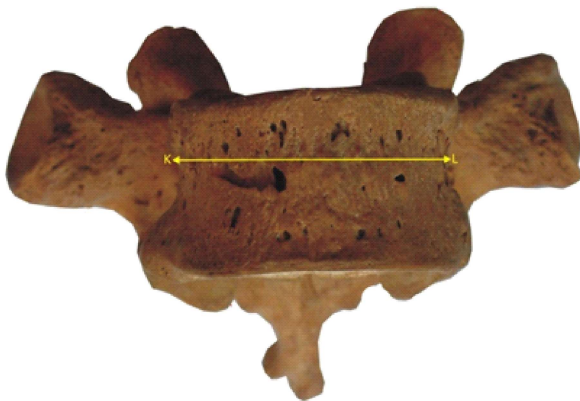
AB: A.P. Diameter on upper surface of V.B. **CD:** Maximum Transverse Diameter on upper surface of V.B. **EF:** Transverse Diameter in the centre on upper surface OF V.B.

Fig. 2:Typical Thoracic Vertebra – Inferior View.



AB: A.P. Diameter on lower surface of V.B. CD: Maximum Transverse Diameter on lower surface of V.B. EF: Transverse Diameter in the centre on lower surface OF V.B.

Fig. 3:Typical Thoracic Vertebra – Anterior View



Transverse Diameter along the waist of V.B.

Anteroposterior (A.P.) diameter of vertebral body (V.B.): It was measured in the sagittal plane on the upper surface (AB in Fig. 1) and the lower surface (AB in Fig. 2) of the vertebral body.

Transverse diameter of vertebral body: It was measured as the *maximum* horizontal diameter on the upper surface of the vertebral body (CD in Fig. 1). If it was not in the centre, then it was also measured in the centre of the vertebral body (EF in Fig. 1). The same measurements were also taken on the lower surface of the vertebral body (CD and EF respectively in Fig. 2) and at level of narrowest point of the waist of vertebra. (KL in Fig. 3).

RESULTS

Table 1 shows the **anteroposterior diameter of vertebral body along upper surface** from

T1 to L5. It increased constantly from 16.22mm at T1(Range:8.1-22.24mm) to 31.30mm at L5 (Range:19.26-37.70mm).

Table 2 shows **anteroposterior diameter of vertebral body along lower surface** from T1 to L5. It increased constantly from 17.02mm at T1(Range:11.12-21.56mm) to 31.33mm at L4(Range:17.00-41.08mm) and then decreased slightly to 31.09mm at L5 (Range:17.18-38.63mm).

On examining the trend, the A.P. diameter of vertebral body along both surfaces found to increase constantly by about 1mm in every next vertebra.

Anteroposterior diameter of vertebral body along upper and lower surfaces was also compared. It was seen that it was more along lower surface by about 1mm from T1-L1 but almost same from L2-L5.

Table 3 depicts the **maximum transverse diameter of vertebral body along upper surface and in the centre** of vertebral body from T1 to L5. Both dimensions showed a very small variation of about 1mm from T1 to T6 but thereafter it increased by 2-3mm every next vertebra till L5.

When two parameters were compared with each other, it was seen that width was less in the centre than the maximum transverse diameter by 4-5mm in thoracic region and by 2-3mm in lumbar region. It was also compared with anteroposterior diameter along the upper surface and was found to be more at all levels by 1.5-11mm than the anteroposterior diameter along the upper surface.

Table 4 depicts the **maximum transverse diameter of vertebral body along lower surface** from T1 to L5. It increased constantly from 29.64mm at T1 (Range: 23.1-34.71mm) to 48.47mm at L5 (Range: 34.58-69.16mm) with slight dips at T3 and T8.

The table 4 also depicts the **transverse diameter of vertebral body along the lower surface in the centre** from T1 to L5. It first decreased from 25.68mm at T1 (Range: 18.2-34.71mm) to 22.49mm at T3 (Range: 15.69-27.78mm) and then increased constantly to 44.5mm at L5 (Range:28.8-63.4mm).

Table 1:Showing A.P. diameter of vertebral body along upper surface.

Author	Eisenstein [5] 1977			Postacchini et al [6],1983		Gilad & Nissan[7], 1986	Krag[8,9], 1986,88	Berry et al,[10]1987	Marchsi et al[11], 1988	Scoles et al[12]1988	Panjabi et al[13]1992	Present study	
Population	Caucasoid	Zulu Negroid	Sotho Negroid	Indian	Italian	-	-	Ohio,USA	Swiss	Ohio,USA	Japanese	North Indian	
(mm)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Range
T1	-	-	-	-	-	-	-	-	-	15.5	-	16.22	8.1-22.24
T2	-	-	-	-	-	-	-	18.1	-	-	-	17.62	10.44-23.00
T3	-	-	-	-	-	-	-	-	-	18.7	-	18.73	11.05-26.69
T4	-	-	-	-	-	-	-	-	-	-	-	19.68	12.55-25.38
T5	-	-	-	-	-	-	-	-	-	-	-	20.5	12.03-27.60
T6	-	-	-	-	-	-	-	-	26.2	23.7	-	21.94	14.28-29.13
T7	-	-	-	-	-	-	-	27	28	-	-	22.91	13.72-28.49
T8	-	-	-	-	-	-	-	-	29.4	-	-	23.87	16.72-31.64
T9	-	-	-	-	-	-	-	-	30.3	27.4	-	24.86	18.90-29.45
T10	-	-	-	-	-	-	-	-	30.8	-	-	25.43	18.25-34.13
T11	-	-	-	-	-	-	-	-	31.2	-	-	26.24	17.40-34.30
T12	-	-	-	-	-	-	-	31.7	31.2	28.8	-	27.17	18.16-35.69
L1	31	28	27	25	29	34.1	31	31.9	30.8	29.5	34.1	28.04	18.50-35.68
L2	32	30	29	27	31	34.7	32.5	33.3	31.9	-	34.6	29.15	19.16-37.06
L3	33	32	31	28	30	34.6	30.5	33.9	33.2	32.6	35.2	30.1	19.84-38.17
L4	34	33	32	29	32	34.9	32	34.9	33.9	-	35.5	30.83	20.12-49.46
L5	33	32	33	29	33	33.9	33	35.1	31.8	34.5	34.7	31.3	19.26-37.70

Table2: Showing the A.P. diameter of vertebral body along lower surface.

Author	Berry et al [10], 1987	Panjabi et al [13], 1992	Present study	
Population	Ohio,USA	Japanese	North Indian	
(mm)	Mean	Mean	Mean	Range
T1	-	-	17.02	11.12-21.56
T2	19	-	18.65	13.80-24.25
T3	-	-	19.9	13.85-28.58
T4	-	-	20.39	14.48-25.60
T5	-	-	21.35	12.65-29.05
T6	-	-	22.98	15.40-31.00
T7	28	-	23.82	15.16-30.06
T8	-	-	24.4	17.62-32.40
T9	-	-	25.43	18.85-29.52
T10	-	-	26.17	18.10-38.10
T11	-	-	27.22	18.52-36.97
T12	31.2	-	28.6	18.36-37.42
L1	32.3	35.3	29.19	15.70-37.34
L2	33.4	34.9	29.9	16.30-36.00
L3	34.2	34.8	30.41	16.72-41.21
L4	35.6	33.9	31.33	17.00-41.08
L5	34.5	33.2	31.09	17.18-38.63

Table 3:Showing the transverse diameter along the upper surface of vertebral body.

Paramt	Transverse diameter of vertebral body along upper surface									
	(a) Maximum					(b) Centre				
Author	Berry et al[10], 1987	Scoles et al ^[12] , 1988	Panjabi et al[13] 1992	Present study		Postacchini et al [6] 1983	Marchesi et al[11], 1988	Present study		
Popu-lation	Ohio, USA	Ohio, USA	Japanese	North Indian		Indian	Italian	Swiss	North Indian	
(mm)	Mean	Mean	Mean	Mean	Range	Mean	Mean	Mean	Mean	Range
T1	-	26.4	--	27.01	17.72-32.10	-	-	-	22.52	15.14-26.96
T2	29.8	-	--	27.06	18.86-38.72	-	-	-	23.07	14.96-27.08
T3	-	27.6	-	26.51	18.73-32.00	-	-	-	22.38	15.01-27.42
T4	-	-	-	26.8	19.10-33.46	-	-	-	22.16	14.15-27.42
T5	-	-	-	27.5	19.06-34.75	-	-	-	23.27	14.02-29.94
T6	-	28.7	-	27.75	19.70-34.60	-	-	28.2	23.37	14.16-30.14
T7	31	-	-	28.81	21.10-35.85	-	-	29.3	24.9	17.46-31.20
T8	-	-	-	29	22.70-36.40	-	-	30.5	25.22	18.75-31.94
T9	-	32.5	-	31.1	20.77-38.12	-	-	31.8	26.94	18.69-32.24
T10	-	-	-	32.8	22.09-42.69	-	-	34	28.56	18.18-37.97
T11	-	-	-	36	24.66-52.17	-	-	37.3	31.79	19.40-52.17
T12	43.8	41.7	-	38.21	27.38-49.30	-	-	39.1	33.63	22.34-45.51
L1	45.2	44.3	41.2	39.14	29.82-49.24	36	41	39.4	36.11	24.20-47.22
L2	47.7	-	42.6	40.41	29.93-49.80	37	43	41.2	38.05	26.56-49.07
L3	49.6	48.4	44.1	42.02	30.00-52.38	40	44	43.3	39.53	26.78-50.35
L4	51.2	-	46.6	43.63	30.56-51.91	41	47	44.3	41.05	27.84-49.73
L5	53.4	52.9	47.3	46.13	31.14-61.24	43	49	46.7	42.2	27.70-56.66

Table 4:Showing the transverse diameter along the lower surface of vertebral body.

Parameter	Transverse diameter of vertebral body along lower surface					
	(c) Maximum				(d) Centre	
Author	Berry et al[10], 1987	Panjabi et al [13], 1992	Present study		Present study	
Population	Ohio, USA	Japanese	North Indian		North Indian	
mm	Mean	Mean	Mean	Range	Mean	Range
T1	-	-	29.64	23.10-34.71	25.68	18.20-34.71
T2	33.5	-	30.35	23.54-36.35	24.68	15.97-32.13
T3	-	-	30.09	21.75-38.20	22.49	15.69-27.78
T4	-	-	30.45	21.05-37.21	22.53	16.00-27.98
T5	-	-	30.74	21.43-36.20	24	16.38-31.26
T6	-	-	31.69	24.80-42.00	24.36	18.28-31.75
T7	33.2	-	32.37	26.48-37.32	26.08	17.64-32.63
T8	-	-	32.02	24.40-38.40	26.85	20.32-34.43
T9	-	-	33.97	23.33-40.00	29.26	17.00-37.72
T10	-	-	36.38	24.90-50.96	31.72	19.82-47.38
T11	-	-	38.56	26.09-51.38	34.25	23.74-50.03
T12	46.8	-	41.41	28.24-52.53	36.11	23.73-51.31
L1	49.1	43.3	42.81	29.95-52.98	38.89	26.80-50.66
L2	54.8	45.5	43.9	31.70-53.93	40.33	27.00-53.10
L3	53.8	48	45.3	32.64-54.50	41.63	27.14-51.86
L4	50.9	49.5	46.85	33.48-60.88	43.67	27.60-60.68
L5	52.7	49.4	48.47	34.58-69.16	44.5	28.80-63.40

Table 5:Showing the transverse diameter along the waist of vertebral body.

Author	Eisenstein[5], 1977			Amonoo-kuofi [14], 1982	Berry et al [10], 1987	Amonoo-kuofi et al [15], 1990	Present study	
Population	Caucasoid	Zulu Negroid	Sotho Negroid	Nigerian	Ohio, USA	Saudi Arabian	North Indian	
(mm)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Range
T1	-	-	-	-	-	-	28.8	19.52-35.92
T2	-	-	-	-	28.1	-	27.64	19.06-34.88
T3	-	-	-	-	-	-	26.84	19.52-39.39
T4	-	-	-	-	-	-	26.48	19.80-31.56
T5	-	-	-	-	-	-	27.28	19.71-33.41
T6	-	-	-	-	-	-	27.48	19.90-32.86
T7	-	-	-	-	28	-	28.59	20.40-33.00
T8	-	-	-	-	-	-	29.03	22.04-34.14
T9	-	-	-	-	-	-	30.66	21.06-35.00
T10	-	-	-	-	-	-	32.8	21.36-42.98
T11	-	-	-	-	-	-	34.82	23.21-42.26
T12	-	-	-	-	37.6	-	36.75	26.23-46.47
L1	39	39	38	41.3	39.5	44.5	37.41	27.06-45.66
L2	40	40	39	42.9	44.8	47	38.02	28.60-47.37
L3	43	42	41	45.8	42.3	49.8	39.22	29.16-45.60
L4	44	44	43	49.6	40.8	53.3	40.92	30.00-48.32
L5	46	45	44	52.8	46.1	57.6	43.9	31.00-58.95

It was also compared with anteroposterior diameter along the lower surface and was found to be more at all levels by 1.5-13.5mm than the anteroposterior diameter along the lower surface.

Table 5 depicts the **transverse diameter along the waist of vertebral body** from T1 to L5. It first decreased from 28.80 mm at T1 (Range: 19.52-35.92mm) to 26.48mm at T4 (Range: 19.38-31.56mm)and then increased to 43.90mm at L5 (Range: 31.00-58.95mm).

DISCUSSION

All the parameters were compared with the previous studies done by various authors on different populations and at different levels (Table No 1 to 5) except for transverse diameter along lower surface in the centre (No data was found in the accessible literature).

It was seen that A.P. diameter along upper surface of vertebral body was less in North Indians by about 2-4mm as compared with Americans.[10] Similarly the results of different other populations indicate that racial variations do exist in this parameter[5-13]. Even regional variations were seen when present study was compared with that by **Postacchini et al** [6]

on Indian skeletons. It was more in North Indians by 2-3mm.(Table 1)

Table 2 compares the A.P. diameter along lower surface of vertebral bodywith earlier studies done by **Berry et al**[10] and **Panjabi et al**[13] in primarily the lumbar region of American and Japanese populations respectively. It was seen that it was less by 3-4mm in North Indians as compared with American populationand by 4-5mm as compared with Japanese population. However, the trend was same in all the studies i.e. it increased from L1-L4 and then decreased at L5.

Maximum transverse diameter along the upper surface of vertebral body was measured by **Berry et al**[10] and **Scoles et al** [12] at different levels in American population and **Panjabi et al** [13]in lumbar region on Japanese population. [See Table 3(a)]Like A.P. diameter, it was also less in North Indians as compared with American and Japanese populations. When compared with American population, difference was 1-3mm in thoracic region but 5-7mm in lumbar region. However, when compared with Japanese, the difference was less (2-3mm). These differences may be attributed to racial variation. The trend was found to be same as shown by

earlier studies.

Table 3 (b) compares the transverse diameter in the centre of vertebral body along the upper surface with studies done by Postacchini et al [6] and Marchesi et al [11]. It was found to be less by 5-6mm in thoracic region and by 3-4mm in lumbar region in North Indians as compared with Swiss population. Similarly when compared with lumbar region of Italians, it was less by 5-7mm in North Indians. However, it was comparable to lumbar region in Indians.

Like Maximum transverse diameter along the upper surface of vertebral body, the same dimension on the lower surface was found to be less in North Indians as compared to Americans [10] and Japanese [13]. However, No comparative data was available in the accessible literature for the transverse diameter in the centre of vertebral body on lower surface.

Table 5 shows the comparison of transverse diameter along the waist of vertebral body. It was seen that, this parameter was comparable to Caucasoids and Negroids [5] at L1-L2 level but lesser by 2-4mm at L3-L5. However, when compared with other populations, marked difference ranging between 5-15mm were observed.

CONCLUSION

The anteroposterior and transverse diameters increased progressively from T1 to L4-5. It may be attributed to the fact that in man, the vertebral column supports the weight of trunk and upper limbs and also the weight of the burdens born upon these parts of the body. These weights subject the vertebral column mainly to the vertical compression forces, the magnitude of which increase in craniocaudal direction i.e. from T1-L5. Therefore it is but natural for the size of vertebral bodies to increase craniocaudally i.e. from T1-L5. Further, it was seen that the A.P. diameter of vertebral body along its lower surface increased upto L4 and then decreased at L5 which means a comparatively less compressive force is exerted upon L5 as compared with L4 or L3. In other words, part of total compressive force must be transmitted to the pelvis by some other mechanism namely neural arches, transverse processes or iliolumbar ligaments. [16]

Conflicts of Interests: None

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