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Case Series

A morphometric study of body, pedicle, lamina and spine of typical thoracic vertebrae (T2-T8)

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Abstract

Introduction: The typical thoracic vertebrae form essential part of the vertebral column which support the spine, aid respiration and anchor ribs. Their unique structure enables limited movement, essential for posture and stability.
Aim and Objective: This study measures various parameters of T2-T8 vertebrae for anatomical and clinical insights.
Materials and Methods: This study analysed 38 dry typical thoracic vertebrae of unknown gender and age from an anatomical collection, free of deformities. Morphometric measurements were taken using a digital vernier calliper.
Results: The typical thoracic vertebra exhibits a body with a superior ap diameter ranging from 14.65 to 25.01 mm (mean 19.13 ± 2.97 mm) and a posterior height of 14.72 to 22.10 mm (mean 17.48 ± 1.63 mm). The superior transverse diameter of 19.34 to 29.00 mm (mean 23.78 ± 2.41 mm) and an average height of right-side pedicles 9.75 ± 1.06 mm. The height of right-side laminae 17.63 ± 1.76 mm and width of right-side laminae are 5.88 ± 1.89 mm. The spinous process, projecting posteriorly has a length ranging from 27.32 to 47.83 mm (mean 35.89 ± 5.36 mm).
Conclusions: Detailed knowledge about this study will guide surgeons and orthopaedician in surgeries like vertebroplasty, fracture reduction surgeries and vertebral prosthetic surgeries.

Keywords: Thoracic vertebrae, Lamina, Pedicle

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1. Introduction

The position of vertebral column is at posteriorly in midline. Primary curvature of the vertebral column is concave anteriorly as remnant of the embryo's original shape. It persists in the thoracic & sacral region. Secondary curvature is concave posteriorly and develops in the cervical & lumbar regions to align the body's centre of gravity. It minimizes the muscular energy needed to maintain upright posture. This arrangement allows for the efficient balance of body's weight on the vertebral column. Here thoracic curve is mainly produced by the reduced ventral arch of vertebral bodies & extends from 2nd to 12th thoracic vertebrae.[7] There are 12 thoracic vertebrae in human body classified as typical or atypical. 2nd to 8th thoracic vertebrae is typical due to its common features while 1st & 9th to 12th thoracic vertebrae are atypical due to its unique features.

Thoracic vertebrae are anatomical landmarks for angle of louis (sternal angle) from where sternal plane passes & divide mediastinum into superior & inferior mediastinum which contains vital organs of thorax. Thoracic vertebrae specially from 4th to 12th are forming posterior boundary of posterior mediastinum. Protects spinal cord & serve as surgical landmark for thoracic medical procedures.

Other than surgical & anatomical approach morphometry of typical thoracic vertebrae are valuable tool for building biological profiles of skeletal remains which can be vary gender, age & race point of view. It also helps in forensic cases. Hence, the present study reflects on morphometric parameters of dry human thoracic vertebrae.

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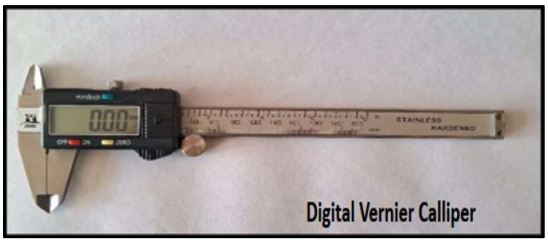
2. Materials and Methods

A cross-sectional study of 38 dry typical thoracic vertebrae (T2-T8) of undetermined age & sex was studied from Department of Anatomy, Government Medical College, Bhavnagar, Gujarat, India.

Fully ossified, dry, intact & typical thoracic (T2-T8) vertebrae were included in this study. Fractured or broken bones with missing anatomical landmarks, pathological bones, paediatric age group and unossified bone were excluded from the study.



All the measurements were measure in unit of "mm".

Measurements were taken with digital vernier calliper with accuracy of ± 0.01 mm.

Data was collected and analysed in Microsoft excel sheet 2021 version.

After identifying typical thoracic vertebrae from anatomical collection, we had put it on a flat surface. Standard anatomical landmarks of vertebrae were identified & measured as per description of parameters with help of digital vernier calliper. All data were recorded systematically in excel sheet. To avoid inter observer variability measurements was taken by one observer. Collected data is prepared for statistical analysis.

2.1. Statistical analysis

After collecting data in excel sheet, statistical analysis was done with help of excel sheet formulas in which we measured mean, SD, minimum & maximum values for basic understanding of the central tendency & variability within the data.

3. Result

In morphometric analysis of 38 dry bony typical thoracic vertebrae (T2-T8) we include different values of range, mean ± SD for different parameters of vertebral body, pedicles, laminae & spinous process.

For vertebral body study shows range of 14.65-25.01 mm with mean ± SD value of 19.13 ± 2.97 mm for superior AP diameter. For inferior AP diameter range is 14.96 - 27.35 mm & value of mean ± SD is 20.24 ± 2.94 mm. For anterior & posterior height of vertebral body range is respectively 12.21 - 20.32 mm & 14.72 - 22.10 mm, while mean ± SD for same parameter is 15.21 ± 1.51 mm for right & 17.48 ± 1.63 mm for left side. For superior transverse diameter have found a range 19.34 - 29.00 mm with mean ± SD of 23.78 ± 2.41 mm. For inferior transverse diameter have found a range 21.49 - 30.92 mm with mean ± SD of 25.56 ± 2.60 mm. For right & left lateral height of body range is respectively 13.44 - 19.45 mm & 12.70 - 20.04 mm and mean ± SD is 16.28 ± 1.53 mm & 16.38 ± 1.60 mm respectively. All these values of vertebral body can be seen in **Figure 3** & **Table 3**.

Table 1: List of parameters

Body of vertebra	**Pedicle of vertebra**
1. superior AP* Diameter	9. Height of Pedicle (Rt. & Lt.) #
2. Inferior AP* Diameter	10. Width of Pedicle (Rt. & Lt.) #
3. Anterior Height of Body	**Lamina of Vertebra**
4. Posterior Height of Body	11. Height of Lamina (Rt. & Lt.) #
5. Superior Transverse Diameter	12. Width of Lamina (Rt. & Lt.) #
6. Inferior Transverse Diameter	**Spinous process of Vertebra**
7. Right Lateral Height	
8. Left Lateral Height	13. Length of Spine

*AP-Anteroposterior

Table 2: Description of parameters

Parts of Vertebra	Parameters	Description
Body of Vertebra	Superior Anteroposterior Diameter	In Midline at Superior Side of Body Distance from Anterior Border till Posterior Border. (**Figure 1**-A & **Figure 2**-A)
	Inferior Anteroposterior Diameter	In Midline at Inferior Side of Body Distance from Anterior Border till Posterior Border. (**Figure 1**-B)
	Anterior Height of Body	In Midline from Anterior View of Body Vertical Distance from Superior to Inferior Surface of Body. (**Figure 2**-C)
	Posterior Height of Body	In Midline Vertical Distance Posteriorly to Body from Superior to Inferior Surface of Body. (Not Shown In Figure)
	Superior Transverse Diameter	Maximum Transverse Distance at Superior Surface of Body. (**Figure 1**-A & **Figure 2**-D)
	Inferior Transverse Diameter	Maximum Transverse Distance at Inferior Surface of Body. (**Figure 1**-B)
	Right Lateral Height	Vertical Distance of Body at Lateral View in Midway at Right Side of Vertebra. (**Figure 1**-C)
	Left Lateral Height	Vertical Distance of Body at Lateral View in Midway at Left Side of Vertebra. (Not Shown in Figure)
Pedicle of Vertebra	Height Of Pedicle	Distance At Midpoint Between Superior End & Inferior End of Pedicle. (Right Side Seen in **Figure 1**-C)
	Width Of Pedicle	At A Midpoint Towards Medial & Lateral Surface with Long Axis & At Right Angle of Pedicle. (**Figure 1**-B)
Lamina of Vertebra	Height Of Lamina	Maximum Distance Between Superior & Inferior Borders of Lamina. (**Figure 1**-D)
	Width Of Lamina	Maximum Distance Between Anterior & Posterior Surface of Lamina. (**Figure 1**-A)
Spinous Process of Vertebra	Length Of Spine	Distance At Midpoint Between 2 Laminae of Posterior Part of Vertebral Arch to Tip of The Spinous Process. (**Figure 1**-D & **Figure 2**-B)

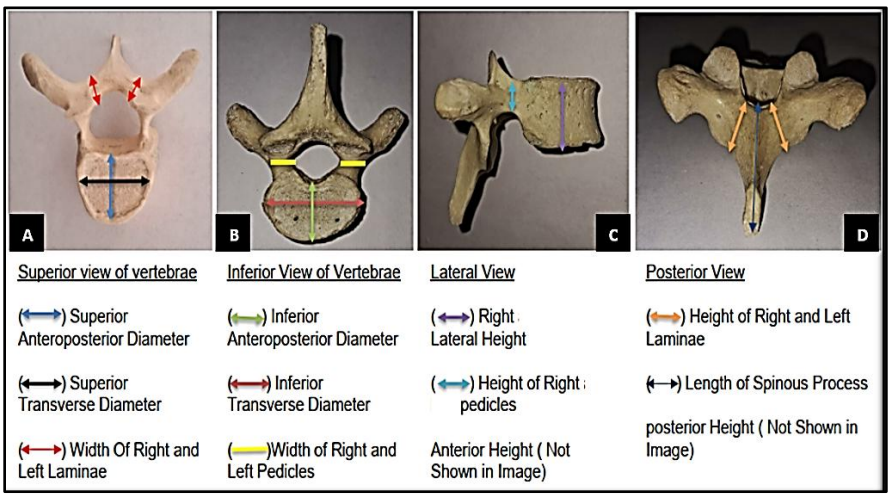


Figure 1: Different view of vertebra showing parameters of body, pedicle, lamina & spinous process

A-Superior view of vertebra shows Diameters of Body & width of Lamina, **B**-Inferior View of Vertebra shows Diameters of Body & width of pedicle, **C**-Right Lateral View of vertebrae shows Lateral Height of body & Height of Right pedicle, **D**-Posterior View of Vertebra shows Height of Lamina & Length of Spine.

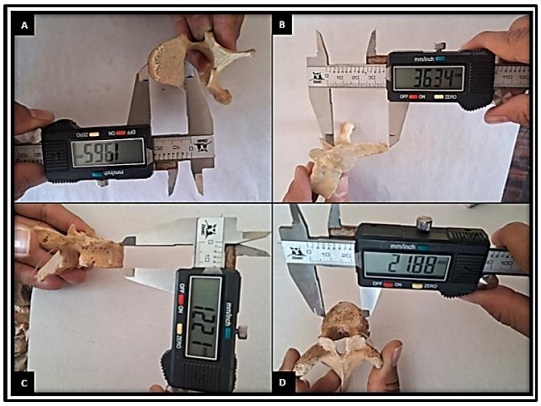


Figure 2: Showing measuring techniques of different parameters of body & spinous process of typical thoracic vertebrae **A-** measuring superior anteroposterior diameter of body, **b-**measuring length of spinous process, c-measuring anterior height of body, **d-**measuring superior transverse diameter of body

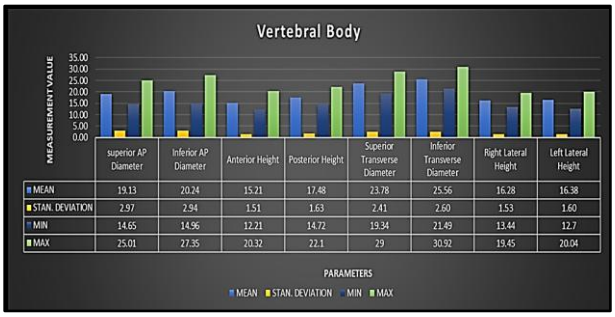


Figure 3: Parameters of vertebral body shown in graph

Table 3: Vertebral body

Parameters	Range (MM)	Mean ± SD (MM)
Superior AP* Diameter	14.65 - 25.01	19.13 ± 2.97
Inferior AP* Diameter	14.96 - 27.35	20.24 ± 2.94
Anterior Height	12.21 - 20.32	15.21 ± 1.51
Posterior Height	14.72 - 22.10	17.48 ± 1.63
Superior Transverse Diameter	19.34 - 29.00	23.78 ± 2.41
Inferior Transverse Diameter	21.49 - 30.92	25.56 ± 2.60
Right Lateral Height	13.44 - 19.45	16.28 ± 1.53
Left Lateral Height	12.70 - 20.04	16.38 ± 1.60

*AP-Anteroposterior

For vertebral pedicle on right side range of height of pedicle is from 7.86-12.14 mm & mean ± SD is 9.75 ± 1.06 mm. While for left side pedicle height range from 8.10 - 12.65 mm & mean ± SD is 9.93 ± 1.03 mm. For width of pedicle on right side range from 2.02 - 7.45 mm & mean ± SD is 4.12 ± 1.26 mm. While for left side range is 1.36 - 8.07 mm & mean ± SD 3.99 ± 1.33 mm. All these values of vertebral pedicle are represented as graph in **Figure 4** & in **Table 4**.

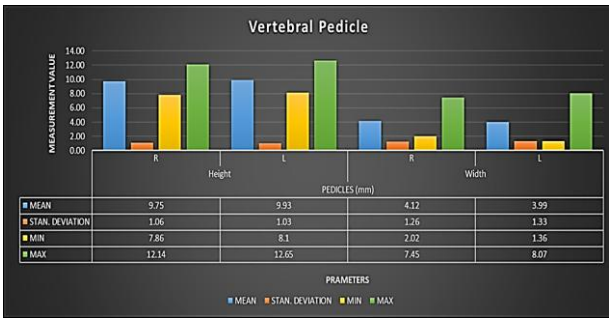


Figure 4: Parameters of vertebral pedicle shown in Graph}

Table 4: Vertebral pedicle

Parameters	Range (mm)		Mean ± SD (mm)	
	Right	Left	Right	Left
Pedicle Height	7.66 - 12.14	8.10 - 12.65	9.75 ± 1.06	9.93 ± 1.03
Pedicle Width	2.02 - 7.45	1.36 - 8.07	4.12 ± 1.26	3.99 ± 1.33

For vertebral laminal height range from 14.08 - 23.11 mm on right side. For left side its 13.82 - 23.26 mm. While mean ± SD for same parameter is 17.63 ± 1.76 mm on right side & for left side its 17.48 ± 1.83 mm. For width of vertebral lamina on right side range is 4.51 - 16.61 mm & mean ± SD is 5.88 ± 1. 89 mm. While for left side range is 4.23 - 16.12 mm & mean ± SD 5.90 ±1. 88 mm. All these data of lamina shown in **Figure 5** & **Table 5**.

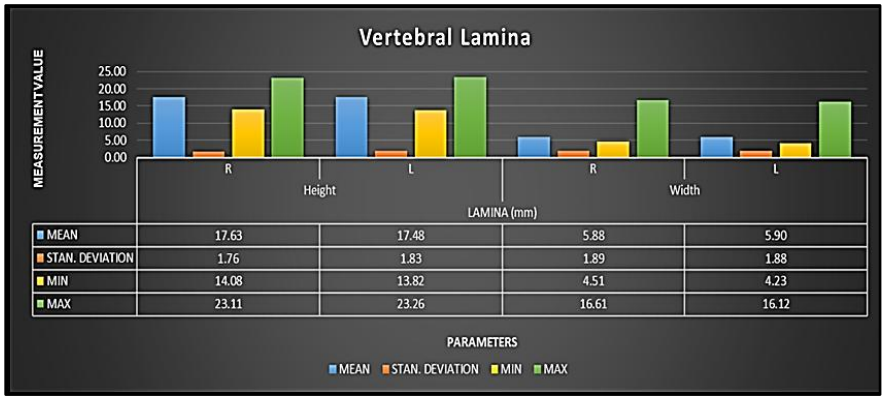


Figure 5: Parameters of vertebral lamina shown in graph

Table 5: Vertebral lamina

Parameters	Range (mm)		Mean ± SD (mm)	
	Right	Left	Right	Left
Lamina Height	14.08 - 23.11	13.82 - 23.26	17.63 ± 1.76	17.48 ± 1.83
Lamina Width	4.51 - 16.61	4.23 - 16.12	5.88 ± 1.89	5.90 ±1.88

For spinous process of vertebra there is length taken as parameter contains range of 27.34 - 47.83 mm & mean ± SD is 35.89 ± 5.36 mm shown with **Figure 6** & **Table 6**.

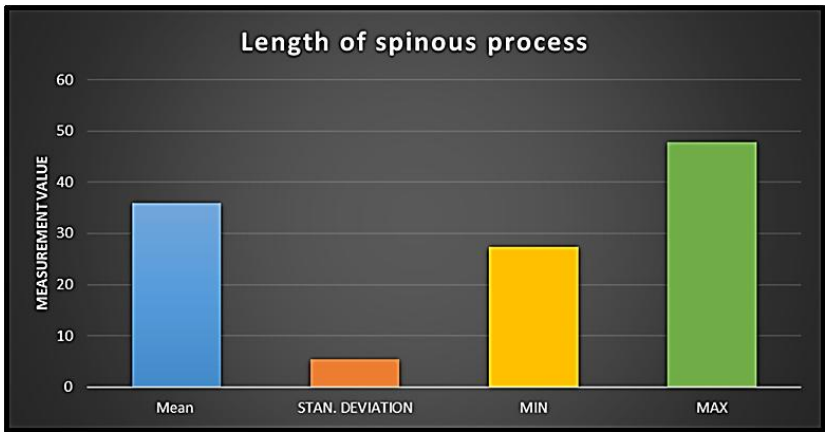


Figure 6: Length of vertebral spinous process

Table 6: Vertebral spinous process

Parameter	Range (mm)	Mean ± SD (mm)
Length of spinous process	27.34 - 47.83	35.89 ± 5.36

Table 7: Comparison of vertebral body parameters with other studies

Study references	Moulya BNH et al[4]	Punjabi MM et al [9]	S.H. Tan Et al[5]	Patil Dhawal K G et al[10]	M S Selukar et al[1]	Egwu OA et al[2]	Hari Narayan Yadav et al[3]	Present study
Year, Populations	2022, Andhra Pradesh, India	1991, USA	2004, Singapore	2014, India	2019, Maharashtra, India	2009, Nigeria	2023, India	2026, Gujarat, India
Material for study	Dry Bones	Dry Bones	Cadaveric Study	Dry Bones	Dry Bones	Cadaveric Study	Dry Bones	Dry Bones
Morphometric parameter	**All measurements shown as mean (mm).**							
superior AP Diameter	21.77	24.26	20.21	20.78	22.37	20.53	18.53	19.13
Anterior Height	18.17	-	15.04	17.17	20.15	17.57	16.24	15.21
Posterior Height	-	16.86	16.41	18.27	21.12	18.65	17.81	17.48
Superior Transverse Diameter	28.22	26.06	23.84	27.02	28.25	26.68	25.58	23.78

Table 8: Comparison of vertebral laminae parameters with other studies

Study References	Hari Narayan Yadav et al[3]	Egwu OA et al[2]	Present study
Year, Populations	2023, India	2009, Nigeria	2026, Gujarat, India
Types of materials	Dry Bones	Cadaveric Study	Dry Bones
Morphometric Parameter	**All Measurements Shown as Mean (mm).**		
Height-Right	17.07	18.13	17.63
-Left	17.20		17.48
Width-Right	5.26	6.86	5.88
-Left	5.13		5.90

Table 9: Comparison of vertebral pedicles parameters with other studies

Study references	Hari Narayan Yadav et al[3]	Present study
Year, populations	2023, India	2026, Gujarat, India
Types of materials	Dry Bones	Dry Bones
Morphometric parameter	All Measurements Shown as Mean (mm).	
Height-right	9.64	9.75
-Left	9.68	9.93
Width-right	3.75	4.12
-Left	3.74	3.99

Table 10: Comparison of vertebral spinous process with other studies

Study references	Egwu OA et al[2]	Present study
Year, populations	2009, Nigeria	2026, Gujarat, India
Types of materials	Cadaveric Study	Dry Bones
Morphometric parameter	All Measurements Shown as Mean (mm).	
Length	37.63	35.89

4. Discussion

The present study provides morphometric data of the vertebral body from a Gujarat population. That demonstrates both similarities and differences when compared with previous studies. The mean Superior Anteroposterior Diameter in the present study (19.13 mm) is lower than that reported by Punjabi mm et al.[9] (24.26 mm), M S Selukar et al.[1] (22.37 mm) and Moulya BNH et al.[4] (21.77 mm). The findings of S.H. Tan et al.[5] (20.21 mm) and Egwu OA et al.[2] (20.53 mm) were similar to present study. This suggests regional and ethnic influences on vertebral dimensions. The Anterior Height observed in the present study (15.21 mm) closely approximates the values reported by S.H. Tan et al.[5] (15.04 mm) and is slightly lower than those reported in Indian

studies by Patil Dhawal K.G. Et al.[10] (17.17 mm) and Hari Narayan Yadav et al.[3] (16.24 mm). Posterior Height in the present study (17.48 mm) shows good agreement with Punjabi mm et al.[9] (16.86 mm) and Egwu OA et al.[2] (18.65 mm), while being lower than the measurements reported by Selukar et al.[1] (21.12 mm).

The present study shows that the Mean Laminar height (right: 17.63 mm; left: 17.48 mm) is comparable with the findings of Egwu OA et al.[2] (18.13 mm) and Hari Narayan Yadav et al.[3] (right: 17.07 mm; left: 17.20 mm). This indicates minimal interpopulation variation in laminar height. A slight right-side predominance was observed, like previous reports. These differences may be attributed to ethnic, geographical and methodological variations, particularly between cadaveric and dry bone studies.

The Pedicle Height in the present study is comparable to that reported by Hari Narayan Yadav et al.[3] with minimal side-to-side variation. Pedicle Width values are slightly higher in the present study. That indicates minor regional differences. Overall, the close agreement between studies highlights the consistency of pedicle dimensions within the Indian population and underscores the importance of population-specific data for safe pedicle screw placement.

The study reveals that length of spine varies significantly where direct comparisons with studies like Egwu et al.[2] (2019) show high value of mean as shown in Table: 10. It is important to note that there are some limitations in this study because of undetermined age & sex of the specimens, methodology and variation of sample sizes as compare to other references.

5. Conclusion

The present study of typical thoracic vertebrae of Gujarat population provides data of typical thoracic vertebrae body, pedicles, laminae & spinous process. Compared with western populations, the present study demonstrated relatively smaller anteroposterior and transverse diameters. But values were same to those reported in other Indian population studies. Pedicle height and width showed mild side-to-side asymmetry and were consistent with previous Indian studies but slightly smaller than Nigerian data. It highlights the importance of population-specific morphometry for safe transpedicular screw fixation. Spinous process length was marginally shorter than cadaveric reports which could be due to methodological or degenerative factors. Laminar height and width closely matched existing Indian literature confirming their reliability for surgical planning.

Hence, these findings reinforce the importance of region and population-specific morphometric databases for spinal surgery, radiological findings, implant design, forensic identification and anthropological research. The present data can serve as a valuable reference for clinicians and researchers who deals with thoracic spine instrumentation and anatomical variations in the Indian population.

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7. Source of Funding

None.

8. Conflict of Interest

None.

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