Original Research Article

Morphometric study of the lower lumbar vertebras and intervertebral discs in the north-eastern population of India using digitized CT scan images

Manumati Munglang[1], Wangju Sumnyan[2*]

{[1]Assistant Professor, Department of Anatomy} {[2]Associate Professor, Department of Radiology} Tomo Riba Institute of Health And Medical Sciences (TRIHMS) and Hospital, P.O- Naharlagun, District- Papum Pare, Arunachal Pradesh, Pin Code- 791110, INDIA.
Email: dr.manumati.munglang@gmail.com , sumnyanwang@gmail.com

Abstract

Background: Many people are affected by low backache worldwide. Low back pain could be due to various reasons like improper lumbar vertebral alignment, nerve compression, improper posture, muscle stiffness etc. The anatomy and knowledge of lumbar vertebral dimensions and lumbar intervertebral disc dimensions could be of great value in studying the etiology of backache. Therefore the present study was undertaken to study the dimensions of the L4 and L5 lumbar vertebras as well as that of the L4-5 and L5-S1 lumbar intervetebral discs, as they are the most dependent part of the vertebral column. **Method:** Computerised Tomographic (CT) scan images of lumbar region (300 each for male and female) were obtained from radiology department of Tomo Riba Institute of Health and Medical Sciences and Hospital, Naharlagun. The antero-posterior and the transverse diameter and the anterior, central and posterior height of the body of L4 and L5 lumbar vertebras as well as the height and the antero-posterior length of the L4-5 and L5-S1 lumbar intervetebral discs were measured and studied both in males and females of different age groups. **Result:** It was seen that both the antero-posterior and the transverse diameters of the L4 and L5 vertebral bodies as well as the antero-posterior diameter of the L4-L5 and L5-S1 intervertebral discs were increased with advancing age, whereas the height of the disc was seen to be decreased. **Conclusion:** It is concluded that with advancing age, the lumbar vertebrae increases in width, whereas the intervertebral disc shows a decrease in height with an increases in width.
Key Words: Backache, Intervertebral disc, Lumbar, Vertebra, CT scan

[*]**Address for Correspondence:**
Dr Wangju Sumnyan, Associate Professor, Department of Radiology, Tomo Riba Institute of Health and Medical Sciences and Hospital, P.O-Naharlagun, District- Papum Pare, Arunachal Pradesh, Pin code- 791110, INDIA.
Email: sumnyanwang@gmail.com
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INTRODUCTION

Many people are affected by low backache worldwide. Low back pain could be due to various reasons like improper lumbar vertebral alignment, nerve compression, improper posture, muscle stiffness etc. The anatomy and knowledge of lumbar vertebral dimensions and lumbar intervertebral disc dimensions could be of great value in studying the etiology of backache. Therefore the present study was undertaken to assess the dimensions of the L4 and L5 lumbar vertebras as well as the L4-5 and L5-S1 intervertebral discs (IVD) and correlate them with age and gender. The lower lumbar vertebras and intervertebral discs were chosen for the study as they are the most dependent part of the vertebral column and primarily involved in weight bearing and transmission. In order to obtain more accurate database, digitized computer tomographic (CT) images were studied using the Picture Archiving Communication System (PACS) coupled with

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its internal measuring system. Ali M *et al.*.[1] established that amongst all referral patients with spinal disorders, most commonly affected was lumbar spine (53.1%) and cervical spine (27.1%) with pain as the most common complaint. Vijay M. Ravindra *et al.*.[2] documented that 266 million individuals (3.63%) worldwide were found to have degenerative spine disease and low back pain annually.

MATERIAL AND METHOD

Computerised Tomographic (CT) scan images of lumbar region (300 each for male and female) were retrospectively obtained from the Radiology department of Tomo Riba Institute of Health and Medical Sciences and Hospital, Naharlagun. The CT scans were done using Siemens Somatom Drive dual source MDCT and stored in the Picture Archiving Communication System (PACS). The CT images obtained from the PACS were retrospectively analysed. The study was divided into two groups (male and female) and each was further divided into three subgroups according to the age as 21 to 40 years, 41 to 60 years and above 60 years.

Measurements:

The measurements for antero-posterior and transverse diameter of lumbar vertebra were obtained from axial CT section in bony window. The AP diameter extended from the posterior cortical margin at the basi-vertebral venous plexus to the anterior cortical margin of the vertebra. The maximum transverse diameter was obtained by drawing a perpendicular line to the AP line extending up to the lateral cortical margin of the vertebral body on either side (Fig.1). The measurements for Anterior (A) / Central (C) and Posterior (P) heights of the lumbar vertebral body were obtained on the sagittal CT section in bony window. The Anterior height was obtained by drawing a perpendicular line from the antero-superior end-plate to the inferior end-plate. Similar measurements were done for obtaining the central and posterior heights of the vertebral body by drawing perpendicular lines from the superior to the inferior end-plates (Fig.2). The measurements for antero-posterior width and height of lumbar intervertebral disc were obtained from sagittal CT section in soft tissue window. The antero-posterior width of lumbar intervertebral disc was obtained by drawing a line connecting the mid-point of the anterior and posterior margin of the intervertebral disc. The height of the intervertebral disc was calculated by drawing a perpendicular line at the mid-point of the intervertebral space (Fig.3). The antero-posterior and the transverse diameter of the L4 and L5 lumbar vertebral bodies (LVB) were measured. The anterior (A), central (C) and posterior (P) height of the L4 and L5 lumbar vertebral bodies (LVB) were measured. The height and the antero -posterior length of the L4-5 and L5-S1 intervetebral discs (IVD) L4-5 and L5-S1 were measured. The measurements obtained were tabulated according to age group in both males and females. The mean and standard deviation was noted and the p-value was calculated using students t-test to find out the significance of the findings. Pearson's correlation of the above parameters with age was also studied.

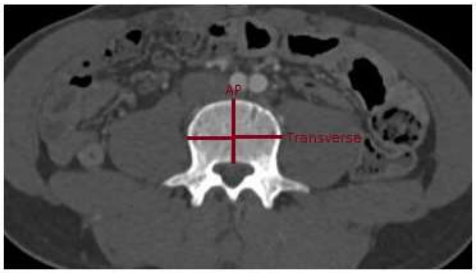

Figure 1: Measurement of antero-posterior and transverse diameter of vertebra: Axial CT section in bony window

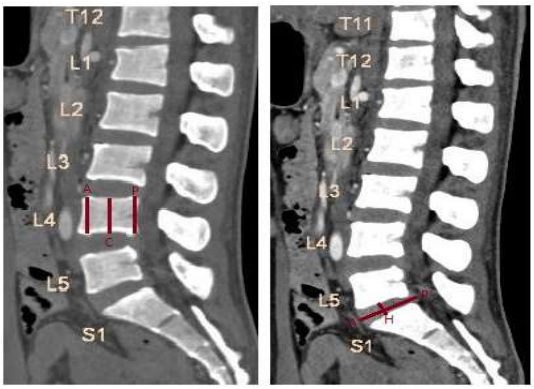

Figure 2: Measurement of Anterior (A) / Central (C) and Posterior (P) heights of the lumbar vertebral body: Sagittal CT section in bony window; **Figure 3:** Measurement of antero-posterior width and height of lumbar intervertebral disc: Sagittal CT section in soft tissue window

RESULT

The study showed an increase in the antero-posterior and the transverse diameters of the L4 and L5 vertebral bodies with increasing age in both males and females, except for the transverse diameter of the L5 lumbar vertebra in females above 60 years. In the female study population, there was a slight decrease from a mean transverse diameter of 42.06 ± 2.85 in the 41-60 years age group to 41.56 ± 3.34 in the above 60 years age group. The study also showed an increase the antero-posterior diameter of the L4-L5 and L5-S1 intervertebral discs with increasing age both in males and females. However, the height of the L4-L5 and L5-S1 IVDs were seen to decrease with advancing age in both males and females (Table No. 1). There was no significant difference in the anterior (A), central (C) and posterior (P) height of the L4 and L5 lumbar vertebral bodies (LVB) and in the dimensions of the L4-L5 and L5-S1 IVDs, when compared between

males and females of the same age groups. There was also no significant difference on comparing the three age groups in both males and females (Table No. 2, 3, 4). The antero-posterior diameter and transverse diameter of L4 and L5 vertebras showed a positive correlation with increasing age in both male and female groups (Table No. 5). The antero-posterior diameter of the L4-L5 and L5-S1 IVDs also showed similar positive correlation with increasing age in both male and female groups (Table No. 5). The anterior (A), central (C) and posterior (P) height of the L4 and L5 lumbar vertebral bodies (LVB) showed a negative correlation with advancement of age in females except for anterior height of L5 vertebra which showed a positive correlation. The height of the L4-L5 and L5-S1 IVDs showed a negative correlation with advancement of age in females. The anterior (A), central (C) and posterior (P) height of the L4 and L5 lumbar vertebral bodies (LVB) showed a positive correlation with age in males except for anterior (A) height of L5 vertebral body which were seen to be negatively correlated. The height of L4-L5 intervertebral disc showed negative correlation with advancement of age in males (Table No.5).

Table 1: Mean dimensions of L4 and L5 vertebral bodies and L4-5 / L5-S1 Intervertebral discs in different age groups in males and females

PARAMETERS		MALES			FEMALES		
		21-40 years Mean±SD	41-60 years Mean±SD	> 60 years Mean±SD	21-40 years Mean±SD	41-60 years Mean±SD	>60 years Mean±SD
L4	AP	32.3±3.11	32.7±2.19	33.86±1.31	29.62±1.40	31.79±2.28	33.24±4.64
VBD	TR	41.6±2.62	43.69±1.69	45.05±3.24	38.9±1.23	41.55±2.28	42.32±3.79
	A	24.57±2.13	22.69±2.03	25.24±2.49	23.05±1.22	22.56±2.53	22.75±1.15
	C	23.46±1.67	22.86±2.36	24.78±2.12	22.3±1.25	21.45±2.42	19.87±4.009
	P	24.73±1.49	23.98±2.34	26.61±3.5	22.76±1.77	22.73±2.84	22.62±1.64
IVD	IVDH	11.64±1.74	11.4±1.91	10.51±1.41	10.28±1.29	9.81±1.82	10.4±3.30
L4-L5	IVDL	37.52±3.56	38.65±7.11	40.7±3.02	34.38±1.38	40.27±2.19	41.63±7.09
	AP	31.58±2.71	30.36±5	33.32±1.41	30.9±2.27	31.71±1.21	33.17±3.02
L5	TR	41.75±3.33	42.42±3.25	45.1±3.04	40.27±1.80	42.06±2.85	41.56±3.34
VBD	A	25.26±2.17	23.69±1.96	25.56±2.75	23±1.50	22.09±2.72	23.3±2.49
	C	23.24±1.46	22.41±1.92	24.3±2.15	22.25±1.07	20.98±1.81	20.31±2.06
	P	22.09±2.24	22.06±2.26	24.41±1.02	21.12±1.52	20.81±2.22	20.85±1.77
IVD	IVDH	9.86±1.89	9.79±2.25	9.96±1.50	9.64±2.12	10.09±1.21	9.12±2.75
L5-S1	IVDL	36.06±3.56	38.07±5.34	38.81±1.51	33.54±1.97	35.39±2.56	38.79±4.43

VBD- Vertebral Body Dimensions, IVD-Intervertebral Disc, AP-Antero-posterior diameter, TR-Transverse diameter, A- Anterior Height, C-Central Height, P-Posterior Height, IVDH-Intervertebral Disc Height, IVDL-Intervertebral Disc Length

Table 2: Comparison of the vertebral body and IVD parameters between males and females in different age groups

PARA-METERS		COMPARISON BETWEEN MALES AND FEMALEs					
		21-40years		41-60 years		> 60 years	
		t-value	p-value	t-value	p-value	t-value	p-value
L4	AP	1.11	0.3821	0.4071	0.7234	0.1819	0.8725
VBD	TR	1.49	0.2735	1.0664	0.3979	0.7743	0.5198
	A	0.8757	0.4735	0.0567	0.9600	1.2839	0.3278
	C	0.7864	0.5140	0.5899	0.6150	1.5338	0.2648
	P	1.2042	0.3517	0.4804	0.6784	1.4635	0.2809
IVD	IVDH	0.8880	0.4683	0.8523	0.4838	0.0433	0.9694
L4-L5	IVDL	1.1630	0.3648	0.3079	0.7872	0.7916	0.5116
	AP	0.2720	0.8111	0.3711	0.7462	0.0636	0.9550
L5	TR	0.5529	0.6359	0.1178	0.9170	1.1085	0.3831
VBD	A	1.2116	0.3494	0.6749	0.5693	0.8615	0.4797
	C	0.7735	0.5202	0.7664	0.5235	1.8951	0.1986
	P	0.5068	0.6627	0.5580	0.6330	2.4645	0.1327
IVD	IVDH	0.1095	0.9228	0.1661	0.8834	0.3792	0.7410
L5-S1	IVDL	0.8759	0.4735	0.6400	0.5877	0.0060	0.9957

VBD- Vertebral Body Dimensions, IVD-Intervertebral Disc, AP-Antero-posterior diameter, TR-Transverse diameter, A- Anterior Height, C-Central Height, P-Posterior Height, IVDH-Intervertebral Disc Height, IVDL-Intervertebral Disc Length, p-value <0.001 is significant.

Table 3: Comparison of the vertebral body and IVD parameters in females between different age groups

PARAMETERS		21-40years and 41-60 years		21-40 years and >60 years		41-60 years and > 60 years	
		t-value	p-value	t-value	p-value	t-value	p-value
L4	AP	1.1470	0.3701	1.0563	0.4016	0.3966	0.7300
VBD	TR	1.4466	0.2849	1.2138	0.3487	0.2462	0.8285
	A	0.2467	0.8281	0.2531	0.8239	0.0967	0.9318
	C	0.4413	0.7021	0.8183	0.4991	0.4772	0.6803
	P	0.0127	0.9910	0.0821	0.9421	0.0474	0.9665
IVD	IVDH	0.2980	0.7938	0.0479	0.9662	0.2214	0.8453
L4-L5	IVDL	3.2179	0.0845	1.4195	0.2916	0.2592	0.8197
	AP	0.4453	0.6997	0.6406	0.5874	0.6346	0.5906
L5	TR	0.7510	0.5310	0.4808	0.6781	0.1610	0.8869
VBD	A	0.4143	0.7189	0.1460	0.8973	0.4640	0.6882
	C	0.8542	0.4830	1.1819	0.3587	0.3455	0.7627
	P	0.1629	0.8855	0.1637	0.8850	0.0199	0.9859
IVD	IVDH	0.2607	0.8187	0.2118	0.8519	0.4566	0.6928
L5-S1	IVDL	0.8099	0.5030	1.5314	0.2653	0.9398	0.4465

VBD- Vertebral Body Dimensions, IVD-Intervertebral Disc, AP-Antero-posterior diameter, TR-Transverse diameter, A- Anterior Height, C-Central Height, P-Posterior Height, IVDH-Intervertebral Disc Height, IVDL-Intervertebral Disc Length, Significant= p-value<0.001.

Table 4: Comparison of the vertebral body and IVD parameters in males between different age groups

PARAMETERS		21-40years and 41-60 years		21-40 years and >60 years		41-60 years and > 60 years	
		t-value	p-value	t-value	p-value	t-value	p-value
L4	AP	0.1487	0.8954	0.6538	0.5804	0.1710	0.8800
VBD	TR	0.7847	0.5148	1.0488	0.4043	6.5200	0.0227
	A	0.9036	0.4616	0.2892	0.7997	1.1225	0.3783
	C	0.2935	0.7968	0.6917	0.5606	0.8559	0.4822
	P	0.3823	0.7390	0.6989	0.5569	0.8901	0.4673
IVD	IVDH	0.1314	0.9075	0.7136	0.5495	0.5302	0.6490
L4-L5	IVDL	0.2010	0.8593	0.9633	0.4370	0.3753	0.7435
	AP	0.3034	0.7903	0.8055	0.5051	0.8058	0.5049
L5	TR	0.2036	0.8575	5.3016	0.0338	0.8517	0.4841
VBD	A	0.7593	0.5270	0.1211	0.9147	0.7831	0.5156
	C	0.4866	0.6746	0.5768	0.6223	0.9273	0.4517
	P	0.0133	0.9906	1.3330	0.3141	1.3403	0.3121
IVD	IVDH	0.0337	0.9762	0.0586	0.9586	0.0889	0.9373
L5-S1	IVDL	0.4429	0.7011	1.0057	0.4205	0.1886	0.8678

VBD- Vertebral Body Dimensions, IVD-Intervertebral Disc, AP-Antero-posterior diameter, TR-Transverse diameter, A- Anterior Height, C-Central Height, P-Posterior Height, IVDH-Intervertebral Disc Height, IVDL-Intervertebral Disc Length, Significant= p-value <0.001.

Table 5: Correlation between the vertebral body / IVD parameters and increasing age

PARAMETERS		MALES (correlation coefficient with increasing age)	FEMALES (correlation coefficient with increasing age)
L4	AP	0.3920	0.4563
VBD	TR	0.4973	0.4839
	A	0.0154	-0.1449
	C	0.1815	-0.3839
	P	0.1959	-0.1255
IVD	IVDH	-0.1331	0.0149
L4-L5	IVDL	0.3489	0.5384
	AP	0.1154	0.4331
L5	TR	0.4188	0.1927
VBD	A	-0.0166	0.0409

	C	0.1282	-0.5073
	P	0.3020	-0.1213
IVD	IVDH	0.0498	-0.0546
L5-S1	IVDL	0.3746	0.6251

VBD- Vertebral Body Dimensions, IVD-Intervertebral Disc, AP-Antero-posterior diameter, TR-Transverse diameter, A- Anterior Height, C-Central Height, P-Posterior Height, IVDH-Intervertebral Disc Height, IVDL-Intervertebral Disc Length

DISCUSSION

In our study, the increase in the antero-posterior and the transverse diameters of lumbar L4 and L5 vertebral bodies suggest the widening of the vertebral body with advancement of age. These parameters were also seen to be positively correlated with age. The slight decrease in the transverse diameter of L5 vertebral body in females above 60years age group could be due to osteoporotic changes mostly affecting the L5 as it is most dependent part of vertebral column. Zhou *et al.*[3] reported an increase in width and depth of vertebra L3 to L5, whereas S.H Tan *et al.*.[4] documented a constant increase in the vertebral body width from L1 to L5. The study did not show any statistical significance in the anterior (A), central (C) and posterior (P) height of the L4 and L5 lumbar vertebral bodies (LVB), when compared between the three age groups and also when compared between males and females of the same age groups. Similarly, Sonali Agichani *et al.*[5] also did not find any statistical significance in the anterior and posterior heights of bodies of all lumbar vertebrae in different age groups studied, however in contrast to our study, the gender difference was statistically significant. S.H Tan *et al.*.[4], Sonali Agichani *et al.*[5] and Gocmen-mas N *et al.*[6] noted that the posterior vertebral body height was more than the anterior except for L5 probably due to wedge shape of the vertebra. Tang R. *et al.*[7] observed a significantly larger geometrical dimensions of lumbar vertebrae in males. Neha Bagri *et al.*.[8] showed that lower body mass density of the vertebra was associated with decrease in the anterior, middle and posterior heights and AP dimensions of vertebral body. Dr. Jaskaran Singh *et al.*[9] demonstrated a constant increase in the anterior vertebral body height from L1-L5(23.5mm) (26.2mm), whereas the posterior height remained same up to L3 (26.5mm) thereafter gradually decreasing up to L5(23.2mm). The increase in the antero-posterior diameter and decrease in height of L4-L5 and L5-S1 intervertebral discs with advancement of age could be due to desiccation of nucleus pulposus and bulging of disc with progression of age. Similarly Zhou SH *et al.*[3] also found a significantly decrease in the mean disc height, however he noted considerable variation in the disc height ranging from 5mm to 16.1mm. Tang R *et al.*.[7] stated that L5-S1 disc had the smallest geometrical dimension. Li H *et al.*.[10] revealed with T2-weighted magnetic resonace (MR) images that, with aging the shape of Nucleus Pulposus (NP) became irregular, while mean areas of signal intensities and T2 values of NP were significantly decreased. Raastad J *et al.*.[11] stated that lumbar disc degeneration and its associated changes such as disc space narrowing are related with low back pain. Feng Zhang *et al.*.[12] documented that the reduction of lumbar intervertebral disc height is the key point in pathological process of intervertebral disc degeneration. The negative correlation of the anterior(A), central (C) and posterior(P) height of the L4 and L5 lumbar vertebral bodies (LVB) and the height of the L4-L5 and L5-S1 IVDs with age in females and the same parameters being positively correlated with age in males except for height of L4-L5 IVD and the anterior height of L5 which were seen to be negatively correlated suggests that women are more exposed to physical and hormone-chemical stress which might have lead to decrease in the height of the vertebrae as compared to men. Yi Xiang *et al.*[13] also stated that postmenopausal women show accelerated disc degeneration and other musculoskeletal degenerative diseases due to estrogen deficiency. Bailey A. [14] documented that biological response to pregnancy, physical stress of child bearing and child rearing and perimenopausal abdominal weight gain are additional cause of low back pain. While Miller JA *et al.*.[15] observed intervertebral disc degeneration at an earlier age (second decade of life) in men than in woman. However, Bailey A.[14] and Leveille SG *et al.*[16] found that the overall prevalence of low back pain is higher in women than in men. The positive correlation of the anterior(A), central (C) and posterior(P) height of the L4 and L5 lumbar vertebral bodies (LVB) with increasing age in males except for the anterior height of L5 which was seen to be negatively correlated, could be due to presence of more osteophytes with advancement of age.

CONCLUSION

Based on the statistical findings in our study, we can conclude that the circumferential dimensions of the L4 and L5 vertebral bodies and the L4-L5 and L5-S1 intervertebral discs increased with advancing age both in male and female suggesting the widening of the vertebrae and the protrusion of the intervertebral disc. These changes could lead to narrowing of the spinal canal and causing low back pain. The study also showed a negative correlation of the anterior, central and posterior height of the L4 and L5 vertebras and the height of the L4-L5 and L5-S1

interverbral discs with age in females and a positive correlation of the same in males except for height of IVD L4-L5 suggesting that females are more exposed to physical and hormone-chemical stress resulting in decreasing vertebral height as age advances.

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