Transverse Diameter of Lumbar Vertebrae in Western Maharashtra Population

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Research Article

Abstract: There are many recorded observations on the anatomy of the vertebral column. A clear picture has been drawn on the anatomy and functions of vertebral column. Similarly, various aspects of lumbar vertebrae have been studied in the past and much of the work has been done on the morphometry of lumbar spinal canal. The present study aims to determine the normal range of lumbar vertebrae measurements in normal plain radiographs of Western Maharashtra population. Various dimensions of lumbar vertebrae from L_1 to L_5 were measured in 200 plain radiographs. Mean transverse diameter of vertebral body as well as of spinal canal were minimum at L_1 and maximum at L_5. Making use of above parameters, canal-body ratio and intersegmental difference were calculated. These parameters and indices can be useful in detection of clinical conditions like spinal canal stenosis and some cases of intraspinal tumours. The present study showed regional and ethnic variation in parameters of lumbar vertebrae, thus emphasizing the need to determine normal range of values for different populations. Details will be discussed.

Key words: lumbar vertebrae measurements, canal -body ratio, intersegmental difference

Introduction:

Backache is one of the common complaints of human beings and throughout the history of healing art we see accounts of innumerable, diversified and heroic attempts at its alleviation. Various causes have been attributed to low backache, of which 'Lumbar Spinal Canal Stenosis' as a causative is of great interest.

The pioneering work of Elsberg & Dyke (1934)[1] and later reports by Hinck, Clark & Hopkins (1966)[2] have established the clinical value of measurements of interpedicular distances in diagnosis of narrowing of spinal canal. Since then, the size of spinal canal has attracted increasing interest for its use in clinical practice. Hence it is necessary to study the dimensions of spinal canal.

Normal values of lumbar interpedicular distances measured from plain radiographs in various ethnic groups as well as both sexes of that ethnic group have been reported in white Americans (Hinck et al. 1966)[2], Nigerians (Amonoo Kuofi, 1982)[3], Spanish subjects (Piera et al. 1988)[4], in North Indians (Sudha Chhabra 1991)[5]and in Gujrathis (Nirvan A.B. 2005)[6].

Recently, it has been pointed out that instead of measuring the vertebral canal for evaluating the degree of stenosis, it would be more reliable if the ratio of vertebral canal and of vertebral body i.e. canal body ratio (C/B)[7] is taken as index for calculating the degree of stenosis. Thus, the present study aims to present a set of normal range of measurements of lumbar vertebrae in Western Maharashtra population by studying transverse diameters of spinal canal and vertebral bodies and to find out if there are any regional and sex differences in the dimensions of lumbar vertebrae by plain radiographs.

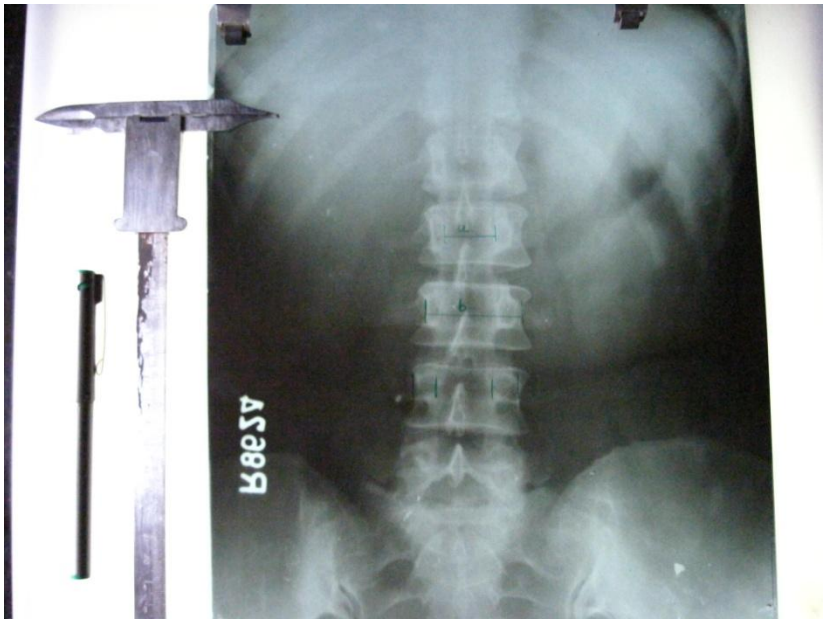
Materials and Methods:

For present study, plain anteroposterior radiographs of lumbar spine of hundred adult male and female each belonging to Western Maharashtra were utilized. These radiographs were of known sex and age group (between twenty five and fifty years of age) which were obtained from various hospitals of Western Maharashtra

The radiographs of both sexes had been taken in lying down position with an anode- film distance of one meter, centered on L_3. The radiographs were screened for readability and attempts to eliminate subjects with significant anomalies

and other problems likely to influence growth and development.

The measurements were made by using vernier calliper and were recorded to the nearest tenth of a millimeter. The dimensions of all vertebrae were studied. The following measurements were obtained from anteroposterior radiographs of lumbar spine (Photograph no.2).



Photograph 1: Materials used for the present study

A) The Transverse Diameter of Spinal Canal / Interpedicular Distance:

This corresponds to transverse diameter of spinal canal and was obtained by measuring the minimum distance between the shadows of pedicles of same vertebra.

B) The Transverse Diameter of Vertebral Body:

This was taken as the midvertebral distance between the points on lateral borders of vertebral body

shadow.

The following indices were obtained from above measurements, using the methods described by respective workers.

1. The ' Canal Body ratio' (C/B)[7] :

This was calculated by considering transverse diameters of vertebral body and corresponding spinal canal as follows.

C/B = Transverse Diameter of spinal canal/ Transverse Diameter of Vertebral Body

2. Intersegmental Difference:

This was calculated as the difference between the transverse diameters of spinal canal of the

consecutive lumbar vertebra.

The data collected was subjected to following statistical tests.

a) Mean
b) Standard deviation
c) Calculated range
d) P- value.

These dimensions of spinal canal and vertebral body in males and females were evaluated for statistical significance. Also, using statistical tests, conditions like spinal canal stenosis and intraspinal tumor were evaluated and discussed.

Observation and Results:

Range, mean and standard deviation of the measurements of adult lumbar vertebrae were calculated. However when dealing with normal distributions, maximum and minimum limits can safely be calculated by adding or subtracting three standard deviation to the mean value of each measurement[8]. This gives the calculated range. Carefully measured individual dimensions falling outside the limits given should thus be viewed with suspicion of pathology or anomaly. It must be borne in mind on the other hand that, some abnormal figures may fall within these limits.

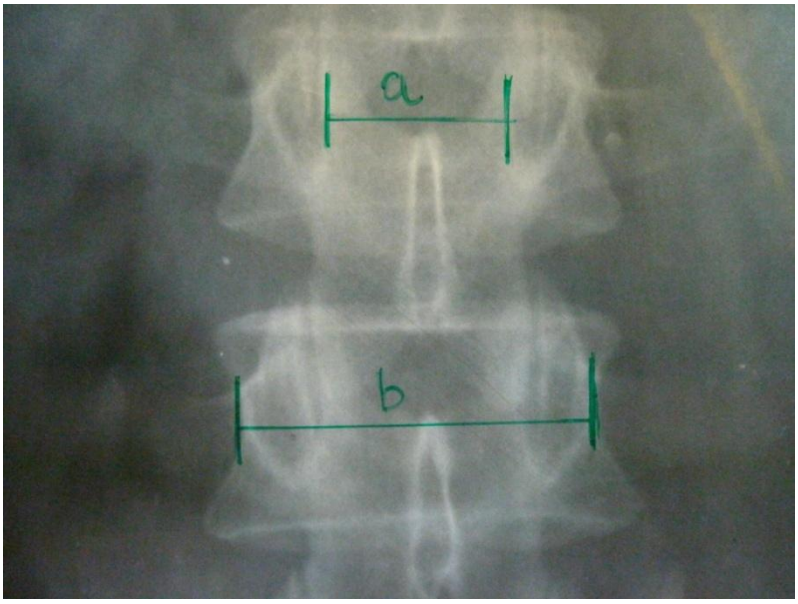
To know whether the difference observed between means of male and female is statistically significant; 'P' value was calculated by applying 'Z' test.

Abbreviations used in following tables are:

1. S.D.:- Standard Deviation
2. P: - Probability or the level of significance for difference between the two means.
3. NS: - Non Significant

Table I: Mean transverse diameters (mm) of spinal canal in both the sexes

Level	Sex Group	Range	Mean	Standard Deviation	Calculated Range ± 3SD	P Value
	Male	20-29	24.38	1.69	19.31-29.46	
L_1	Female	16-27	21	2.44	13.69-28.31	<0.001
	Male	21-30	25.25	1.86	19.67-30.82	
L_2	Female	16-28	21.81	2.69	13.74-29.88	<0.001
	Male	22-33	27.08	2.08	20.84-33.33	
L_3	Female	18-30	23.56	2.78	15.23-31.89	<0.001
	Male	23-35	29	2.28	22.15-35.85	
L_4	Female	20-32	25.44	2.70	17.34-33.55	<0.001
	Male	27-39	32.42	2.29	25.55-39.28	
L_5	Female	23-36	28.63	2.79	20.27-36.99	<0.001



Photograph no. 2: Shows the parameters measured
(a) Transverse diameter of spinal canal (b) Transverse diameter of vertebral body

Table II: Intersegmental Difference of the present study

Level	Male	Female
L_1/ L_2	0.86	0.81
L_2/ L_3	1.84	1.74
L_3/ L_4	1.92	1.89
L_4 /L_5	3.42	3.19

Table III: Mean transverse diameter (mm) of vertebral bodies in both sexes

Level	Sex Group	Range	Mean	Standard Deviation	Calculated Range ±3SD	P Value
	Male	35-50	43.49	3.00	34.50-52.48	
L_1	Female	28-44	37.26	3.30	27.36-47.16	<0.001
	Male	39-52	45.87	2.79	37.50-54.24	
L_2	Female	30-46	39.26	3.30	29.35-49.17	<0.001
	Male	42-55	48.65	2.80	40.24-57.05	
L_3	Female	33-48	41.81	3.39	31.63-52.00	<0.001
	Male	45-58	51.49	2.84	42.98-60.00	
L_4	Female	35-51	44.41	3.41	34.18-54.65	<0.001
	Male	49-63	55.77	3.12	46.42-65.13	
L_5	Female	37-55	47.36	3.79	35.98-58.74	<0.001

Table IV: Canal Body ratio in the present study

Level	Mean Transverse diameter of Spinal Canal		Mean Transverse Diameter of Vertebral Body		CANAL-BODY RATIO	
	Male	Female	Male	Female	Male	Female
L_1	24.38	21.00	43.49	37.26	0.56	0.56
L_2	25.25	21.81	45.87	39.26	0.55	0.56
L_3	27.08	23.56	48.65	41.81	0.56	0.56
L_4	29.00	25.44	51.49	44.41	0.56	0.57
L_5	32.42	28.63	55.77	47.36	0.58	0.61

Discussion:

The importance of the radiographic measurement of the spinal canal was first emphasized in 1934[1] by Elseberg and Dyke who first established a normal range of interpedicular distances in the thoracic and lumbar spine and applied their method to the diagnosis of intraspinal tumours.

Low backache is a common clinical problem. The etiology in many of these patients is narrowing of the lumbar canal. In the recent years, there has been a renewal of interest in spinal stenosis syndromes, especially in the extent to which the cauda equina may be compressed within the lumbar spinal canal by constriction or narrowing of the bony ring of the canal in contrast to impingement of soft tissues. Narrowing of the spinal canal may be developmental, or it may be the consequence of degenerative changes from ageing, injury or disease, or of spinal operations. The age group selected for the present study is very much same as the age group used for earlier such studies, so that the ethnic differences in the trait could be well compared.

When the mean values of different dimensions of the vertebrae were compared with the data

available from previous studies they showed a significant difference at all lumbar level, thus necessitating separate normal ranges for male and female. Sometimes there is considerable overlapping of the ranges in male and female. This probably reflects the wide variations of body sizes among male and female subjects.

I. TRANSVERSE DIAMETER OF SPINAL CANAL:

As per Table no.I, it is seen that, the mean transverse diameter of the spinal canal goes on increasing from L_1 to L_5.The transverse diameter is minimum at L_1 and maximum at L_5. This increasing trend of transverse diameter of spinal canal is also seen in both the sexes however, the mean values are lower in females than males. This difference in males and females is statistically highly significant. Considering the calculated range, the limits of narrowing of spinal canal or intraspinal tumour can be suspected as described below. The values less than the lower limits of the calculated range are suggestive of spinal canal stenosis. Similarly, the values more than the upper limits of the calculated range are suggestive of intraspinal tumour (Table no. V). As per table no. VI, it is seen that, the mean interpedicular distance in males is highest in North Indians while it is lowest in Nigerians. The findings of the present study fall in between the two. As per the table no.VII, the mean values in females are comparable with those of Nigerians while the values when compared with North Indians, these are slightly less. It is probably because of obvious difference in the built of the two.

Table V: Shows the values (mm) suggestive of spinal stenosis and intraspinal tumour in the present study

	PRESENT STUDY			
	Suggestive of Spinal Stenosis		Suggestive of Intraspinal Tumour	
LEVEL	MALES	FEMALES	MALES	FEMALES
L_1	< 19.31	< 13.69	>29.46	>28.31
L_2	< 19.67	< 13.74	>30.82	>29.88
L_3	< 20.84	< 15.23	>33.33	>31.89
L_4	< 22.15	< 17.34	>35.85	>33.55
L_5	< 25.55	< 20.27	>39.28	>36.99

Table VI: Comparison of mean transverse diameter (mm) of the spinal canal in males of previous studies and of the present study.

Authors	**TRANSVERSE DIAMETER OF SPINAL CANAL**					
	n	**L_1**	**L_2**	**L_3**	**L_4**	**L_5**
Hinck et al. 1966[2] (White Americans)	59	25.9	26.5	26.8	27.6	30.7
Amonoo Kuofi H.S. 1982[3] (Nigerians)	150	22.6	22.7	24.5	26	28.7
Piera et al. 1988[4] (Spanish)	110	27.79	28.39	29.44	30.89	34.31
Sudha Chhabra et al. 1991[5] (North Indians)	124	26.0	27.70	29.70	35.50	37.40
Nirvan A.B. et al. 2005 [6] (Gujaratis)	101	24.0	25.4	26.4	27.9	30.9
Present study (Western Maharashtra)	110	24.38	25.25	27.08	29	32.42

Table VII: Comparison of mean transverse diameter (mm) of the spinal canal in females of previous studies and of the present study.

Authors	TRANSVERSE DIAMETER OF SPINAL CANAL					
	n	L_1	L_2	L_3	L_4	L_5
Hinck et al. 1966[2] (White Americans)	59	24.3	24.9	25.4	26.9	29.0
Amonoo Kuofi H.S. 1982[3] (Nigerians)	140	21.30	22.50	23.70	25.40	28.40
Piera et al. 1988[4] (Spanish)	105	25.66	26.25	27.53	29.53	33.39
Sudha Chhabra et al. 1991[5] (North Indians)	91	24.1	25.7	27.3	30.1	34.4
Nirvan A.B. et al. 2005[6] (Gujaratis)	101	23.3	24.3	25.8	27.0	29.8
Present study (Western Maharashtra)	90	21	21.81	23.56	25.44	28.63

II. INTERSEGMENTAL DIFFERENCE:

As per table no II, it is observed that with a gradual increase in the transverse diameter of spinal canal from L_1 to L_5, the intersegmental difference is also seen to be steadily increasing from L_1/L_2 to L_4/L_5 in Western Maharashtra males and females. Knowledge of the magnitude of the intersegmental differences could be of value in the detection of isolated segmental changes. It is evident from table no. VIII that most of the studies show a gradual increase in the transverse diameter of spinal canal from L_1 to L_5.Thus, the intersegmental difference is also seen to be steadily increasing from L_1/L_2 to L_4/L_5. However it is more pronounced in L_4/L_5.

Table VIII: Comparison of intersegmental differences in males and females between previous studies and the present study.

Authors	Males				Females			
	L_1/L_2	L_2/L_3	L_3/L_4	L_4/L_5	L_1/L_2	L_2/L_3	L_3/L_4	L_4/L_5
Hinck et al. 1966[2] (White Americans)	0.6	0.3	0.8	3.1	0.6	0.5	1.0	2.6
Amonoo Kuofi H.S. 1982[3] (Nigerians)	0.1	1.8	1.5	2.7	1.2	1.2	1.7	3.0
Piera et al. 1988[4] (Spanish)	0.6	1.16	1.34	3.42	0.59	1.28	2.0	3.8
Sudha Chhabra et al. 1991[5] (North Indians)	1.7	2.0	2.8	4.9	1.6	1.6	2.8	4.3
Nirvan A.B. et al. 2005[6] (Gujaratis)	1.4	1.0	1.5	3.0	1.0	1.5	1.2	2.8
Present study (Western Maharashtra)	0.86	1.84	1.92	3.42	0.81	1.74	1.89	3.19

III. TRANSVERSE DIAMETER OF VERTEBRAL BODY :

Table no. III shows the increasing diameter of vertebral body from L_1 to L_5. This is probably because of the increase in load bearing from above downwards. It is also seen that the transverse diameter of vertebral body is larger in males than in females. The differences between the means of the two are statistically highly significant.

The mean transverse diameters of vertebral bodies in males of present study are comparable with North Indians at all levels except at L_5 (Table no. IX). As per table no. X, it is seen that there are slight variations in the mean values of transverse diameters of vertebral bodies in females of various study groups; however these values are comparable with each other. The variation is more pronounced in the lower lumbar vertebrae.

Table IX: Comparison of mean transverse diameters (mm) of vertebral bodies in males of the previous studies and present study.

Authors	Transverse diameter of vertebral body					
	n	L_1	L_2	L_3	L_4	L_5
Amonoo Kuofi H.S. 1982[3] (Nigerians)	150	41.3	42.9	45.8	49.6	52.80
Sudha Chhabra et al. 1991[5] (North Indians)	124	42.7	45.4	48.3	51.5	59.4
Nirvan A.B. et al. 2005[6] (Gujaratis)	101	39.9	42.2	44	46.4	51.5
Present study (Western Maharashtra)	110	43.49	45.87	48.65	51.49	55.77

Table X: Comparison of mean transverse diameters (mm) of vertebral bodies in males of the previous studies and present study.

Authors	Transverse diameter of vertebral body					
	n	L_1	L_2	L_3	L_4	L_5
Amonoo Kuofi H.S. 1982[3] (Nigerians)	140	37.5	39.7	42.5	45.7	50.5
Sudha Chhabra et al. 1991[5] (North Indians)	91	39.3	41.5	44.2	47.0	55.6
Nirvan A.B. et al. 2005[6] (Gujaratis)	101	38.8	40.4	42.9	45.0	49.6
Present study (Western Maharashtra)	90	37.26	39.26	41.81	44.41	47.36

IV. CANAL BODY RATIO:

The size of vertebral body should vary proportionately with the build of the individual. In order to find out the relationship between the canal and body size, a comparison was made by finding the ratio between the mean transverse diameter of canal and mean transverse diameter of vertebral body at various vertebral levels[3]. The results showed that as the size of vertebral body changes, the transverse diameter of canal also varied, maintaining a ratio of 0.6 at each vertebral level in both the sexes. Thus any deviation of the canal body ratio from its approximate value of 0.6 to one or the other side indicates possibility of intraspinal tumour. Calculation of canal body ratio for different segments can also help in specifying whether an individual's measurement on spinal canal are within the normal limits for the respective body size or not, thus helping to identify a stenosis or enlargement of the spinal canal. Table no. XI shows comparison of canal body ratio between different populations of the world which is approximately constant at 0.6 in most of the study groups.

Table XI: Comparison of canal body ratio between previous studies and the present study

Authors	CANAL- BODY RATIO									
	Male					Female				
	L_1	L_2	L_3	L_4	L_5	L_1	L_2	L_3	L_4	L_5
Amonoo Kuofi H.S. 1982[3] (Nigerians)	0.55	0.53	0.53	0.52	0.54	0.57	0.57	0.56	0.56	0.56
Sudha Chhabra et al. 1991[5] (North Indians)	0.61	0.61	0.61	0.63	0.63	0.61	0.62	0.62	0.64	0.63
Nirvan A.B. et al. 2005[6] (Gujaratis)	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Present study (Western Maharashtra)	0.56	0.55	0.56	0.56	0.58	0.56	0.56	0.56	0.57	0.61

Thus, in the present study it is seen that the mean values in females are slightly lower than in males which is probably due to the greater differences in general somatic size in between both the sexes. Also, comparison of results of the present study with those of previous studies showed that there were marked differences between the mean values reported for different geographical areas. The reasons for these differences are not clear, but, interplay of racial, ethnic and environmental factors cannot be ruled out.

Summary:

In the present study, transverse diameter of lumbar spinal canal and vertebral body were measured on plain anteroposterior radiographs in Western Maharashtra population. Also from these parameters, indices were calculated. It was found that these parameters showed statistically significant differences in their mean values for males and females indicating sexual dimorphism. Comparison with other groups showed ethnic variation. Furthermore, careful study of these parameters can be useful in detection of clinical conditions like spinal canal stenosis and intraspinal tumours.

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