

# MEASUREMENTS OF THE NORMAL ADULT LUMBAR SPINAL CANAL

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## Abstract

To assess the normal dimensions of the lumbar spinal canal, 100 normal healthy subjects of either sex between 25 and 45 years age were x-rayed for lumbar vertebral column in both posteroanterior and lateral views and the canal was measured by Jones and Thomson methods.<sup>1</sup> The lumbar spinal canal showed constant dimensions in both sexes in all age groups when studied separately in the male and female subjects. However, no change in relative dimensions was observed between 25 and 45 years. The canal showed gradual decrease in measurement from L1 to L5 vertebral levels in both sexes but relative width of the canal was more in the females than in the males of the same age group. The normal values of the canal to vertebral body ratio (C/B) varies between 1:2.0 and 1:5.0. The ratio 1:2.0 indicates a wider canal whereas any ratio beyond 1:5.0 would be conclusive of stenosis of the lumbar vertebral canal (JPMA 39: 264, 1989).

## INTRODUCTION

Low backache is common problem which affects all classes of society; rich and poor, white and black, males and females. One of the causes of low backache is the stenosis of the lumbar spinal canal, a condition in which the anteroposterior and lateral dimensions of the bony canal are less than normal for the relevant age and sex of the individuals. Kirkldy-Willis et al<sup>2</sup> classified the lumbar spinal canal stenosis into developmental, degenerative and other types. Verbiest<sup>3</sup> described developmental stenosis due to the properties of the neural arch, pedicles, laminae and articular processes in which the interpedicular distances are normal whereas lateral sagittal diameters are short due to thickened laminae and articular processes. The degenerative stenosis accompanied by osteoarthritis of the segmental spine is more marked opposite the intervertebral disc and posterior articular processes whereas anteroposterior and lateral diameters may be normal.<sup>2</sup> The combined stenosis shows overall narrowing of spinal canal or segmental narrowing, protrusion of disc or any combination of these, associated with more neurological symptoms than developmental and degenerative types.<sup>4</sup> Kobayashi and Hashi<sup>5</sup> reported secondary spinal canal stenosis associated with long term ventriculoperitoneal shunt whereas Bowen and Ferrer<sup>6</sup> reported the stenosis caused by a Harrington hook in neuromuscular disease. To measure the size of the spinal canal various methods have been used such as conventional tomography,<sup>1</sup> computed tomography,<sup>7-11</sup> ultrasound<sup>12</sup>, myelograms<sup>13</sup> and conventional method of plain radiographic measurements.<sup>1,14-21</sup> The plain radiographic method of measurement appeared to be acceptable method for our country as it is easy, simple, less costly and does not require special staff and equipment. The present study is therefore designed to evaluate the normal size of the lumbar spinal canal in both males and females of our population so that baseline data is available for the Radiologists in the country.

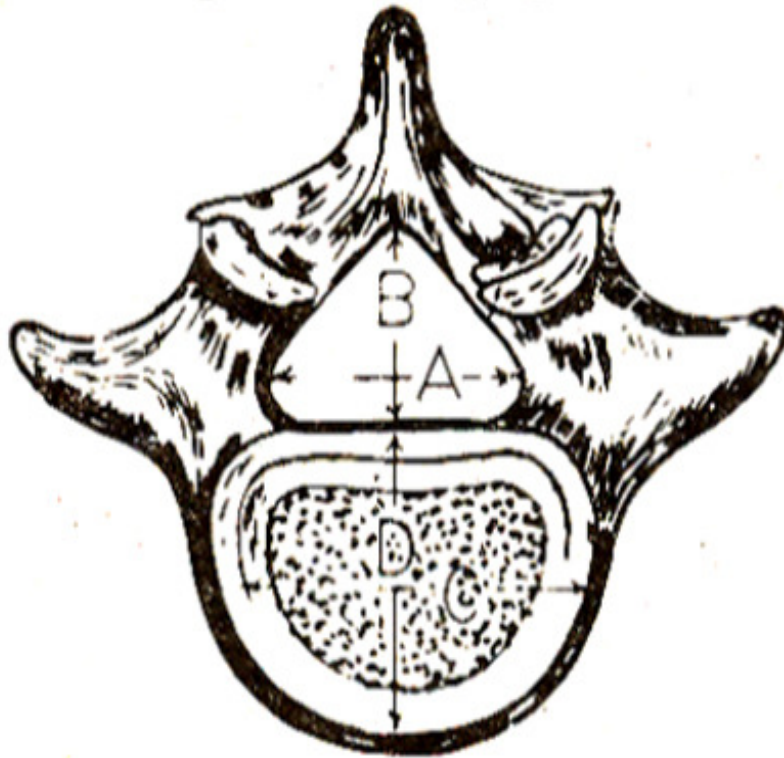
## SUBJECTS AND METHODS

One hundred clinically normal adult males and females of matching age groups between 25 and 45 years were selected for the present study. The subjects were volunteers from various departments of JPMC and patients who attended outpatient departments with complaints other than low backache. The cases were grouped as follows:— Plain radiographs in both anteroposterior and lateral views of the lumbar vertebral column were taken for each subject.

Group	Sex	Cases Studied	Age		
			Min	Max	Mean
A	M	15	25	30	26.9
A1	F	15	25	30	27.6
B	M	13	31	35	33.0
B1	F	13	31	35	33.1
C	M	12	36	40	37.5
C1	F	12	36	40	38.1
D	M	10	41	45	42.6
D1	F	10	41	45	42.3

The canal to vertebral body (C/B), ratio was measured with the method described by Jones and Thomson<sup>1</sup> which is briefly outlined below: The shortest distance between the two pedicle of the concerned vertebra was measured and designated as [A] and the width of the body of the vertebra was designated as [B] as shown in Figure 1.

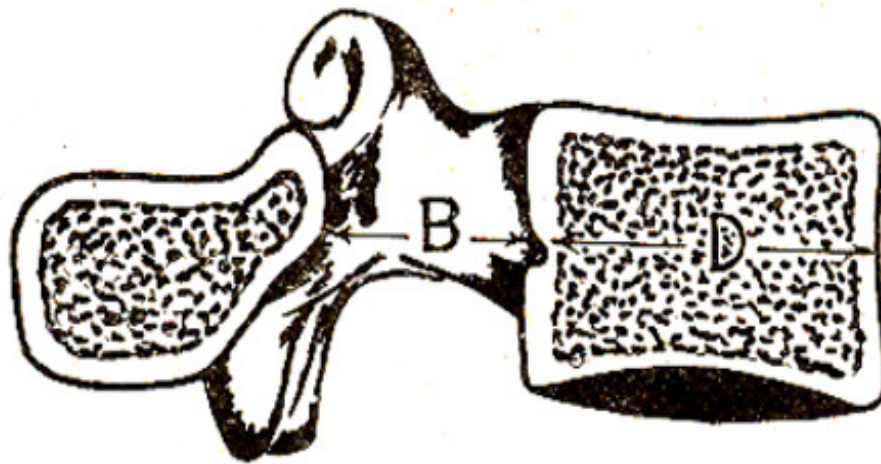
1.



SUPERIOR ASPECT OF A LUMBAR  
VERTEBRA TO THE FOUR DIAMETERS.

**Figure 1.**

The midsagittal distance of the vertebral canal between middle of the back of vertebral body to the base of opposing spinous process was measured and labelled as [B] and the midsagittal distance of the body between anterior and posterior borders of each vertebral body was measured and labelled as [D] as shown in Figure 2.



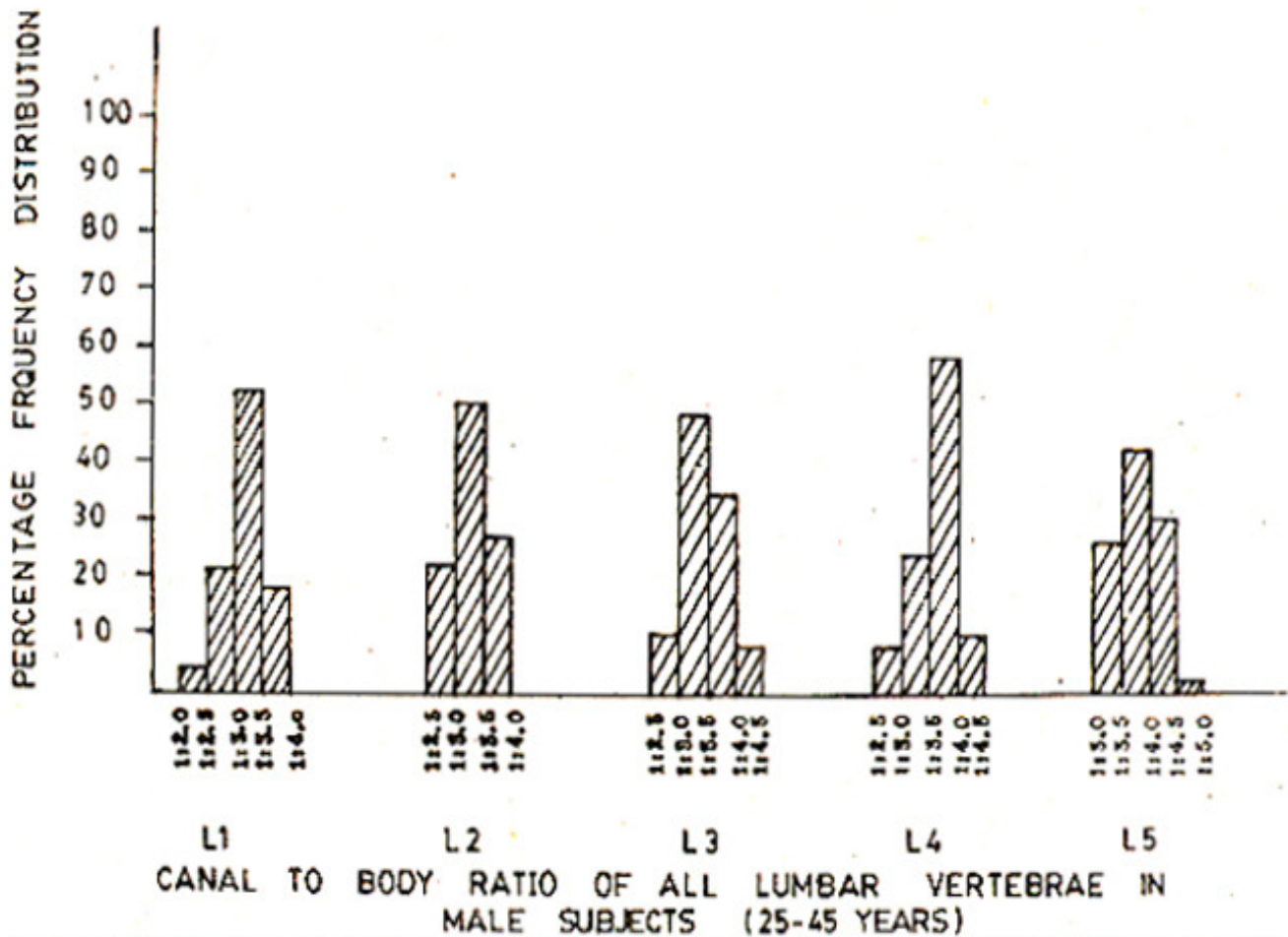
MEDIAN SAGITTAL VIEW OF A LUMBAR VERTEBRA TO SHOW THE TWO DIAMETERS.

**Figure 2.**

The multiplication products of A and B to the multiplication products of C and D is referred as canal to body (C/B) ratio.

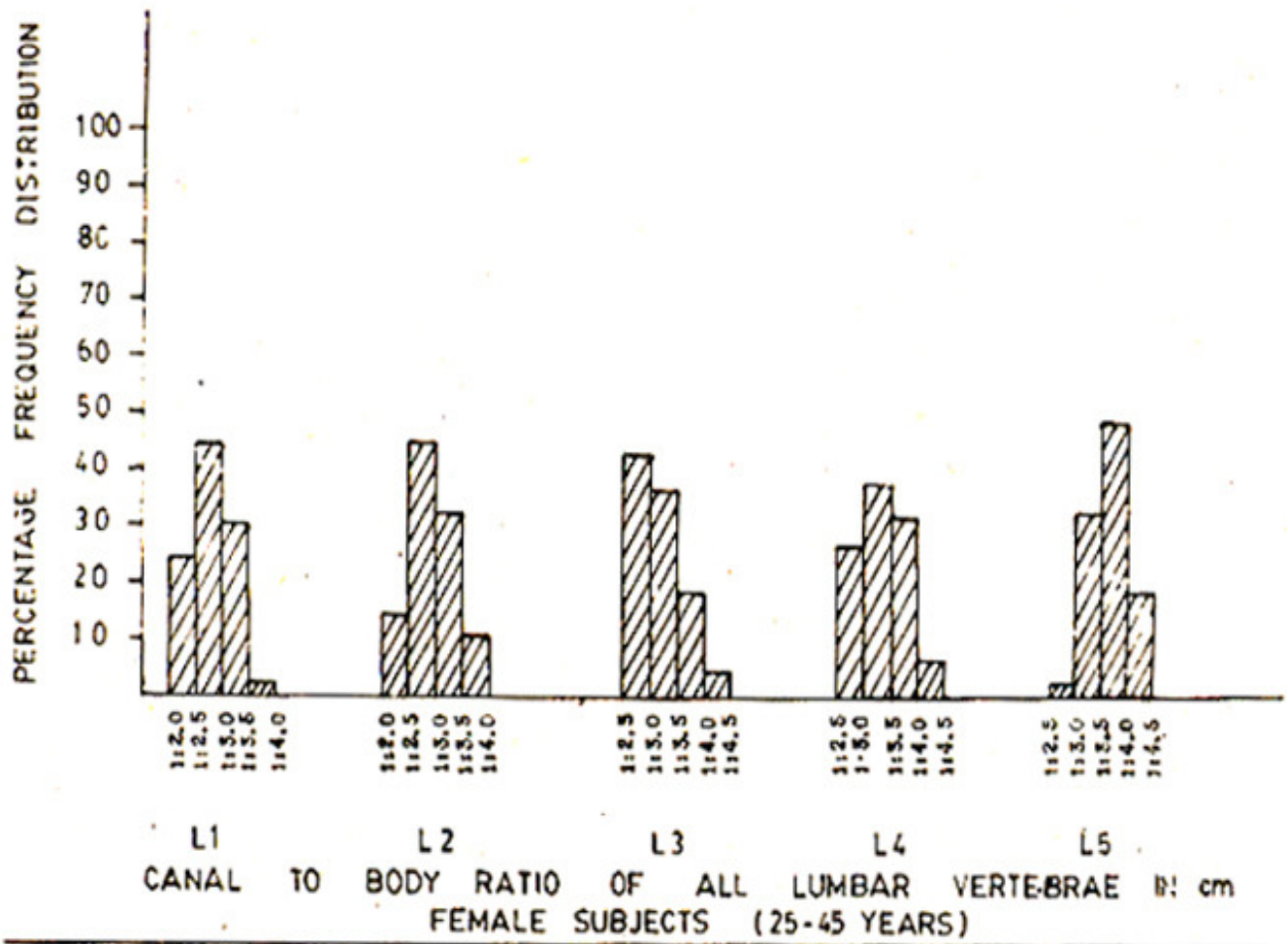
## **RESULTS**

The C/B ratio of 100 normal subjects from either sex revealed a consistently smaller, ratio at L1 vertebral level which gradually increases at successively lower levels. This shows that lumbar vertebral canal is wider at rostral vertebral levels and relatively narrows down at its caudal end in either sex of all the age groups studied. The normal values of C/B ratio varies between 1:2.0 and 1:5.0 in all cases. The ratio 1:2.0 indicates a wider canal but ratio beyond 1:5.0 would be conclusive of stenosis of the lumbar vertebral canal. It has been observed that C/B ratio in the females is lower than in the males at all vertebral levels indicating that female canal is relatively wider than that of male. The comparison of the C/B ratio at all vertebral levels between males and females of matching age groups were statistically analysed. The difference between the mean values of C/B ratio of vertebral levels; L1, L2, L3 and L4 was statistically significant whereas no significant difference was observed at L5 level indicating that dimensions of lumbar vertebral canal are relatively greater in females between L1 and L4 vertebrae. The C/B ratio in the male subjects ranges between 1:2.0 and 1:5.0 with 1:2.0 at L1 (4%) and 1:5 at L5 (2%) with a peak frequency distribution pattern ranging between 22% and 58% at all vertebral levels (Figure 3A).



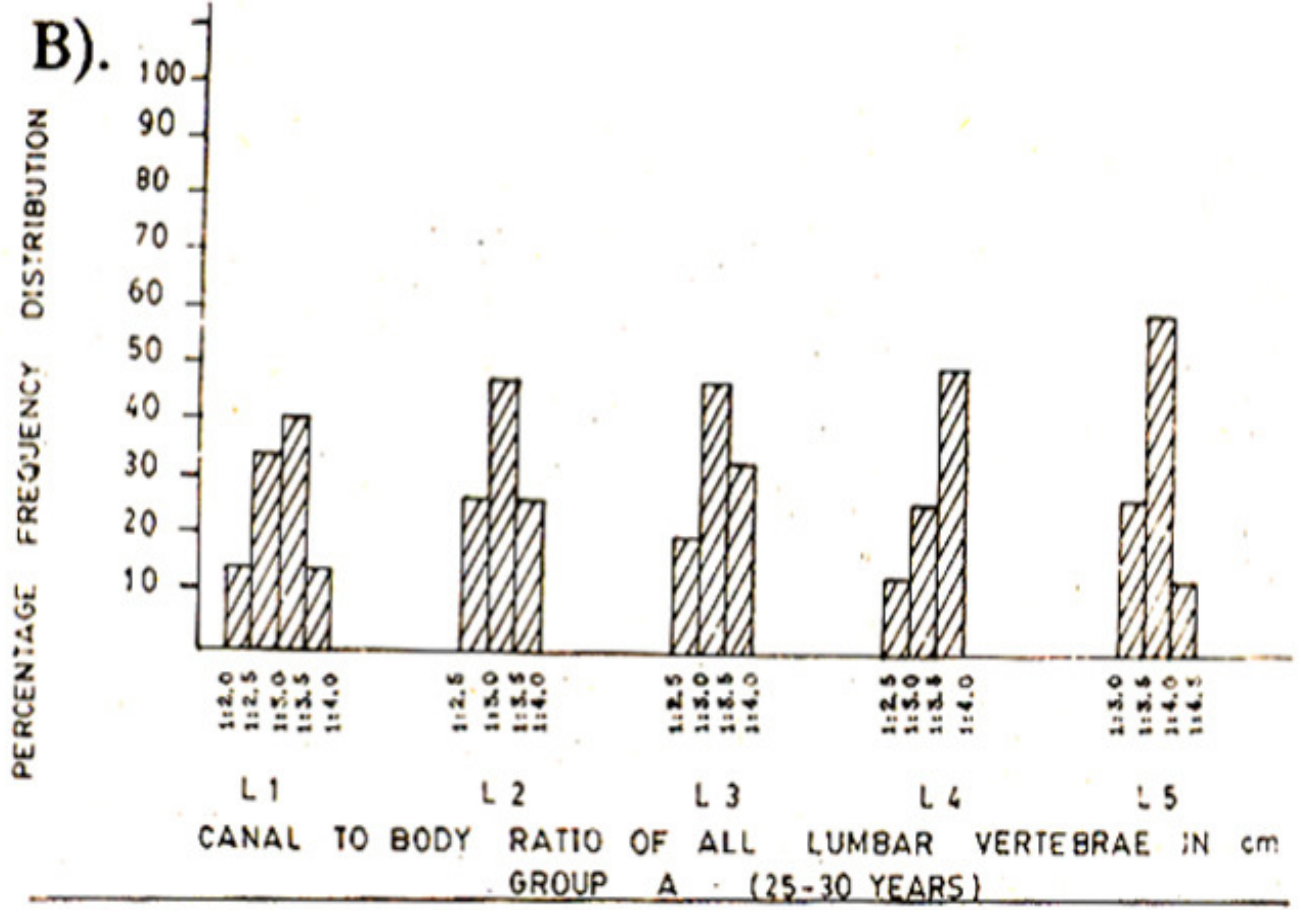
**Figure 3A.**

The C/B ratio in the female subjects ranges between 1:2.0 and 1:4.5 with 1:2 at L1 and L2 (24% & 4% respectively) and 1:4.5 at L3, L4 and L5 (41%, 6% & 18% respectively) and a peak frequency distribution pattern ranging between 32% and 48% at all vertebral levels (Figure 3B).

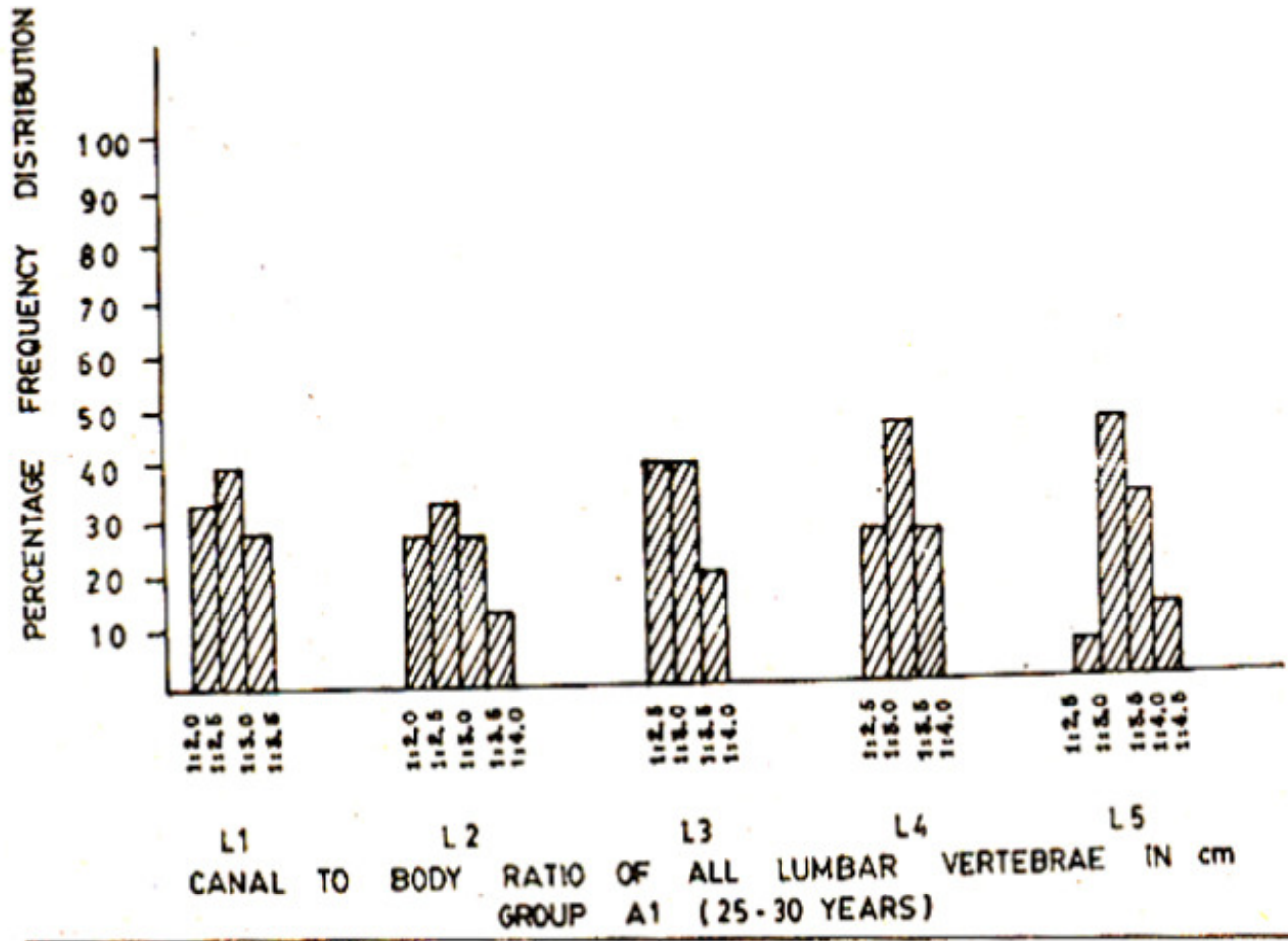


**Figure 3B.**

Statistical analysis of the corresponding lumbar vertebral canal in both sexes (groups A and A1) has shown that the difference is statistically significant at vertebral levels L1, L2, L3 and L4 respectively, whereas no significant difference in C/B ratio could be observed at L5. The C/B ratio of the canal ranges between 1:2 and 1:4.5 with 1:2 at L1 (13%) and 1:4.5 at L5 (13%) with a peak frequency distribution pattern ranging between 26% and 60% in group A, whereas 1:2 at L1 and L2 (30% and 26% respectively) and 1:4.5 at L5 (13%) with a peak frequency distribution pattern ranging between 20% and 47% in group A1 (Figure 4A and B).

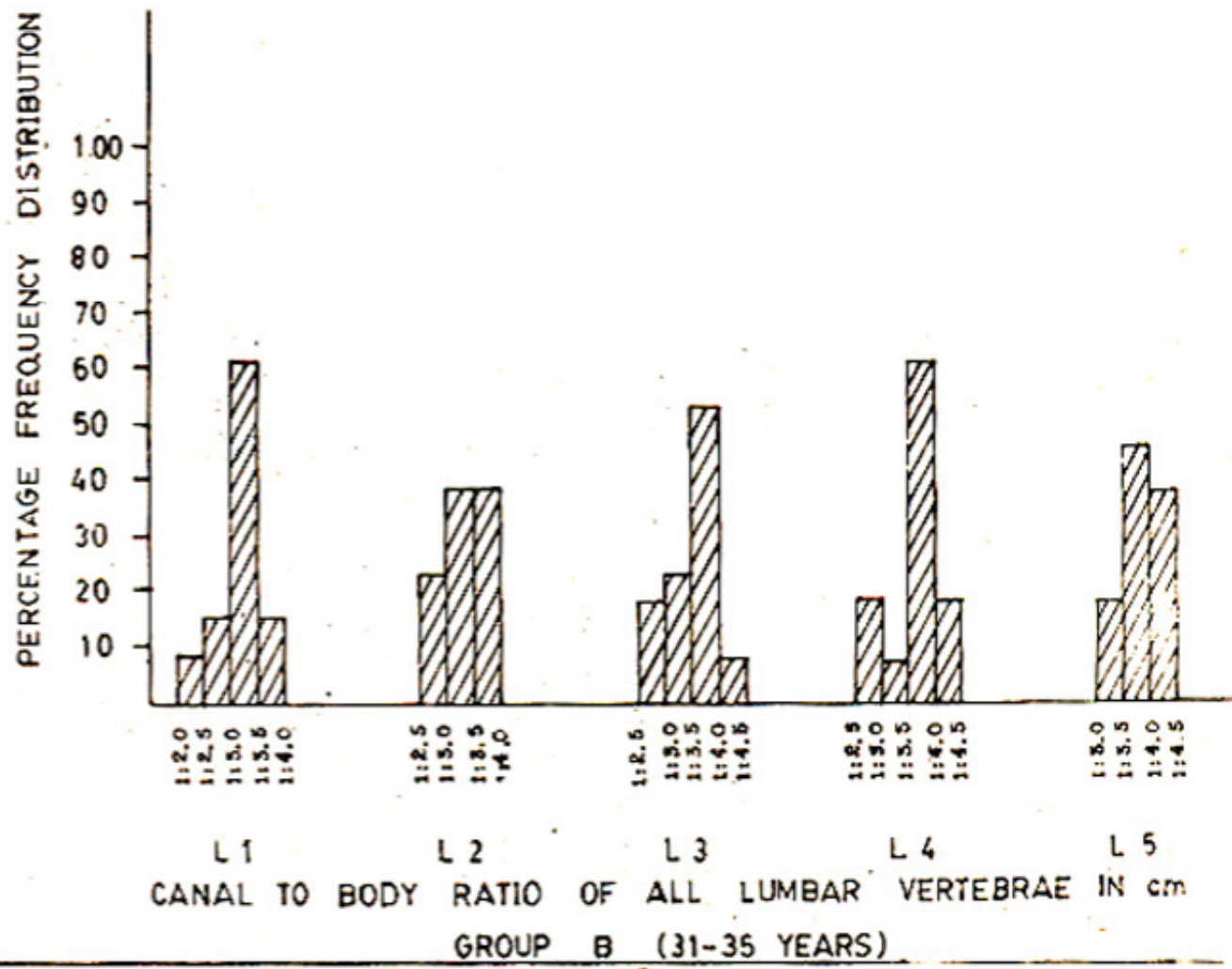


**Figure 4A.**

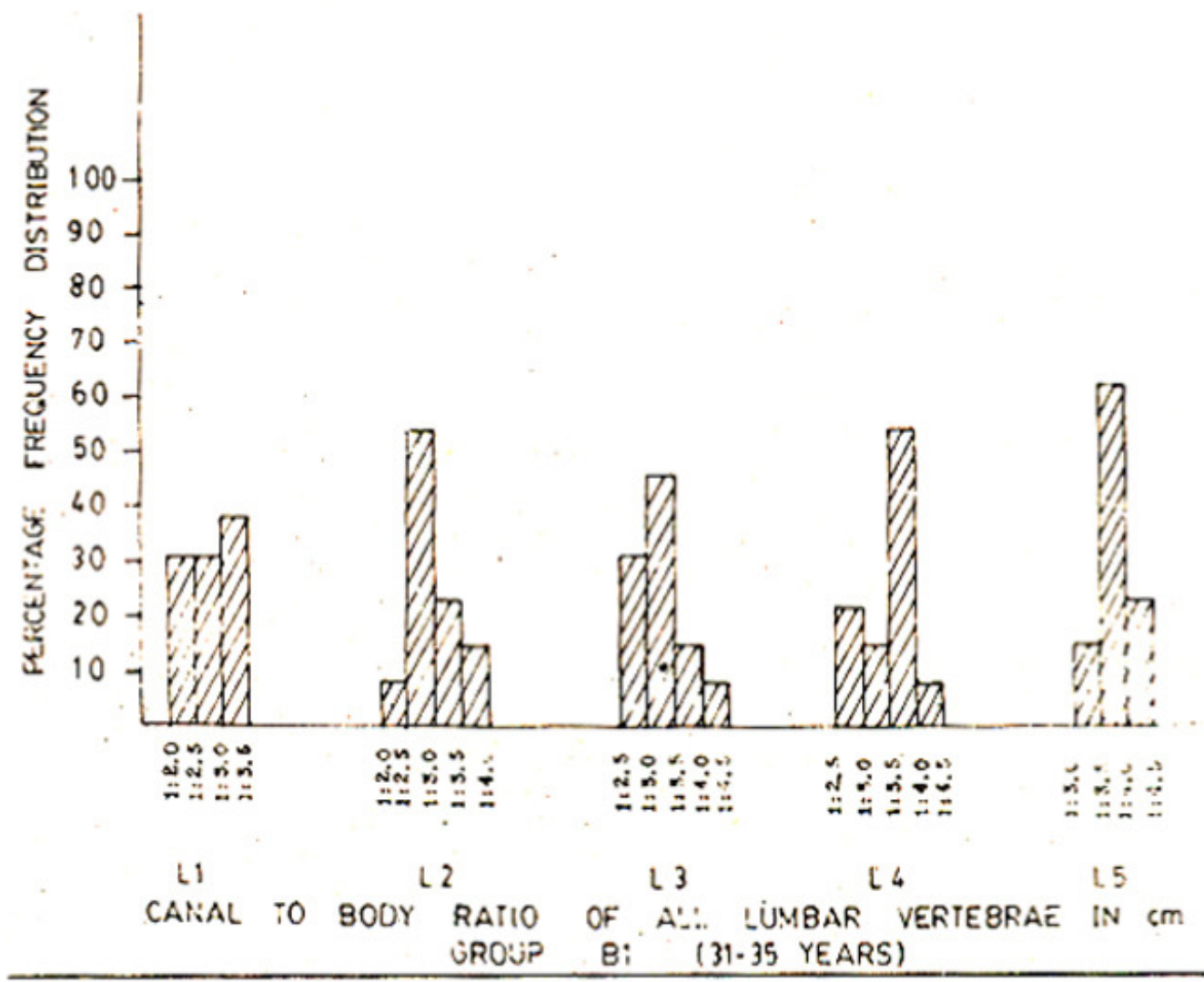


**Figure 4B.**

Statistical analysis of the corresponding lumbar vertebral canal in both sexes (groups B and Bi) has shown that the difference is statistically significant at vertebral levels L1 and L2, whereas no significant difference in C/B ratio could be observed at L3, L4 and L5. In both groups B and Bi the C/B ratio of the canal ranges between 1:2 and 1:4.5. However, in group B 1:2 at L1 (8%) and 1:4.5 at L3, L4 and L5 (8%, 18% and 38% respectively) with a peak frequency distribution pattern ranging between 15% and 60% whereas in group Bi, 1:3 at L1 and L2 (31% and 8% respectively) and 1:4.5 at L3, L4 and L5 (8%, 8% and 23% respectively) with a peak frequency distribution pattern ranging between 15% and 62% (Figure 5A and B).



**Figure 5A.**



**Figure 5B.**

The lumbar vertebral canal is comparatively greater in females (Group Ci) than in males (Group C) at L1, L2 and L3 vertebral levels, whereas no statistically significant difference in C/B ratio could be observed at L4 and L5. In group C the C/B ratio ranges between 1:2.5 and 1:5.0 whereas in Ci 1:2.0 and 1:4.5. In group C 1:2.5 at L1, L2 and L3 (42%, 17% and 16% respectively) and 1:5.0 at L5 (8%) with a peak frequency distribution pattern ranging between 25% and 58% whereas in group Ci 1:2.0 at L1 and L2 (41% and 17% respectively) and 1:4.5 at L3, L4 and L5 (8%, 8% & 8%) with a peak distribution frequency ranging between 17% and 67% (Figure 6A and B).

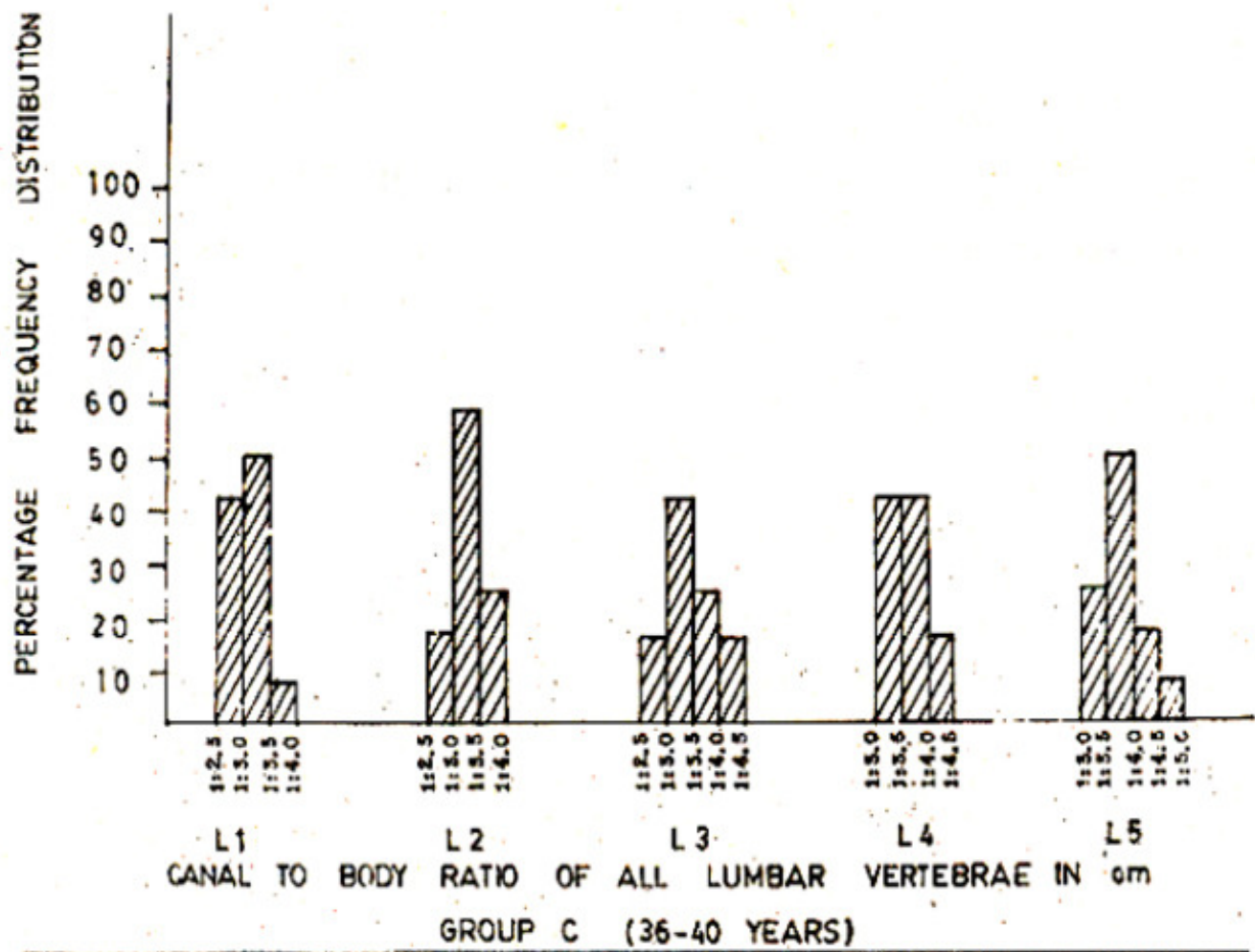
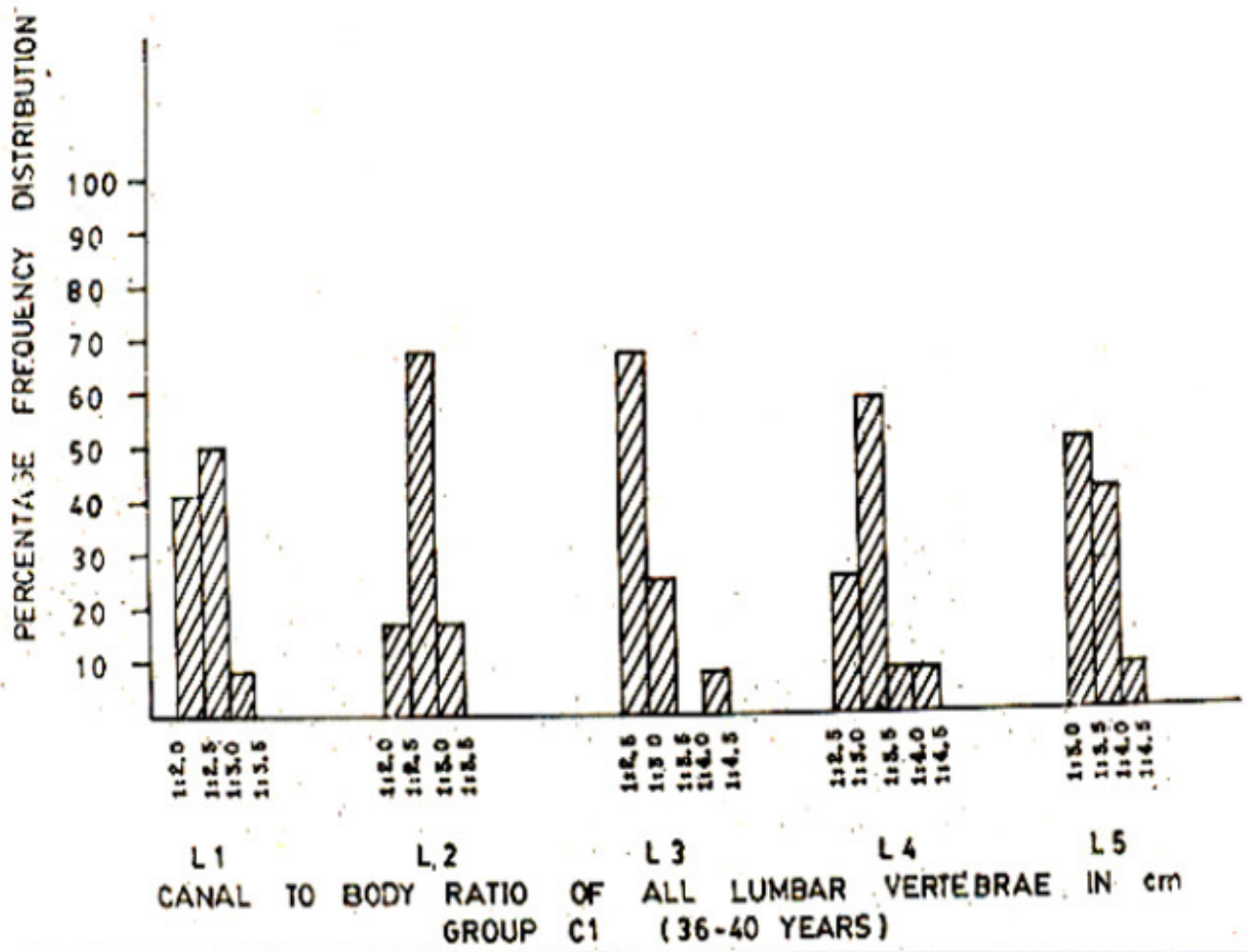


Figure 6A.



**Figure 6B.**

The difference in C/B ratio in both sexes (group D and D1) is not statistically significant at any vertebral level between L1 and L5. In group D, the C/B ratio of the canal ranges between 1:2.0 & 1:4.5 whereas in group D1 1:2.0 and 1:4.5. In group D 1:2.5 at L1 & L2 (20% and 10% respectively) and 1:4.5 at L3, L4 and L5 (10%, 10% and 50% respectively) with a peak frequency distribution pattern ranging between 10% and 80% whereas in group D1 1:2.0 at L1 (20%) and 1:4.5 at L4 and L5 (10% and 20% respectively) with a peak frequency pattern ranging between 20% and 60% (Figure 7A and B).

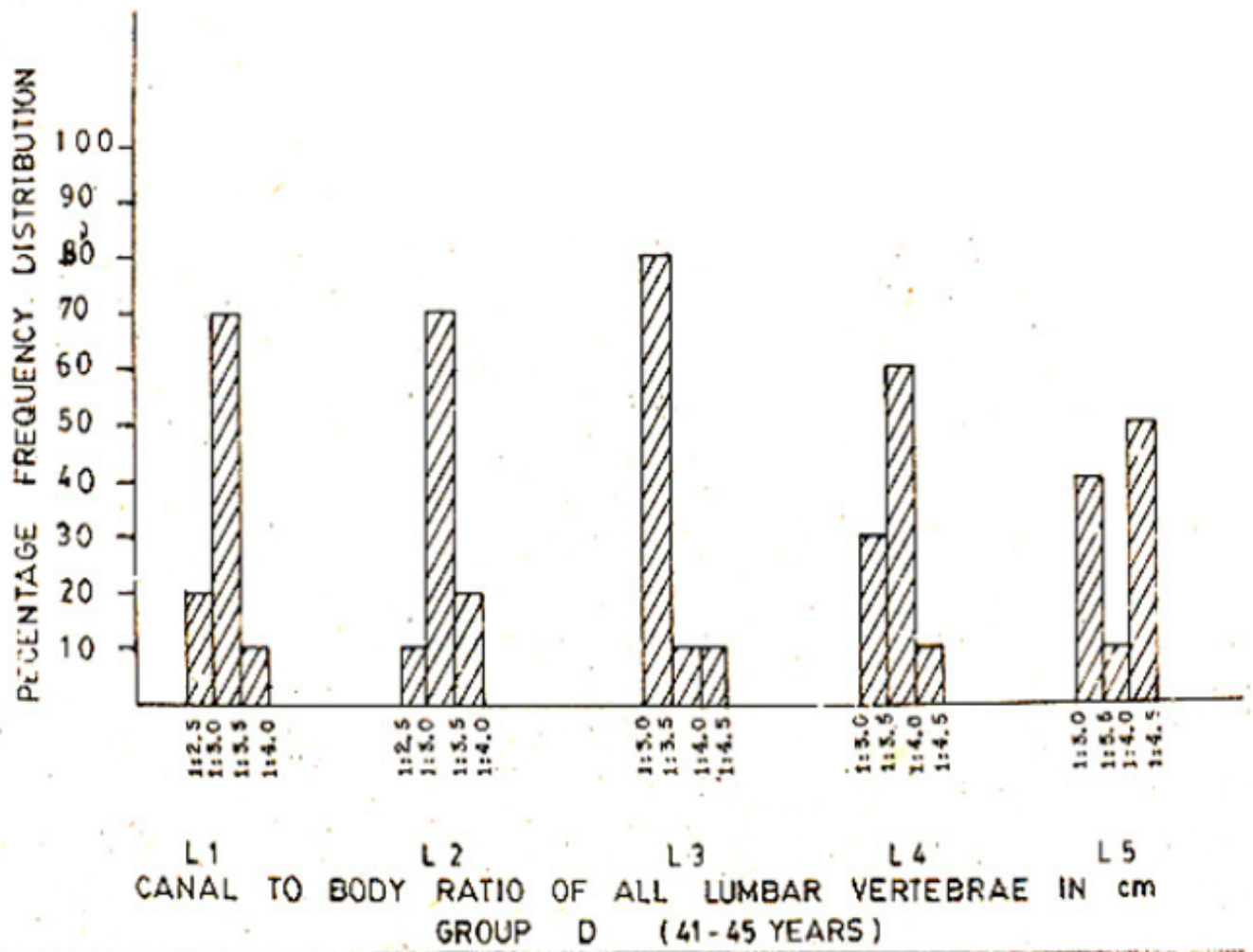
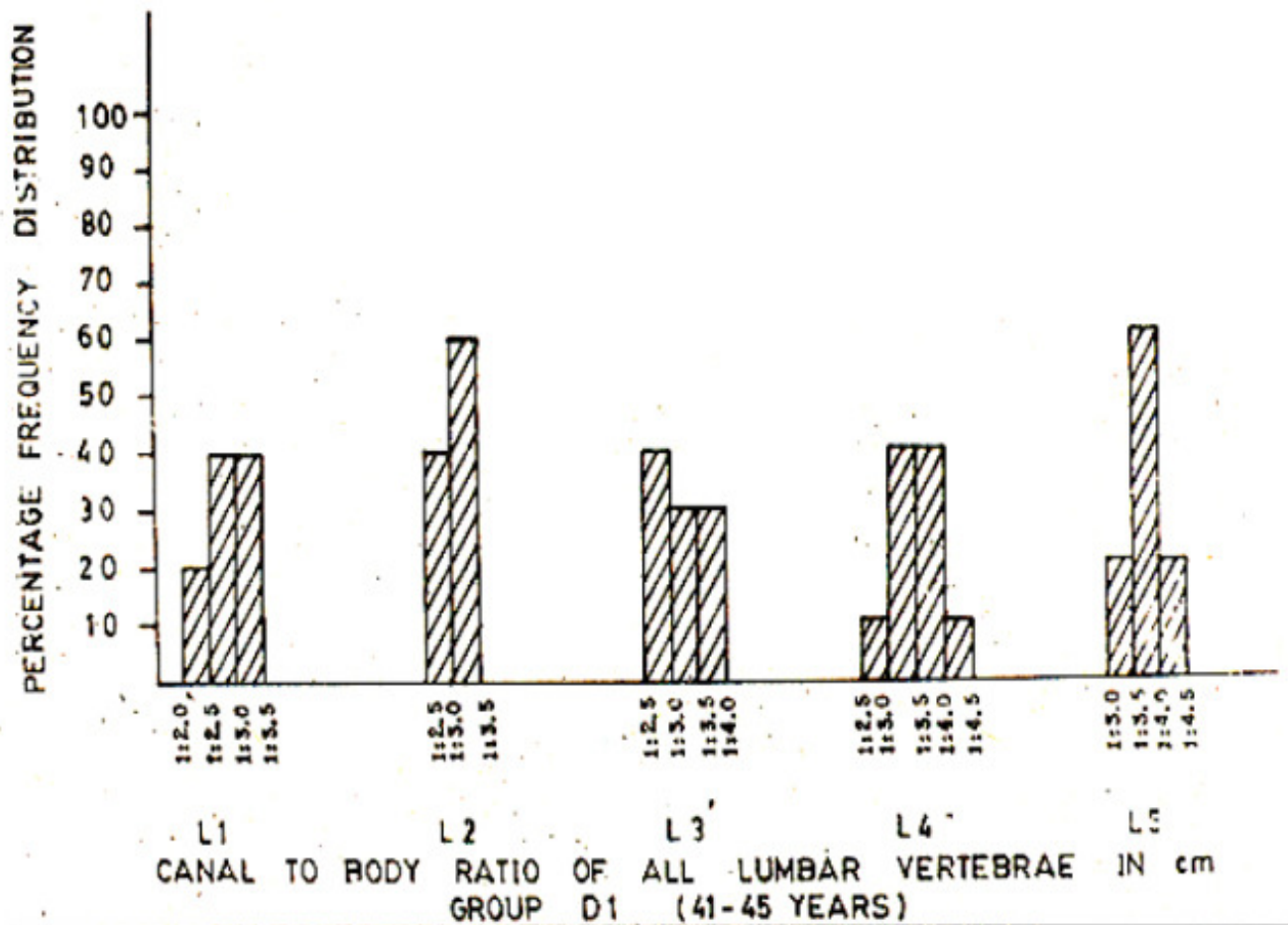


Figure 7A.



**Figure 7B.**

The above observations show that there is no change in the dimensions of the lumbar vertebral canal in ages ranging between 25 and 45 years in both male and female subjects. However, the dimensions of the lumbar than those in the male subjects. It can therefore be deduced that in males the canal is widest at L1 and in females at L1 and L2 vertebral levels which gradually narrows down at successive subjacent vertebral levels and attains relatively narrowest dimensions at L5 vertebral level. In groups A, B, C, A1 and B1 the vertebral canal is widest at L1 which gradually narrows down and attains narrowest dimensions at L4 and L5 vertebral levels whereas in group C1, attains narrowest dimensions at L5. In groups D and D1, the lumbar vertebral canal is widest at L1 and L2 but gradually narrows down at successive subjacent vertebral levels to attain narrowest dimensions at L3, L4 and L5 in group D and at L4 and L5 vertebral levels in group D1.

## DISCUSSION

The importance of size and shape of the lumbar vertebral canal in relation to the occurrence of symptoms of the spinal cord or root compression, especially in spondylosis or other abnormalities is well recognized. The useful application of the C/B ratio<sup>1</sup> in clinical appraisal of the size of the lumbar canal is that it obviates the need to know variables like X-ray magnification factor and the build of individuals so that any anteroposterior and lateral radiographs of the lumbar spine can be used to assess the size of the spinal canal. Concerning the direct measurements of the canal, Highman<sup>1</sup> considered it unreliable unless correction was made for the patient position and geometric magnification factor. Advantage of C/B ration method is that such corrections are unnecessary. sary. Measurement of C/B

ratio of the spinal canal is, therefore, useful aid in the diagnosis of the lumbar spinal canal stenosis syndrome. In this study the C/B ratio in both male and female subjects varied between 1:2.0 and 1:5.0. This is in conformity with the findings of Jones and Thomson<sup>1</sup> as C/B ratio studied by them in both sexes varied between 1:2.1 and 1:4.7 which is very close to the present study except that they did not elaborate on the percentage frequency distribution pattern in their population. The results of the present study can successfully be compared with the results of myelographic measurements of lumbar final canal in 2000 subjects by Roberson et al<sup>22</sup>, in which a constant narrowing of the lumbar spinal canal from above downwards was observed. Moreover, computerized tomographic study by Postacchini et al<sup>11</sup> also indicated a gradual narrowing of the lumbar spinal canal from L1 to L5. Our results are also similar to the study of Eisenstein<sup>18,19</sup> who measured the C/B ratio of the spinal canal in two racial groups i.e. Caucasoid and Negroids. His results revealed that C/B ratio of both caucasoid and Negroid female subjects is less (wider canal) than those of the males, proving thereby that in females the spinal canal is relatively wider than those in the males. The results of the present study are also comparable to those of Porter et al<sup>12</sup> who measured the spinal canal by diagnostic ultra sound and reported that the mean values of the spinal canal in the female subjects are greater than those in the male subjects. The comparison of C/B ratio at corresponding lumbar vertebral levels in males and females separately in different age groups ranging between 25 and 45 years revealed no statistically significant difference at any vertebral level. This indicates that dimensions of the canal remain constant between 25 and 45 years, an indication for the completion of the development of the vertebral canal at the age of 25 years and that the subjects selected were not affected by any disease process leading to stenosis of the canal. While comparing the results of the present study with other workers who used plain radio-graphs for lumbar vertebral canal measurement, it was found that the method is successful for our circumstances, the technique is simple, cheap, and non invasive but with limitation of not providing information on soft parts which may compress the nerves to produce symptoms. The minor statistical differences noted at individual vertebral levels can be explained on the basis of fewer number of cases studied. Moreover regional and racial differences were not included as the study was on randomized small group of subjects in which minimum statistical differences cannot probably be removed. Our results are very close to various workers who used plain radiographs, myelographs, ultrasound and computerised tomography. The method is easier, simple, painless, less costly and does not require sophisticated instruments and highly trained personnel. A well trained technician in ordinary radiography is capable of carrying out the procedure.

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