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Maximum and minimum lumbar interpedicular distances in normal adult Nigerians

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INTRODUCTION

The pioneering work of Elsberg & Dyke (1934) and later reports by Landmesser & Heublein (1953), Verbiest (1954, 1955), Simril & Thurston (1955), Schwarz (1956), Hinck, Clark & Hopkins (1966) have established the clinical value of measurements of interpedicular distances in the diagnosis of narrowing of the spinal canal. Verbiest (1954) pointed out that the bony canal could be developmentally narrow, whilst Scheslinger & Taveras (1953) and Verbiest (1954, 1955) described some of the effects of the narrow canal. Since then, the size of the spinal canal has attracted increasing interest. Various techniques, including plain radiographs, myelography, epidural venography, computed tomography and diagnostic ultrasound, have been used to measure the size of the lumbar spinal canal (Hinck *et al.* 1966; Kirkaldy-Willis, Paine, Cauchoix & McIvor, 1974; Gargano, Jacobson & Rosomoff, 1974; Eisenstein, 1977; Sheldon, Sersland & Leborgne, 1977; Chynn, Altman, Shaw & Finby, 1978; Porter, Wicks & Ottewell, 1978; Bestawros, Vreeland & Goldman, 1979). Although each technique has its own limitations, Chynn *et al.* (1978) observed that plain radiographs are of great value in the diagnosis of lumbar spinal canal stenosis.

Normal values of lumbar interpedicular distances measured from plain radiographs have been reported by Hinck *et al.* (1966) in white American subjects and by Eisenstein (1977) in both black and white South African subjects. There were marked differences in the width of the lumbar spinal canal studied by these two workers; Eisenstein further observed that the negroid lumbar spinal canal was marginally less capacious than that of the caucasoid. Because there is no information in the literature on the size of the normal lumbar canal in other black populations, two questions come to mind: (1) Are there significant regional or ethnic differences in the dimensions of the lumbar spinal canal? (2) What are the maximum and minimum limits of the width of the normal lumbar canal in Nigerians? The present study was undertaken in an attempt to find the answers.

MATERIALS AND METHODS

Plain anteroposterior radiographs of the lumbar spine were selected in 290 patients (150 males and 140 females) aged between 20 and 45 years, who attended the casualty department of the University of Ilorin Teaching Hospital for suspected recent accidental damage to the lumbar spine and in whom no bony injury could be found. Care was taken to exclude radiographs of patients who had attended hospital with backache. The radiographs were screened for readability and first

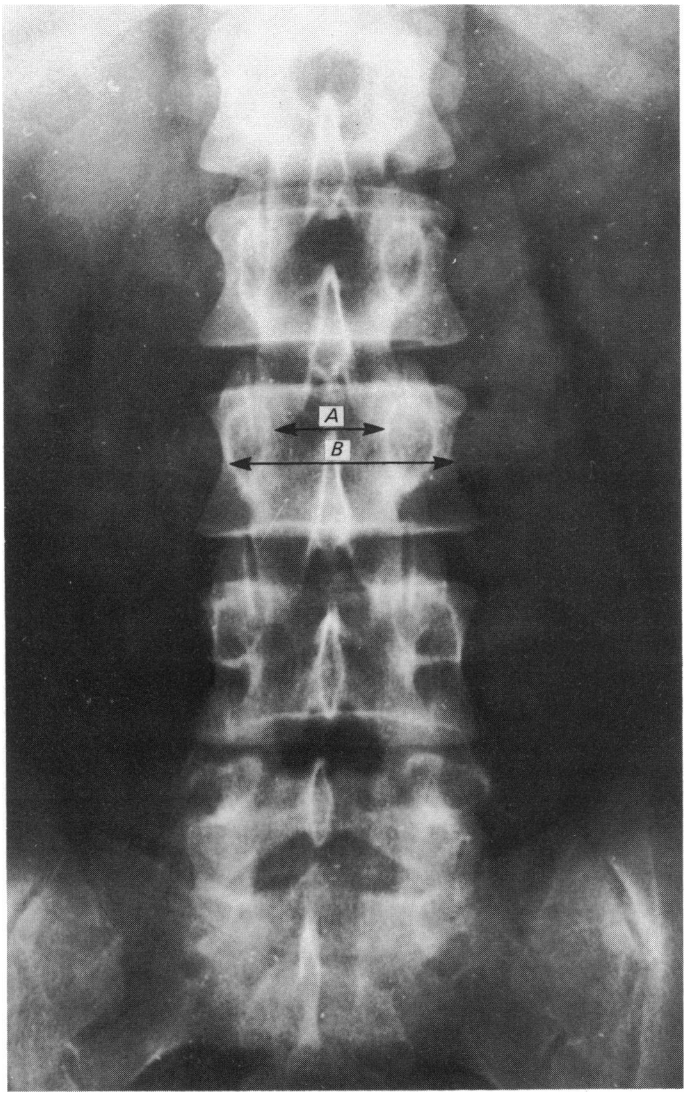

Fig. 1. Anteroposterior view of the lumbar segment of the vertebral column showing measurements used to assess the lumbar canal. *A*, interpedicular distance; *B*, transverse diameter of the vertebral body.

interpreted by a diagnostic radiologist. All radiographs had been taken with an anode-film distance of 100 cm. Measurements were made by the author using vernier calipers and were recorded to the nearest tenth of a millimetre: the interpedicular distance was taken as the shortest distance between the medial surfaces of the pedicles of a given vertebra; and the width (transverse diameter) of the vertebral body was measured at the level of the narrowest part of the waist of the vertebra (Fig. 1). The ratio of the width of the bony spinal canal (interpedicular distance) to the width of the corresponding vertebral body was calculated for each level by dividing the value of *A* by the value of *B*. In the same 290 radiographs, pedicle indices were calculated for each lumbar vertebra by first measuring the

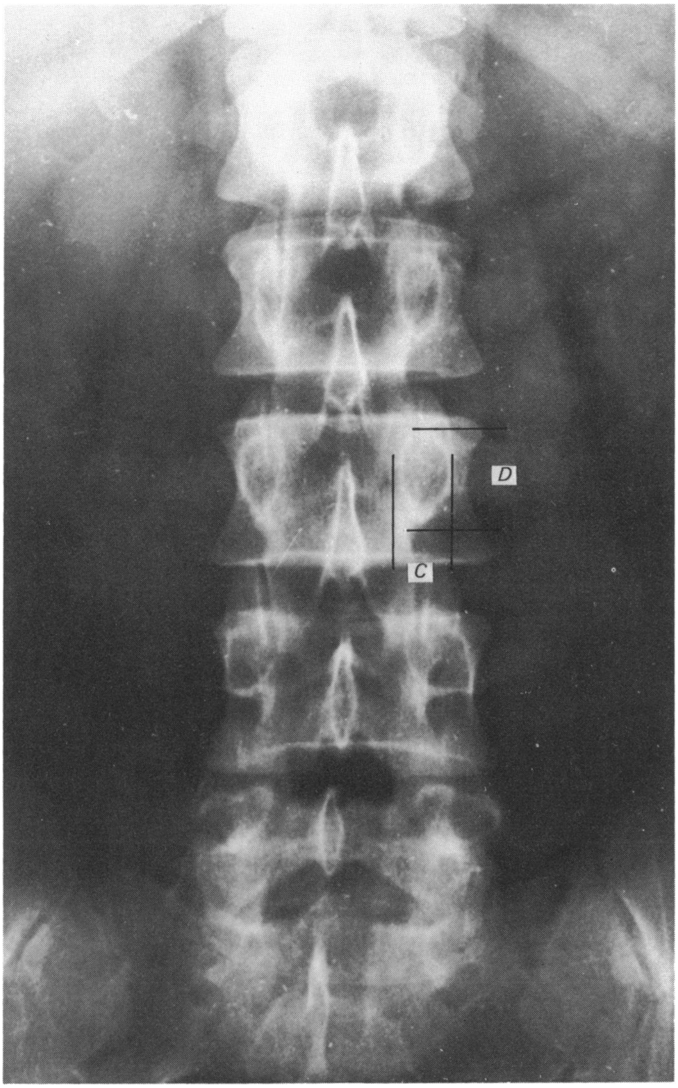

Fig. 2. Anteroposterior view of the lumbar segment of the vertebral column showing the measurements used in calculating the pedicle index. *C*, transverse diameter of pedicle; *D*, cephalocaudal diameter of pedicle.

width of the right pedicle in two mutually perpendicular planes *C* and *D* (Fig. 2) and obtaining the product of the two measurements.

OBSERVATIONS

Interpedicular distances

The mean values and standard deviations of interpedicular distances were calculated separately for each lumbar vertebral level in males and females (Table 1). Generally, the mean interpedicular distances showed a steady increase from L1 to L5 in both sexes; and although the male lumbar canals were consistently wider than the females, the difference did not exceed one millimetre (1 mm) at any level (Fig. 3).

Table 1. *Mean lumbar interpedicular distances, standard deviations and coefficient of variation in male and female adult Nigerian subjects*

	Males			Females		
	Mean interpedicular distance (mm)	Standard deviation	Coefficient of variation (%)	Mean interpedicular distance (mm)	Standard deviation	Coefficient of variation (%)
L1	22·6	1·9	8·4	21·3	2·0	9·4
L2	22·7	1·7	7·5	22·5	2·0	8·9
L3	24·5	1·5	6·1	23·7	1·8	7·6
L4	26·0	1·7	6·5	25·4	1·6	6·3
L5	28·7	2·3	8·0	28·4	2·0	7·0

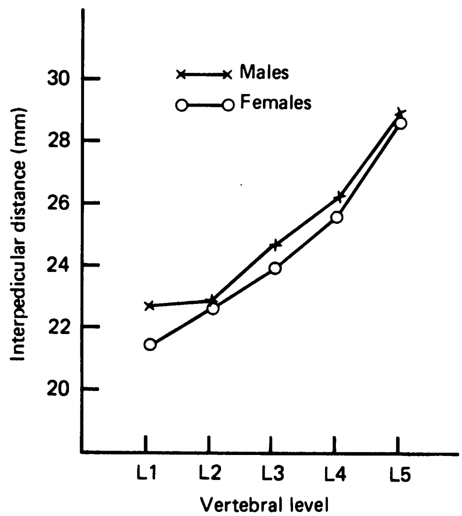

Fig. 3. Mean values of lumbar interpedicular distances in males and females.

The female lumbar canal showed more variability at L1, L2 and L3. This is attributable, perhaps, to the greater differences in general somatic size, as compared to males. At L4, no difference was observed in the standard deviations of the two sexes. The most striking feature was the magnitude of variability at L5 in both sexes. This was probably due to the much larger interpedicular distance at this level; the males showed a higher variability at this level as compared with the females, probably because in a few instances the distances were actually smaller in the male.

Norms for use in clinical appraisal have been worked out for each lumbar level by calculating the 95 % tolerance ranges separately for males and females, using the formula given by Bradford Hill (1977). These ranges, which are the high and low limits within which the central 95 % of normals may be expected to fall, varied somewhat in width from vertebra to vertebra (Table 2 and Fig. 4). Carefully measured individual interpedicular distances falling outside the limits given should 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.

Table 2. *Tolerance range (95 %) of interpedicular distance of each lumbar vertebra in adult males and females*

Level	Male range (mm)	Female range (mm)
L1	18·8–26·4	17·3–25·3
L2	19·3–26·1	18·5–26·5
L3	21·5–27·5	20·1–27·3
L4	22·6–29·4	22·2–28·6
L5	24·1–33·3	24·4–32·4

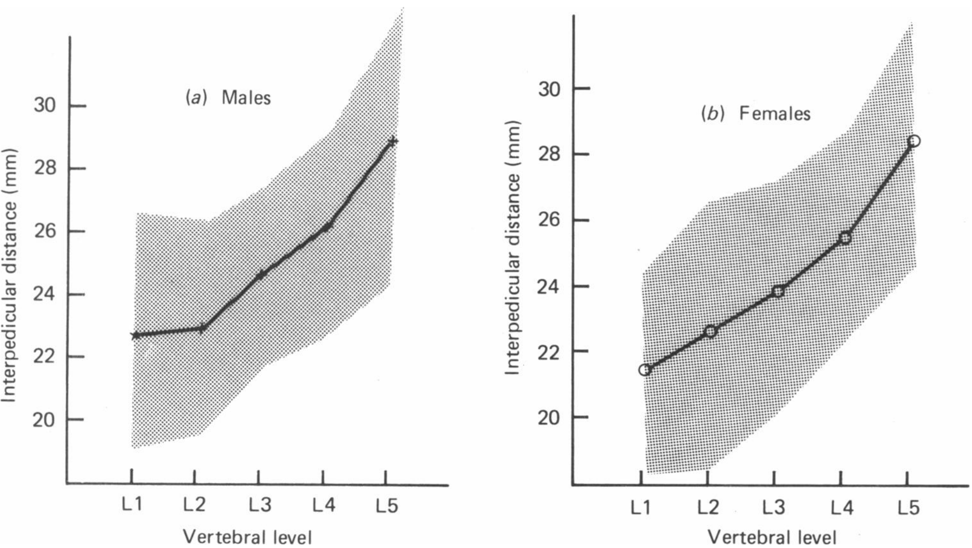

Fig. 4 (*a*–*b*). Maximum and minimum limits (95 % tolerance ranges) of interpedicular distances in adult Nigerians; (*a*) males, (*b*) females. The solid line represents the mean interpedicular distance.

For comparison, the present values of mean interpedicular distances have been plotted in relation to those of Hinck *et al.* (1966) who studied white American subjects and Eisenstein (1977) who measured both white and black South African subjects (Fig. 5). The general pattern of a steady increase in interpedicular distance from L1 to L5 is evident in all groups. The lumbar canals of white American subjects have the highest, whilst the Zulu subjects studied by Eisenstein (1977) have the lowest figures for interpedicular distances. Nigerian subjects appear to have wider spinal canals than white South Africans at L3, L4 and L5, whilst in the upper lumbar region (L1 and L2) the lumbar canal of the white South African seems to be wider than that of the Nigerian. The values of interpedicular distances in females are lower than those in males in all groups, but the pattern of variation is similar to that of males except that the canal of the white South African females exceeded that of Nigerians in width only at L1 level.

It is interesting to note that the mean interpedicular distances for male and female white American subjects fell just within the upper limits of the normal ranges for male and female Nigerians, respectively, whilst those of the white South

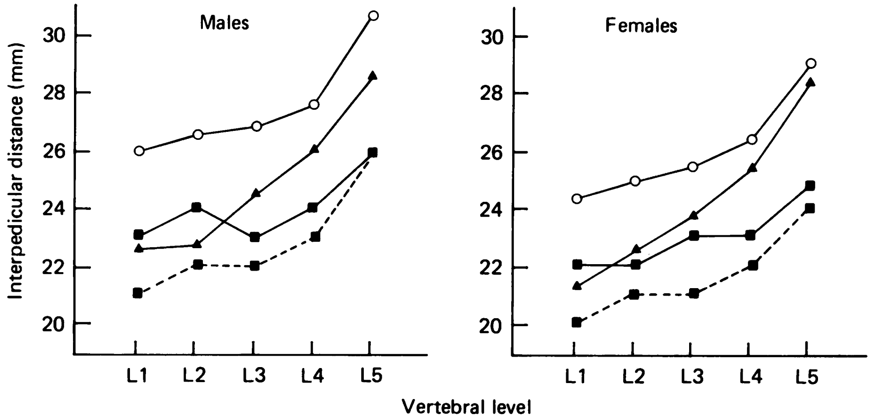

Fig. 5. Comparison between mean measurements of lumbar interpedicular distances from the present study, and the studies of Hinck *et al.* (1966) and Eisenstein (1977). ○—○, Hinck *et al.* (1966), ▲—▲, present study; ■—■, Eisenstein (1977) - Caucasoid; ■--■, Eisenstein (1977) - Zulus.

Table 3. *Mean pedicle indices, standard deviations and coefficient of variation for each lumbar vertebra in males and females*

	Males			Females		
Level	Mean pedicle index	Standard deviation	Coefficient of variation (%)	Mean pedicle index	Standard deviation	Coefficient of variation (%)
L1	173·1	34·5	19·9	141·6	23·3	16·5
L2	175·6	32·6	18·6	147·3	30·4	20·6
L3	190·0	34·4	18·1	171·0	30·6	17·9
L4	207·7	36·0	17·3	183·6	23·9	13·0
L5	234·6	47·6	20·3	199·1	29·9	15·0

African subjects fell just within the lower limits of the Nigerian values. The mean for the black South African subjects, clearly, fell below the lower limits of Nigerian subjects.

Pedicle index

The properties of the bony part of the neural canal depend on the pedicles, laminae and articular processes. Theoretically, excessively thick pedicles are likely to encroach on the neural canal. An attempt was therefore made to determine the relationship between the interpedicular distance and the size of the pedicle. Pedicle indices were used to assess the size of the pedicles.

These indices showed a steady increase from L1 to L5; mean indices were consistently higher in males than in females and males showed more variability in this parameter than females (Table 3 and Fig. 6*a*). It is noteworthy that the coefficients of variation of pedicle indices were not paralleled by those of interpedicular distances. This probably means that whilst the pedicles might show marked variability in sizes, they did not necessarily encroach on the normal spinal canal; instead, the width of the canal increased proportionately with pedicle indices from L1 to L5 (Fig. 6*b*).

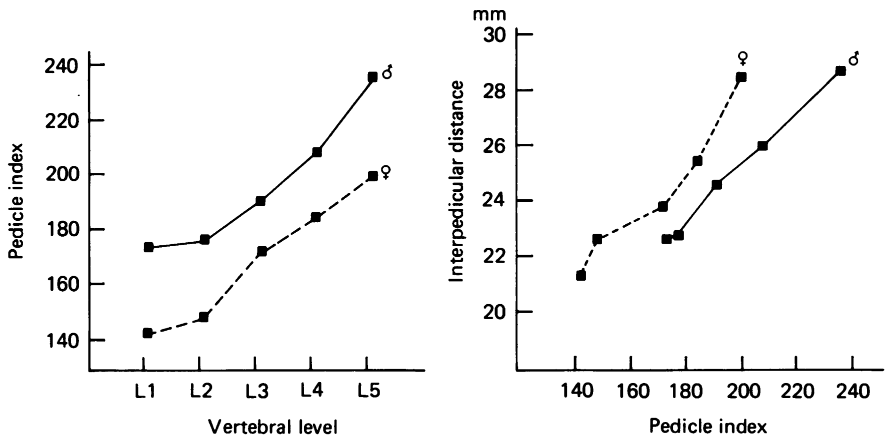

Fig. 6. (*a*) Graph showing the mean pedicle index at each lumbar level in males and females. (*b*) Graph showing the relationship between interpedicular distance and pedicle index in males and females.

Table 4. *Canal to body ratio for each lumbar vertebra in adult males and females*

	Males			Females		
Level	Mean interpedicular distance (mm)	Width of body (mm)	Canal/body ratio	Mean interpedicular distance (mm)	Width of body (mm)	Canal/body ratio
L1	22·6	41·3	0·6	21·3	37·5	0·6
L2	22·7	42·9	0·6	22·5	39·7	0·6
L3	24·5	45·8	0·6	23·7	42·5	0·6
L4	26·0	49·6	0·6	25·4	45·7	0·6
L5	28·7	52·8	0·6	28·4	50·5	0·6

Width of bodies; canal/body ratio

Because the thickness (strength) of the pedicle reflects the increasing bulk of muscle to be borne in this region, it was thought that the pedicle index as well as the interpedicular distance must bear some relationship to the build of the individual.

A comparison between the size of the canal and physique was made using the width of the vertebral body as an index of physique. The results expressed as canal: body ratio (Table 4) showed that although the width of the vertebral body increased from L1 to L5, the width of the canal maintained a constant relationship with the size of the body at all levels. This fact is clearly of importance, because if differences in physique are proven to exist between different populations, e.g. males and females, or, as in the present case, between the sample of Hinck *et al.* (1966) and the subjects used in the present study, then it can be reasonably assumed that interpedicular distances would vary proportionately. Another useful application of this (canal/body) ratio in clinical appraisal of the size of the lumbar canal is that it obviates the need to know variables like the X-ray magnification factor and the build of the individual, so that any anteroposterior radiograph of the lumbar spine can be used to assess the size of the canal.

DISCUSSION

A vast majority of back pains, though not accurately localised, have a limited distribution, and arise from a limited part of the spine (Kellgren, 1977). Because most of the complex spinal structures are inaccessible to detailed physical examination, it is necessary to develop ancillary methods of examining them. Pedicles produce visible landmarks on plain anteroposterior radiographs and therefore interpedicular distances can be measured accurately. Mean interpedicular distances vary among different age groups, and between the two sexes (Hinck *et al.* 1966). Normally, these distances increase steadily from L1 to L5, but it has been reported by Weir & Abrahams (1978) that the distances can actually decrease from above downwards in mongolism (Trisomy 21).

The lumbar part of the neural canal houses the cauda equina, and narrowing of the bony ring of the canal, which may be developmental or acquired, may lead to compression of these nerve roots and cause low back pain (Sarpyener, 1945; Schleslinger & Taveras, 1953; Verbiest, 1954, 1955, 1977). Measurement of the width of the lumbar spinal canal is therefore a useful aid in the diagnosis of the lumbar spinal stenosis syndrome. The technique, which is simple and relatively non-invasive with respect to the patient, has one main limitation, i.e. it does not give any information about the part of the canal formed by soft tissues, although it is recognised that compression of the nerves by soft tissues could also produce symptoms.

Comparison of the present results with those of Hinck *et al.* (1966) and Eisenstein (1977) shows that there are marked differences between the mean values reported for the three geographical areas. The reasons for these differences are not very clear but an interplay of racial, ethnic and environmental factors cannot be easily ruled out. None of the earlier studies was correlated with the stature of the individuals, but judging from the report of Hinck *et al.* (1966), in which interpedicular distances increased with age, and were higher in males, it seems reasonable to suggest that growth of the vertebral column and definitive build of the individual play important roles in determining the width of the lumbar spinal canal. The present results have confirmed that, in normal Nigerians, the width of the canal increases proportionately with the size of the vertebra, always maintaining a canal:body ratio of 0·6. The correlation of size of canal with physique is, however, difficult to apply to Eisenstein's (1977) results. For although he measured interpedicular distance as the greatest distance between the pedicles, the mean values reported were much lower than those of Hinck *et al.* (1977) or of the present study. Owing to the meticulous nature of his work, it is unlikely that the figures reported were erroneous. It is probable that the marked differences observed were due to regional (environmental) differences in the size of the canal. It must be noted, however, that the ages of the subjects studied by Eisenstein (1977) ranged from 16 to 96 years. Hinck *et al.* (1966) have shown that before the age of 19 years, the lumbar spinal canal is distinctly narrower than it is in the adult. Inclusion of these younger subjects in the sample could lead to a lowering of the value of mean interpedicular distance. It seems, therefore, that to make a definite diagnosis of narrowing of the lumbar spinal canal based on measurement of interpedicular distances, there must be base-line figures that are applicable not only to the geographical location but also to the age group under consideration. These figures could also be of forensic importance because of the observed racial, ethnic and regional variations.

SUMMARY

Interpedicular distances were measured on plain anteroposterior X-rays of normal adult Nigerians. Figures obtained for this population differ from other reports. The width of the normal canal appears to be subject to individual and racial variations. The significance of these findings is discussed.

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