Interpedicular Diameter of the Lumbosacral Spinal Canal of Normal Sudanese Population

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Abstract: Back pain due to Spinal Canal Stenosis (SCS) is a worldwide health problem. It causes suffering and distress to patients and their families, a clear definition of SCS is lacking because of anatomical differences between populations; this makes the comparison and interpretation of literature on incidence, prevalence and treatment difficult. The Objectives were to determine the normal dimension of the interpedicular spinal canal among Sudanese population, identify age, sex and racial related differences in morphometry of the spinal canal interpedicular diameter among Sudanese groups. Material and Method: The study was a descriptive cross-sectional study. Random sampling technique was used targeting 142 asymptomatic populations. A checklist was used to collect the data. The Results: The study included 142 normal asymptomatic Sudanese subjects (57% male and 43% female). The mean interpedicular spinal canal diameter of the study subjects showed a steady increase in the mean (± SD). L1 was M 21.99(2.23), F 21.20(2.10) and S1 M 33.12(3.30), F 32.21(3.16) in both sexes. Males had slightly wider canal diameter than females at all levels and the difference is statistically significant. The corresponding transverse diameter of the lumbosacral vertebral bodies increases gradually from L1 to S1 in both sexes.Conclusion: A normal interpedicular diameter of lumbosacral vertebral canal for Sudanese population has been set. And no differences exist between populations living in different country regions.

Keywords: Interpedicular diameter, lumbosacral, canal body ratio, Sudanese.

I. INTRODUCTION

Diagnosis of spinal canal Stenosis depends on determining the normal diameters of central and lateral spinal canal and on the neural foramen measurements. [1, 2] . Due to socio demographic and ethnic differences many of the reported research on normal anatomical values of the spinal canal were inconsistent. Few studies have reported significant associations between some of the radiographic parameters and certain demographic and anthropometric factors [3- 11] Reports shown racial & ethnic spinal bony differences as well as age and sex differences in the spinal canal size [12, 13].most of the interpretations were due to socioeconomic condition [14] , nutritional status, genetic constitution [`15] climatic condition[16] , physical setting of the habitat [17] and level of physical work [18] . As a consequence, human populations possess characteristics that stamp them as residents of particular areas of the world [19]This study aims to :Determine the normal interpedicular (transverse) diameter of the spinal canal in lumbosacral region among adult Sudanese population using the MRI, Identify age, sex and racial related differences in morphometry of the spinal canal interpedicular diameter

II. MATERIAL AND METHODS

This study is a comparative descriptive cross-sectional study.

The Study Population:

The study included MR images of 142 normal (asymptomatic) Sudanese subjects, between the ages of 20 to 45 years.

Exclusion Criteria

Any participant with a history of low back pain or trauma or, lower-limbs radiating pain, congenital anomalies of the back vertebrae, spinal disease , previous surgery to the spine, females who were pregnant or suspected to be pregnant were excluded from the study.

Study Area

The study was conducted in Khartoum city, the capital of Sudan. Due to the recent massive expansion of its population; Khartoum state is considered by the statisticians and anthropologist to be representative to different regions, states of Sudan.

The study was ethically approved from the Technical Ethical Committee (TEC), Faculty of Medicine, University of Gezeira; Verbal informed consent was taken from the study participants. The socio-demographic data of the cases were obtained using check list.

Measurement Method

284 (MRI) measurements were performed in Ribat Teaching Hospital. The Magnetic Resonant Image (MRI) used was scanner (Siemens, Germany) 1.5 tesla with the synergy spine coil. The images were taken using the following protocol: (1) T1 for sagittal and axial planes, the intensity of the images were constructed with a TE/TR of 10/500 ms. (2) T2 for axial and axial intensity of images were constructed with a TE/TR of 120/3500 ms. The slice thickness was 3 mm. the images were taken from the upper

and lower end plate of each vertebra from LI to S1 including section through the disc.Transverse diameter of the spinal canal was measured in the cross-sectional Images of each of the Lumbosacral Vertebra**;** Measured as the minimum distance between the mid points on the medial surfaces of the pedicles (Interpedicular Distance) of the same vertebra, notice line (A) (Figure1). The images were done by an expert radiology technician (working for more than 20 years). And the measurements done both by the author & revised by the radiology technician (double check)

Figure (1): spinal canal and vertebral body diameters

Statistical analysis

The mean and standard deviation values for both measurements were calculated. Then the Independent t-test, ANOVA and Pearson Correlation were also performed to determine the associations between the different variables. Significant difference was set at $P < 0.05$. Analysis was conducted using SPSS (Statistical Package for Social Sciences) for windows, version 20, 0

III. RESULTS

Half of the study subjects (45.1%) were young adults; their age between 20-28years old Fig (2), the males were (57%) Fig (3). The mean height was 168cm and the mean weight was 66 kilogram. Most of the subject's roots from Khartoum and central regions Fig (4)

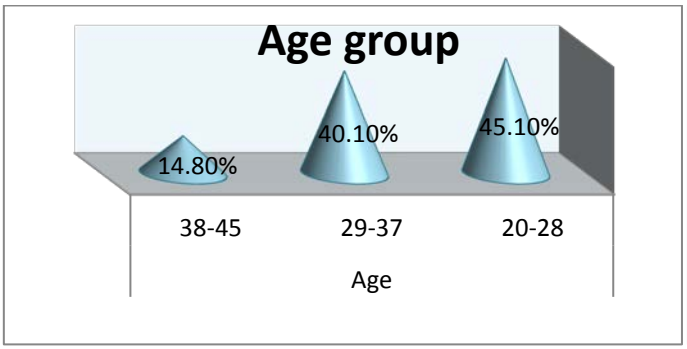


Figure (2) Age distribution of the study subjects

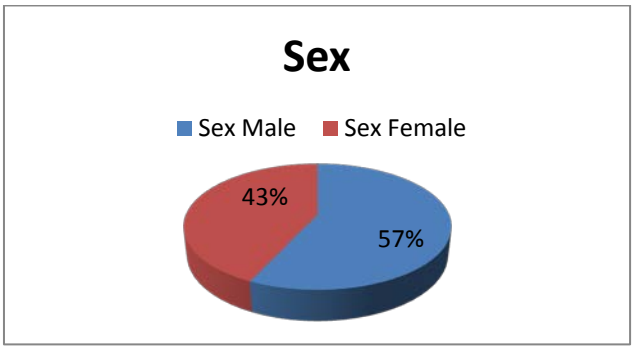
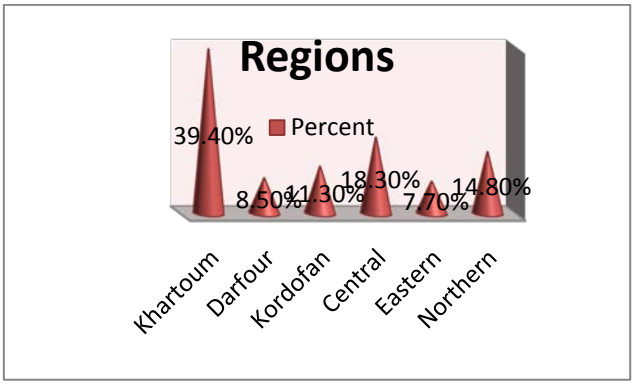


Figure (3) Sex distributions of the study subjects



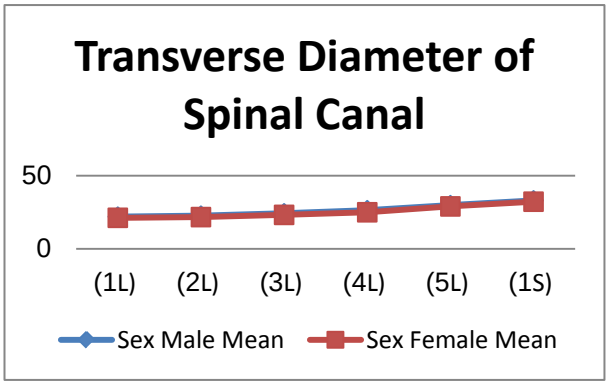


Figure (4) Distribution of the study subjects in Sudan regions. Figure (5) Transverse diameter of spinal canal

Interpedicular (Transverse) Diameter of the Spinal Canal

Male interpedicular lumbar canal diameter was wider than female canal; the difference was statistically significant in vertebrae from (L1-L4). $P < 0.05$.Table (1)

Interpedicular diameters showed a steady increase in the mean (± SD) from L1 (M 21.99, F 21.20) to S1 (M 33.12, F 32.21) in both sexes Fig (5).

Table (1) Transverse diameter of spinal canal of study subjects among both sexes.

Transverse Diameter	Sex				P-value
	Male		Female		
	Mean	Standard Deviation	Mean	Standard Deviation	
(L1)	21.99	2.23	21.20	2.10	.034
(L2)	22.66	3.15	21.69	1.92	.037
(L3)	24.29	2.56	23.20	2.20	.009
(L4)	26.41	2.84	24.99	2.88	.004
(L5)	29.87	3.86	28.99	3.64	.172
(S1)	33.12	3.30	32.21	3.16	.098

Transverse Diameter of Vertebral Body

The transverse diameters of the vertebral bodies showed a steady increase in the mean (± SD) from L1 – S1 in both sexes. Male transverse lumbar vertebral bodies were wider than female with statistical significant difference from L1-L3. *P-v* < 0.05. (Table, 2).

Table (2) Body of vertebra (Transverse diameter) of asymptomatic study subjects among both sexes.

Transverse Diameter of Vertebral Body	Sex				P-value
	Male		Female		
	Mean	Standard Deviation	Mean	Standard Deviation	
(L1)	35.31	3.52	33.39	3.24	.020
(L2)	36.35	3.64	34.04	3.08	.006
(L3)	38.37	4.01	36.02	3.20	.009
(L4)	40.06	4.70	38.47	3.46	.103
(L5)	40.54	4.58	39.31	4.25	.248
(S1)	40.59	6.11	39.69	6.00	.537

Influence of age on the interpedicular diameter of lumbosacral vertebrae

Table (3) showed the presence of association between age and lumbosacral interpedicular diameter only at (L5).

Table (3) (ANOVA) Association between age groups and the transverse diameter of spinal canal among the study subjects

Plane	**L1** Mean & p-value	**L2** Mean & p-value	**L3** Mean & p-value	**L4** Mean & p-value	**L5** Mean & p-value	**S1** Mean & p-value
interpedicular canal diameter	21.65(.855)	22.05(.524)	23.46(.255)	25.41(.126)	28.96(.044)	32.65(.140)

Influence of height and weight on interpedicular diameter of the lumbosacral vertebrae

Table (4) showed presence of significant relationships between the height or weight and the interpedicular diameters of lumbosacral region at the level of (L1, L2, and S1). As shown in table (3) below.

Table (4) Association between weight, height and spinal canal transverse diameter in asymptomatic study subjects (Pearson Correlation)

Plane	Correlation	Height	Weight
SC Transverse diameter (L1)	Pearson Correlation	.231**	.302**
SC Transverse diameter (L2)	Pearson Correlation	.156	.280**
SC Transverse diameter (L3)	Pearson Correlation	.135	.128
SC Transverse diameter (L4)	Pearson Correlation	.224**	.146
SC Transverse diameter (L5)	Pearson Correlation	.231**	.048
SC Transverse diameter (S1)	Pearson Correlation	.369**	.198*

**. Correlation is significant (strong correlation) at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Influence of regions on the interpedicular diameter of lumbosacral vertebrae

There were no differences detected between the interpedicular diameters of the Sudanese population who originated from the different country regions as shown in table (5) below

Table 5 Association between regions and spinal canal transverse diameter of the study subjects

Plane	**L1** Mean & P-value	**L2** Mean & P-value	**L3** Mean & P-value	**L4** Mean & P-value	**L5** Mean & P-value	**S1** Mean & P-value
Interpedicular canal diameter	21.5(.142)	22.3(.911)	23.9(.947)	27.2(.224)	30.1(.143)	32.5(.886)

IV. DISCUSSION

Many previous studies shown variation of normal morphology of the spinal vertebrae, these studies used various assessment methods and techniques (X-ray, CT, MRI or cadaveric direct measurements); each of them has advantages and limitations [20- 22].

MRI was used in the current study, it is safe, reliable & it can define the bony anatomy and visualize the other surrounding soft tissues. Now it is the best investigation method used for the diagnosis of suspected spinal diseases.[23]

The interpedicular diameters of Sudanese were smaller than that of the Saudi [13] and Egyptian [21] population, and larger than the normal interpedicular values of the Turkish [24] and Iran [25]. However, the pattern shows a steady increase in the mean (± SD) from L1 – S1 in all results of the above mentioned population.

V. CONCLUSION

These findings are of significant value for radiologist and spinal surgeons. As well as for the manufacturers who are designing spinal implants for Sudanese. The Interpedicular diameters increase in diameter from L1 to S1in both sexes. There is significant difference in this diameter between both sexes and no significant difference between the populations originating from different country regions.

Study limitation

The sample size of the study participants was small basically due to lack of radiological centers & services in many states of the country. So we recommend large scale study to be done in the future.

Acknowledgement

We would like to thank the volunteers who participated in the study and those who supported us during the data collection stage. Special thank for ministry of higher education & scientific research for their fund & support

REFERENCES

[1] Geisser ME HA, Tong HC, Yamakawa KS, Quint DJ, Hoff JT, Spinal canal size and clinical symptoms among persons diagnosed with lumbar spinal stenosis. *Clin J Pain* 2007;23:780-5.

[2] Singh K, Samartzis D, Vaccaro AR, Nassr A, Andersson GB, Yoon ST, Phillips FM, Goldberg EJ, An HS, Congenital lumbar spinal stenosis: a prospective, control-matched, cohort radiographic analysis. *Spine J* 2005;5(6):615-22

[3] Chen, Y.L. and Lee, Y.H.A non-invasive protocol for the determination of lumbosacral vertebral angle. *Clinical Biomechanics* 1997*; 12:* 185-189.

[4] Saraste, H., Broström, L-A., Aparisi, T. and Axdorph, G. Radiographic measurement of the lumbar spine: A clinical and experimental study in man. *Spine* 1985*; 10(3)*: 236-241.

[5] Tibrewal, S.B. and Pearcy, M.J. Lumbar intervertebral disc heights in normal subjects and patients with disc herniation. *Spine* 1985*; 10(5)*: 452-454.

[6] Brinckmann, F.W., Biggemann, M., Tillotson, M. and Burton, K. Measurement of disc height, vertebral height and sagittal plane displacement from lateral radiographic views of the lumbar spine. *Clinical Biomechanics* 1998*;13(2)*: S1-S63.

[7] Chernukha, K.V., Daffner, R.H. and Reigel, D.H. Lumbar lordosis measurement: A new method versus Cobb Technique. *Spine* 1998*; 23(1)*: 74-79

[8] Nourbakhsh, M.R., Moussavi, S.J. and Salavati, M. Effects of lifestyle and workrelated physical activity on the degree of lumbar lordosis and chronic low back pain in the Middle east population. *Journal of Spinal Disorder* 2001; 14(4): 283-292.

[9] Shao Z RG, Schiltenwolf M. Radiographic changes in the lumbar intervertebral discs and lumbar vertebrae with age. *Spine* 2002;27(3):263-8.

[10] Yochum, T.R. and Rowe, L.J. *Essentials of Skeletal Radiology*. Volume 1. 3rd ed. Williams and Wilkins. Philadelphia, USA.2005

[11] Kim, H-J., Chung, S., Kim, S., Shin, H., Lee, J., Kim, S. and Song, M-Y. Influences of trunk muscles on lumbar lordosis and sacral angle. European Spine Journal 2006; 15(4): 409-414.

[12] Postacchini F, Ripani M, and Carpano S.Morphometry of the lumbar vertebrae: an anatomic study in two caucasoid ethnic groups. Clin Orthop 1983; 172: 296 – 303.

[13] Al-Anazi AR.Radiographic measurements of the transverse diameter of the spinal canal at lumbar vertebrae L3 - L5 and canal/body ratio in normal adult Saudis. Pan Arab Journal of Neurosurgery 2008;12:59-62.

[14] Tanner, J.M., Hiernaux, J. and Jarnan, S,Growth and physique studies, In: Human Biology- A Guide to Field Methods. IBP Hand book no, 9. J.S.Weiner and J.A.Lourie (Eds.). Blackwell Scientific Publication, Oxford; 1969 pp. 315-340.

[15] Stini, W.A. Nutritional stress and growth: Sex difference in adaptive response. Am. J. Phys. Anthropol 1969; 31(3): 417-426

[16] Khongsdier, R. and Mukherjee, N. Growth and nutritional status of Khasi boys in North East India relating to exogamous marriages and socioeconomic classes. Am. J. Phys. Anthropol 2003; 122: 162-170.

[17] Roua, R.J. The impact of the environment on height in Europe: Conceptual and theoretical considerations.Ann. Hum. Biol 2000; 27(2): 111-126.

[18] Silventoinen, K. Determinants of variations in adult body height. J. Biosoc. Sci 2003;35: 263-285

[19] Stini, W.A. Adaptive strategies of Human populations under nutritional stress, In: Physiological and Morphological Adaptation and Evolution. paris: Mouton Publishers1979; pp. 387-403

[20] El-Rakhawy M, Labib I, Abdulaziz E. Lumbar vertebral canal stenosis: concept of morphometric and radiometric study of the human lumbar vertebral canal.Anatomy 2010;4:51-62.

[21] Tarek A and Osama A , Geometrical Dimensions and Morphological Study of the Lumbar Spinal Canal in the Normal Egyptian Population. Orthopedics 2013; 36: 229 -34.

[22] Midia M. and Miabi Z. Quantitative size Assessment of the Lumbar Spinal Canal by Computed Tomography. Acta Medica Iranica 2007;45:5.

[23] Firooznia H. Spinal stenosis. In: *Firooznia H*, *Golimbu C*, Rafii M, *Rauschning W*, *Weinreb JC*, editors(1992). MRI and CT of the Musculoskeletal System. St Louis: Mosby;. p. pp141 – 206.

[24] Varolici T, Cezayirlii E, Erturk M, Kayalioglu G, Hayretdagi C, Comparative Morphometry of the Lower Lumbar Vertebrae: Osteometry in Dry Bones and Computed Tomography Images of Patients With and Without Low Back Pain. The Journal of International Medical Research. 2006;34:316 – 30.