ORIGINAL ARTICLE

Measurement of Lumbosacral Angle in Normal Nepalese Population by Computed Tomography

Umesh Prasad Khanal

Department of Radiology and Imaging, Tribhuvan University Teaching Hospital, Kathmandu, Nepal

ABSTRACT

Objective: The aim of this study was to quantify the lumbosacral angle in Nepalese population who had no history of diseases of the spine. **Materials and Methods:** This prospective study was performed in the Department of Radiology and Imaging of TUTH. Data were collected over a period of 4 months (July–September 2017) with a total of 105 patients who underwent routine computed tomographic scans of the abdomen. The age, sex, weight, and height were noted, and body mass index (BMI) was calculated. The local security authority (LSA) was measured on a dedicated workstation, in the sagittal orientation of thin reformatted images according to Ferguson's method. **Results and Discussion:** In this study, the lumbosacral angle varied from 20° to 49° with a mean value of 33.48 (+6.44°). The obtained values were also classified according to various age groups, gender, and BMI. There was a significant difference in the values between different age groups, gender, and BMI compared to other patients. **Conclusion:** The study concluded that the mean lumbosacral angle in Nepalese population is 33.48° and is affected by age, gender, and BMI of the patient.

Key words: Ferguson's method, lumbar spin, lumbosacr alangle

INTRODUCTION

Commonly called the backbone the human vertebral column consists of a chain of 33 vertebrae with intervertebral discs of fibrocartilage between them. On an average intervertebral discs are 23 in number and account for 1 quarter of the entire length of the vertebral column which varies from person to person. Vertebral column is formed by Seven (7) cervical vertrebrae in the neck, twelve (12) thoracic vertebrae in chest, five (5) lumber vertebraein lower back, sacral vertebrae and four (4) and coccygeal vertebrae make the whole column. There is wide variation in vertebral columns. Lumbarization and sacralization are also frequent. The vertebral column is mainframe of the posterior trunk functionally supporting the head, allows to erect human body against the gravity, allows for movement, protects the spinal cord, and absorbs the stress from walking, running, and lifting. It gives attachments sites for limbs, thoracic cage, and postural muscles. The spinal column is stabilized by anterior and posterior longitudinal ligaments, muscles, subcutaneous tissues, and skin.

Beyond 3 years of age human vertebral column is S-shaped with four bends in cervical, thoracic, lumbar, and pelvic curvatures. The thoracic and pelvic curvatures are considered primary curvatures whereas cervical and lumbar bends are labeled as secondary curvatures, as child acquires these curvatures after crawling and walking.

Abnormal spinal curvature can be due to congenital and acquired disease of vertebrae bone, ligaments, and muscles. Pathologies such as chronic infections, metabolic disease of bone, and trauma are known to alter the curvatures. Lateral curvatures of the spine are known as scoliosis, and anterioposterior bending is known as kyphosis. Many conditions produce the mixed kyphoscoliosis also. Postural habit, muscle spasm leads to temporary scoliosis in many

Address for correspondence:
Dr.Umesh Prasad Khanal, Assistant Professor, Department of Radiology and Imaging, Institute of Medicine, Tribhuvan University Teaching Hospital, Kathmandu, Nepal. E-mail: upkhanal2007@gmail.com/umeshkhanal@iom.edu.np

individuals, in old age due to osteoporosis there may be kyphosis, both kyphosis and scoliosis are seen in the thoracic and lumbar region of the spine in most of the cases.

Lumbosacral angle is the angle between the superior surface of the sacral with the horizontal line forming the long axis of [Figure 3]. This angle is one of the clinically important radiographic angles. There are many methods to measure LSA, plain radiography, goniometry, flexible ruler, software methods, and spinal compass are some of the techniques to quantify it.

The determination of LSA is one parameter that is of importance in evaluating the cause of low back pain syndromes. It is useful in the management of patients with low back pain, disorders such as infections inflammation and degenerative disease of the lumbosacral region.

Fergusson's method is the gold standard to precisely to measure the LSA. Exact measurement of LSA can be done by use of sagittal reformatted images acquired during abdominal computed tomography. Compared to lateral supine radiography the images in this reformatted images have superior spatial resolution in submillimeter like thickness. No previous data are available in Nepalese context about the LSA study till now.[3-6]

A representative vertebra and intervertebral disc are shown in Figure 1. The most obvious feature of a vertebra is the body, or centrum - a mass of spongy bone and red bone marrow covered with a thin layer of compact bone. This is the weight-bearing portion of the vertebra. Its rough superior and inferior surfaces provide a firm attachment to the intervertebral discs. Dorsal to the body of each vertebra is a triangular canal called the vertebral foramen. The vertebral foramina collectively form the vertebral canal, a passage for the spinal cord. The foramen is bordered by a bony vertebral arch composed of two parts on each side: A pillarlike pedicle and platelike lamina. Extending from the apex of the arch, a projection called the spinous process is directed toward the rear and downward. A transverse process extends laterally from the point where the pedicle and lamina meet. The spinous and transverse processes provide points of attachment for the spinal muscles. A pair of superior articular processes project upward from one vertebra and meet a similar pair of inferior articular processes that project downward from the vertebra just above. Each process has a flat articular surface (facet) facing that of the adjacent vertebra. These processes restrict twisting of the vertebral column, which could otherwise severely damage the spinal cord. When two vertebrae are joined, they exhibit an opening between their pedicles called the intervertebral foramen. This allows passage for spinal nerves that connect with the spinal cord at regular intervals. Each foramen is formed by an inferior vertebral notch in the pedicle of the superior vertebra and a superior vertebral notch in the pedicle of the one just below it.

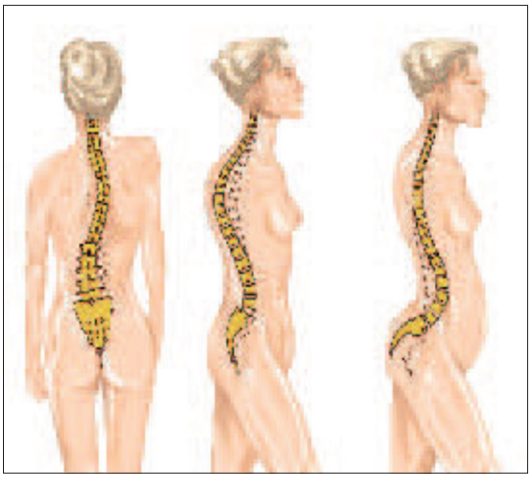


Figure 1: Graphical illustration showing abnormal spinal curvatures

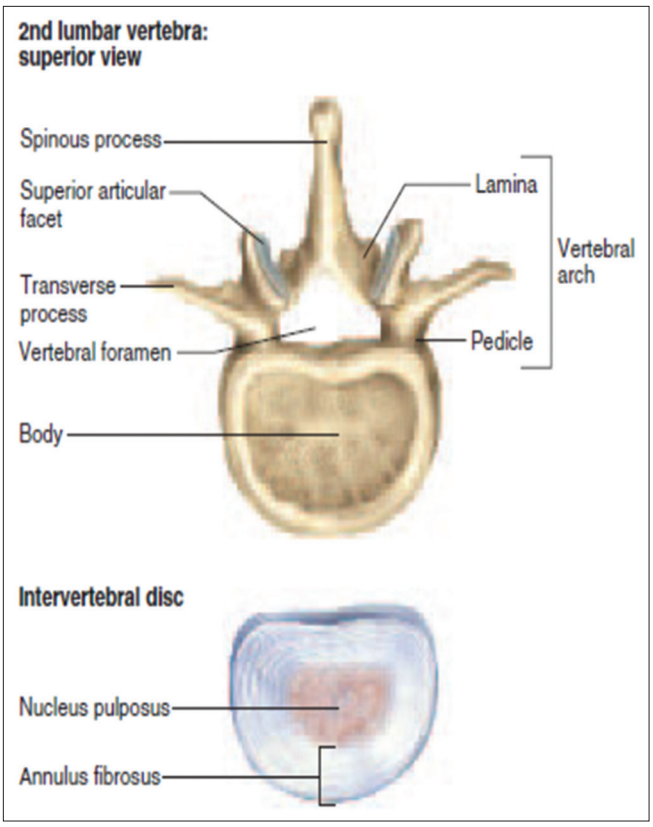


Figure 2: Normal anatomy of a typical lumbar vertebra and Intervertebral disc

An Figure 2 is a pad consisting of an inner gelatinous nucleus pulposus surrounded by a ring of fibrocartilage, the annulus fibrosus. The discs help to bind adjacent vertebrae together, support the weight of the body, and absorb shock. Under stress - for example, when you lift a heavy weight - the discs bulge laterally.

Lumbosacral angle

The angle is defined as the angle formed by horizontal line (drawn through the sacrum) and the top (superior surface) of

the first sacralvertebra. . This angle is used to assess possible musculoskeletal contributions to lower back pain. The other name is called sacral base angle, Ferguson's angle.[7-9]

A wide normal variation in this measurement has been noted. The value will increase from the recumbent to an upright position by 8–12°.

Anterior convexity of the lumbar spine is defined as lumbar lordosis. The development of the lumbar lordosis begins as an infant starts to stand, usually between 12 and 18 months of age, and it continues to develop until the completion of spinal growth, normally between 13 and 18 years. The degree of the curvature of lumbar lordosis is believed to be affected by factors such as position, sex, age, and pathological conditions. However, most authors believe that pathological conditions such as birth defects, trauma, inflammatory, and degenerative disorders may affect it.[1,2]

The lumbosacral angle, variously called the "sacro-horizontal angle," the "sacral angle," the "sacral LSA," the "Ferguson's angle," and the "LSA," is the angle formed between a line across the plane of the superior margin of the Figure 4 and a horizontal line.[6]

METHODOLOGY

This was a quantitative, descriptive, and cross-sectional study performed in the Department of Radiology and Imaging, TUTH. The study population consisted of patients referred to the department for computed tomographic examination of the abdomen (contrast-enhanced computed tomography (CT) abdomen, CT Urogram, CT KUB, etc.), within the 3-month study period. Purposive sampling technique was used in the sampling of the population. The total sample size consisted of all patients referred for CT examination of the abdomen. The total number of 105 patients above 18 years of age was included in the study; however, patients with known lumbar pathologies who had undergone spine surgery were excluded from the study. Technically inappropriate images were also excluded.

The study variable chosen for this study was the lumbosacral angle measured by Ferguson's method.

The radiographic technique remains the gold standard for lumbar lordosis measurement, and measurement can be measured precisely in a supine lateral lumbosacral spine X-ray as compared to other clinical methods such as goniometry, spinal mouse, and inclinometer. However, in this study, we have utilized the computed tomographic scans of the abdomen for the measurement of lumbosacral angle. This method was chosen because the patient should not be over-radiated and precise measurement was possible with the use of submillimeter slice thickness of computed tomographic scans.

Measurement of the lumbosacral angle by Ferguson's method

Tools and technique for data collection

The study was conducted in Siemens Somatom Definition AS+ 128 slice CT scanner. The patients were well explained about the procedure, and informed consent was obtained. The patients' age, height, weight was taken, and body mass index (BMI) were calculated. After the successful completion of the examination, the volumetric images (1 mm × 0.5 mm) were retrospectively reconstructed in the bone window in all three planes, that is, coronal, sagittal, and axial planes which were done by the software inherent in the workstation. The sagittal images were chosen for this study.

For the measurement of lumbosacral angle, Figure 5 was applied according to which two lines were drawn, and the resultant angle was measured. First, a horizontal line was made parallel to the bottom of the image. Second, an oblique line was drawn through and parallel to the sacral base. The posterior angle, thus, formed was measured.

Table 1: Mean and standard deviation of the age, height, weight, BMI, and LSA of the participants

Variables	Mean±SD
Participant's age	38.54±12.732
Participant's height	5.0438±0.53492
Participant's weight	58.1714±10.97327
Participant's BMI	25.0191±5.47240
Lumbosacral angle	33.4857±6.42279

BMI: Body mass index

Table 2: Mean and standard deviation of lumbosacral angle with respect to age group

Age group	Lumbosacral angle
	Mean±SD
0–20	30.8000±7.69415
21–30	31.4687±6.56965
31–40	34.0952±5.54892
41–50	34.8636±5.37450
51–60	35.1818±6.39670
>60	32.6667±13.27906

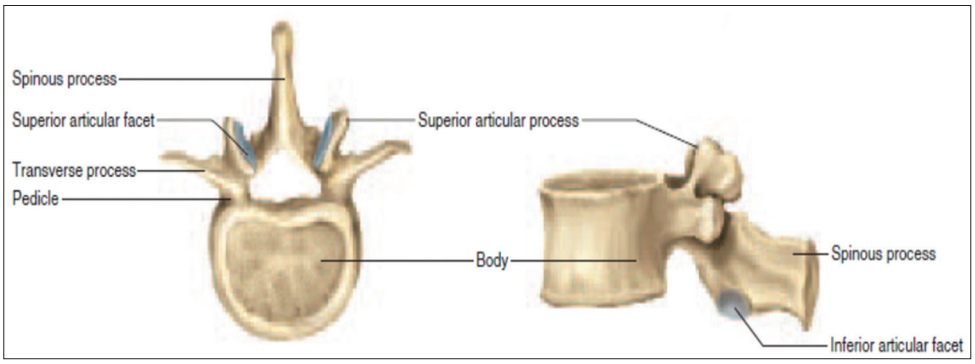
Table 3: Mean and standard deviation of lumbosacral angle with respect to gender

Gender	Lumbosacral angle
	Mean±SD
Male	32.1509±5.99165
Female	34.8462±6.651663

Table 4: Correlation of lumbosacral angle and age group, height group, weight group, and BMI group

Gender	Age group	Height group	Weight group	BMI group
Lumbosacral angle				
Pearson correlation	0.216*	−0.061	0.131	0.226*
P value	0.027	0.534	0.181	0.020

*Correlation is significant at the 0.05 level (*P* value)



Figuer 3: Diagrammatic illustration showing different parts of lumbar vertebra

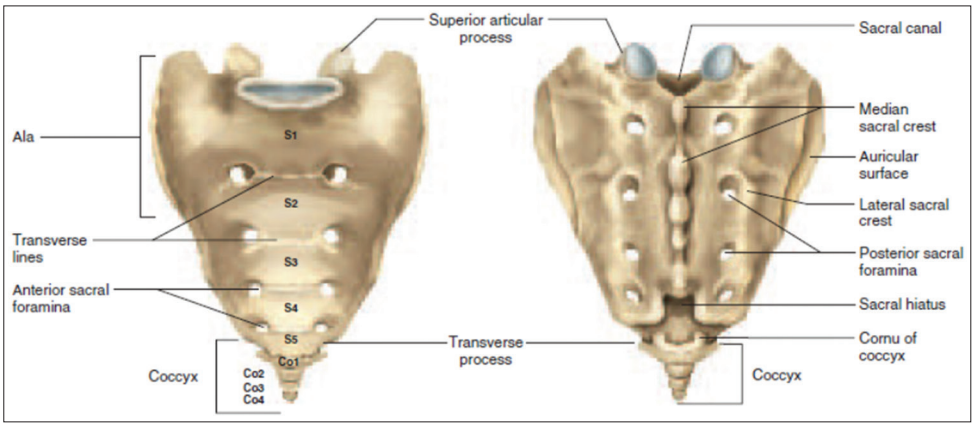


Figure 4: Diagrammatic illustration showing different parts of sacrum

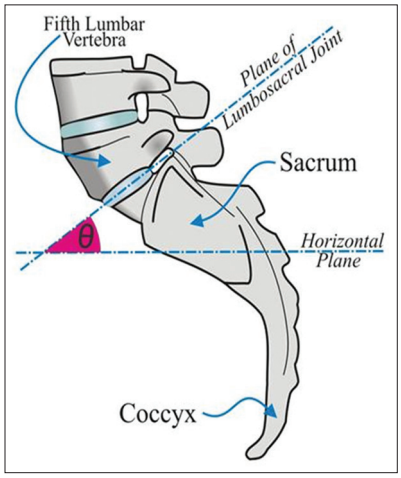


Figure 5: Schematic diagram demonstrating measurement of lumbosacral angle by Ferguson's method

The data were tabulated and analyzed using statistical software (SPSS ver.20).

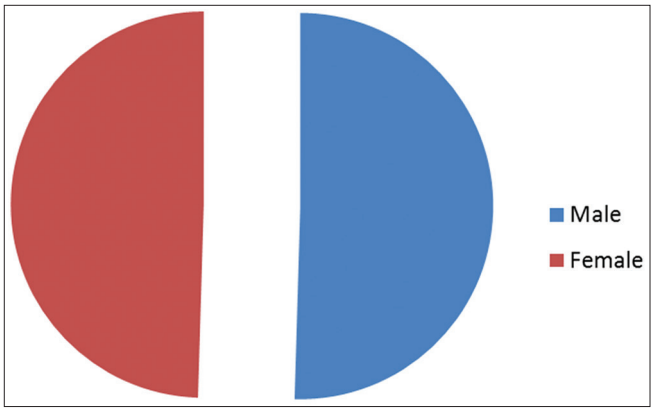
RESULTS

Distribution of population

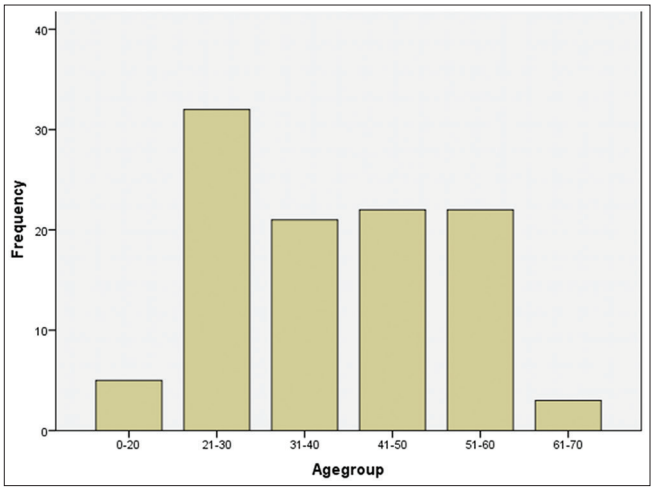
A total of 105 patients were selected for this study. Among them, 53 patients were male and 52 patients were female. The mean age was found to be 38 (±12) years. The mean height and weight were found to be 5.04 (±0.53) ft. and 58.17 (±10.97) kg, respectively [Tables 1-4 and Graphs 1-5].

In a total population, the Figure 6 was found to be minimum 20° and maximum 49° with a mean value of 33.48 (±6.44) degrees. However, the main objective of this study was to correlate the resulting lumbosacral angle with various age groups, according to gender and according to patients' BMI.

Figure 6: Reconstructed sagittal section of Lumbosacral angle area and its measurement method

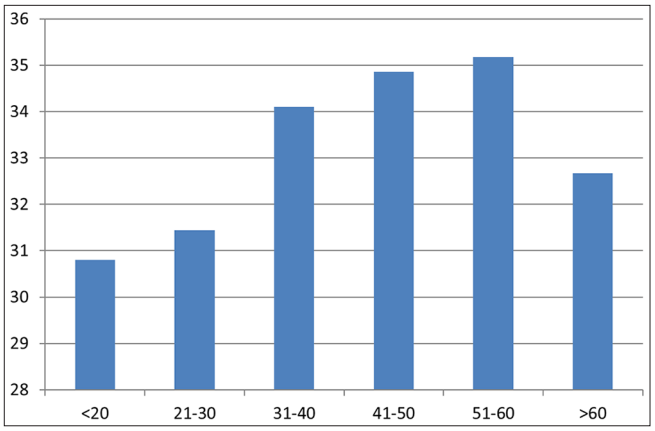


Graph 1: Demonstrating frequency of male and female population

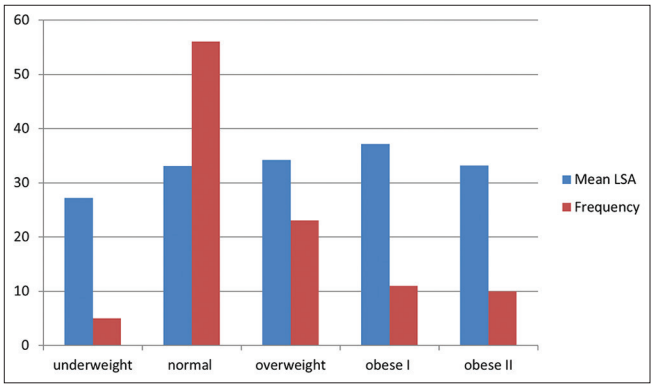


Graph 2: Population distribution with respect to age group

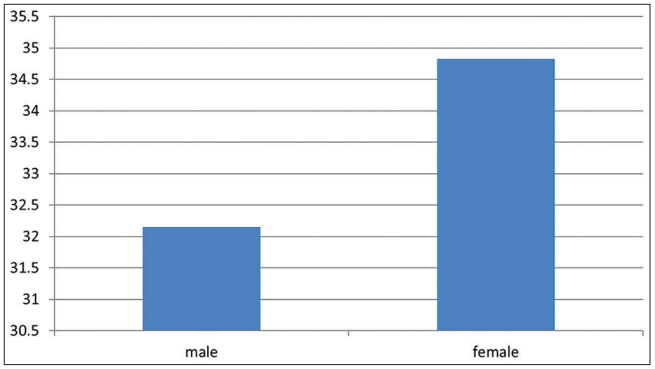
According to age group of patients, the total population was divided into 6 age groups, that is, <20, 21–30, 31–40, 41–50, and 51–60 and more than 61–70 years of the total population belonged to age Group 1, 32 belonged to age Group 2, 21



Graph 3: Demonstrating mean value of lumbosacral angle for various age groups



Graph 4: Mean value of lumbosacral angle for various categories of BMI along with their respective frequencies



Graph 5: Mean value of LSA according to gender

belonged to age Group 3, 22 belonged to age Group 4, 22 belonged to age Group 5, and 3 patients belonged to age Group 6. The frequency can be shown in the Graph 2.

The lumbosacral angle was also calculated according to various age groups which resulted that Group 1 had a mean angle of 30.80 (±7.69°), Group 2 had 31.44 (±6.62°), Group 3 had 34.10 (±5.54°), Group 4 had 34.86 (±5.37°), Group 5 had 35.18 (±6.39)°, and Group 6 had 32.67 (±13.29)° with a total

mean of 33.48 (±6.44)°. Thus, the maximum angle was found in patients of age 51–60 years and the minimum was found in patients under the age of 20. No statistically significant variation was observed in LSA values in different age groups ($P > 0.05$).

For the correlation of mean lumbosacral angle with BMI of the patients, the total population was divided into five different categories, that is, underweight, normal, overweight, and obese I and II. The mean lumbosacral angle observed for different categories was 27.20 for underweight patients, 33.05 for normal patients, 34.22 for overweight patients, 37.18 for obese I patients, and 33.20 for obese II patients. Thus, maximum angle was found in patients with a high BMI and minimum was found in patients with the lowest BMI. No statistically significant variation was observed in LSA values in patients with differing BMIs ($P > 0.05$).

According to gender wise classification, mean angle for male patients was 32.15 (±5.9°) and for female patients was 34.84 (±6.65°). No statistically significant variation was found in LSA values between patients of different genders ($P > 0.05$).

There was a significant correlation of age and BMI of the patient with the value of lumbosacral angle but no correlation of height and weight with the lumbosacral angle.

DISCUSSION

Okapala *et al*.[1] measured the lumbosacral angle retrospectively in normal individuals and reported variation of 18–71 with a mean value of 44.5. The author showed no significant variation between various age and sex groups. This study did not support this result as this study presented that the value of the lumbosacral angle has a significant relation with age and gender of the patient.

Maduforo *et al*.[14] reported a value of 36.0 (±9.4)° in a prospective study of 100 male subjects (aged 0–75 years) of South region of Nigeria. This study concluded that lumbosacral angle does not increase significantly after the age 36–40 years. However, this study presented that the lumbosacral angle increased till 60 years of age, and the lumbosacral angle does not increase significantly after the age of 60 years.

Troyanovich *et al*.[15] in their retrospective study of 50 normal healthy subjects in the erect posture recorded 39°.

In the erect position, Hellems and Keats[2] have shown in a retrospective study of 319 normal males aged 17–58 years, who undertook X-ray as part of the routine pre-employment examination, that the LSA measures 41.1 (±7.7)°. Moreover, this study also resulted the same that there are no significant changes in the lumbosacral angle with the age group, but the value intending to be increased up to the age of 60 and decrease afterward.

Kalichman *et al*.[17] concluded there was no difference in the lumbosacral angle between males and females and this study found that there was a significant variation between them. Hence, this study did not support this study.

With respect to the BMI category, this study concluded that the lumbosacral angle increases with increase in BMI so this study supported the one performed by by Onyemachi *et al*.[16] which stated that there was an increase in lumbosacral angle in individuals with raised BMI.

CONCLUSION

Thus, we can conclude that in normal Nepalese population in supine CT of abdomen and pelvis, the mean lumbosacral angle was found to be 33.48 (±6.44°). The angle did not vary considerably within different height and weight groups; however, there was an increase in lumbosacral angle in individuals with raised BMI, and with increase in age of the individual.

LIMITATION OF THE STUDY

The major limitation in this study was limited number sample size. With the use of computed tomographic scans, we assume that the precise measurement was possible as compared to the previous studies which were done using lateral lumbar spine radiographs. Another limitation was that the scans were taken in the supine position. However, various similar studies have made use of upright position radiographs for the study of lumbosacral angle. Another study utilizing more sample size is recommended.

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How to cite this article: Khanal UP. Measurement of Lumbosacral Angle in Normal Nepalese Population by Computed Tomography. J Clin Res Radiol 2018;1(2):1-7.