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Biophysics of Lower Back Pain

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Abstract

Lower back pain is one of the most predominant problems in the general public. It has been traditionally regarded as a mechanical problem by both orthodox and complementary practitioners. This study was conducted to evaluate the lumbosacral angle which is an inherent cause of lower back pain and also investigate the shearing and compressing forces on the lumbar spine. The study was carried out at in a Hospital within the Metropolis. A total of 210 patients' data consisting of 72 males and 138 females was considered. The lumbosacral angle was measured using Ferguson's method with the MicroDicom software. Patients were grouped into ages; 0 – 20, 21 – 30, 31 – 40, 41 – 50, 51 – 60, 61 – 70, 71 – 80 and 81 – 100. The number of patients in each age group was; 7, 12, 26, 28, 56, 27, 11 and 7 respectively. The average lumbosacral angle evaluated, according to age group was; 36.3°, 39°, 35.81°, 36.23°, 36.55°, 37.5°, 35.89 ° and 34.92°. The overall lumbosacral mean was determined to be 36.50°. The lumbosacral angle evaluated was used to determine the corresponding compressive and shear forces at the lumbar region which are the principal predictors of the lower back pain.

Keyword: Low back pain; Lumbosacral angle.

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1. Introduction

The lumbar spine is convex anteriorly and this curve is known as the 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 the spinal growth normally 13 and 18 years [1]. The lumbar vertebrae being main load-bearing region of the whole vertebrae column is of great clinical importance; and its aberration contributes to the development of a range of pathological symptoms for instance lower back pain [2-5].

Lower back pain is a very common health problem worldwide and a major cause of disability, affecting performance at work and general wellbeing. It affects people of all ages, from children to the elderly and is a very frequent reason for medical consultations. Both orthodox and complementary practitioners have traditionally regarded it as a mechanical problem of the spine. In many cases, lower back pain is associated with spondylosis, a term that refers to the general degeneration of the spine associated with normal wear and tear that occurs in the joints, discs, and bones of the spine as people get older [6-9]. Lumbosacral angle (LSA), sacrovertebral disc angle, lumbar lordosis angle (LLA), Lumbosacral disc angle (LSDA) and sacral inclination angle (SIA), and are geometric angles of the spine that can be evaluated radiologically. Some known factors influencing these angles include age, posture and obesity [10-12]. Younger adults between 30 and 60 years are more likely to experience back pain from the disc space itself or from a back muscle strain or other soft tissue strain. Older adults above 60 years are more likely to suffer from pain related to joint degeneration such as osteoarthritis or spinal stenosis or from a compression fracture [13 and 14]. Normal stress, on the other hand, arises from the force vector component perpendicular to the spine's cross section on which it acts. However the compressive force on the spine goes a long way to be the force that acts downward on the lumbar spine as in squeezing downwards on the lumbosacral region. It arises from the force vector component parallel to the spine's cross section on which it acts. The spine is bound to fracture when heavy compression is made on it.

In order to know the causes and preventive measures to reduce lower back pain, many researchers considered the determination of the lumbosacral angle as a key parameter in evaluating the possible aetiology of lower back pain syndromes. The objective of this study was to measure the lumbosacral angle in our study populace and investigate the shearing and compressing forces on the lumbar spine.

2. Materials and Methods

LSA was measured in a study of lateral erect lumbosacral spine radiographs taken in 210 patients of all genders (72 males and 138 females) across all age groups from 0 – 100 years; mean (standard deviation) was 36.5. The diagnostic radiographic data were acquired from the Saint John of God Hospital in the Brong-Ahafo Region of Ghana. The hospital has an excellent orthopaedic centre. The constraints and limitation of the study are patients who voluntarily reported at the Hospital with lower back pain symptoms. Patients were attending a follow-up appointment to see a Consultant Orthopedist for routine medical management, and had attended the Pain Clinic at least once before. Chronic pain was defined as present if it was linked to a benign condition, was ongoing, and had persisted for more than 3 months despite medical treatment. The other inclusion criteria were (i) no visual and/or auditory problems, (ii) aged over 10 years. Patients were invited to participate in the study by the

Consultant following their medical appointment. The study was approved by the Hospital Ethics Committee and all participants gave written, informed consent.

The LSA (formed between a line across the plane of the superior margin of S₁ and a horizontal line, Figure 1) was measured by the Ferguson’s technique with the MicroDicom software and data analysed. The shear and compressive forces were determined. Patients were convened into eight age groups; 0 – 20, 21 – 30, 31 – 40, 41 – 50, 51 – 60, 61 – 70, 71 – 80 and 81 – 100 years. Each group had 7, 12, 26, 28, 56, 27, 11 and 7 patients respectively

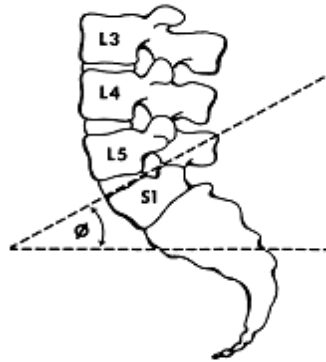


Figure 1: Ferguson’s Method showing the Lumbosacral Angle (LSA)

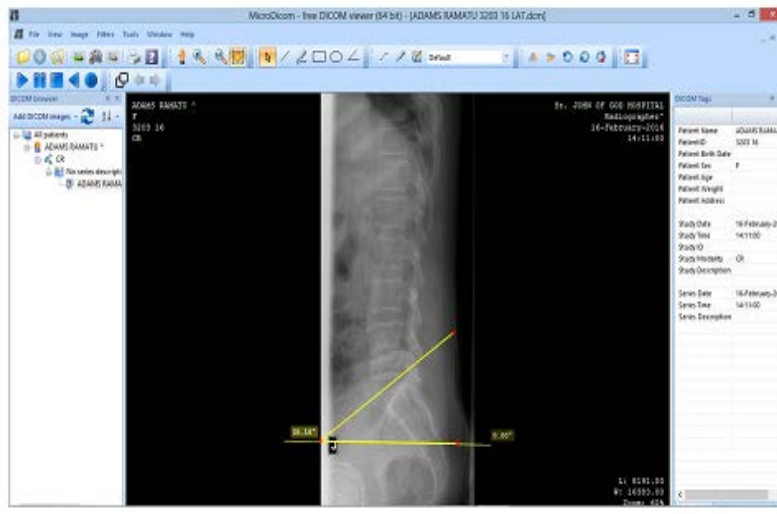


Figure 2: Radiograph of a normal lateral lumbosacral spine with measurement lines for the normal lumbosacral angle.

The shear force is mathematically expressed as;

$$F_S = W \cos \theta \quad (1)$$

Where;

F_S = Shearing force.

W =Weight that rests on the lumbosacral region.

θ = the lumbosacral angle using the Ferguson’s method.

And the compressive force as;

$$F_S = W \sin \theta \quad (2)$$

Where;

F_S = Compressive force.

W =Weight that rests on the lumbosacral region.

θ = the lumbosacral angle using the Ferguson’s method.

3. Results

A total of 210 normal lateral radiographs were assessed. The mean age (SD) of patients was 21.8 (15.4) years, shown in Figure 3 is the age distribution. 72 (34.3%) males and 138 (65.7%) females were involved in this study.

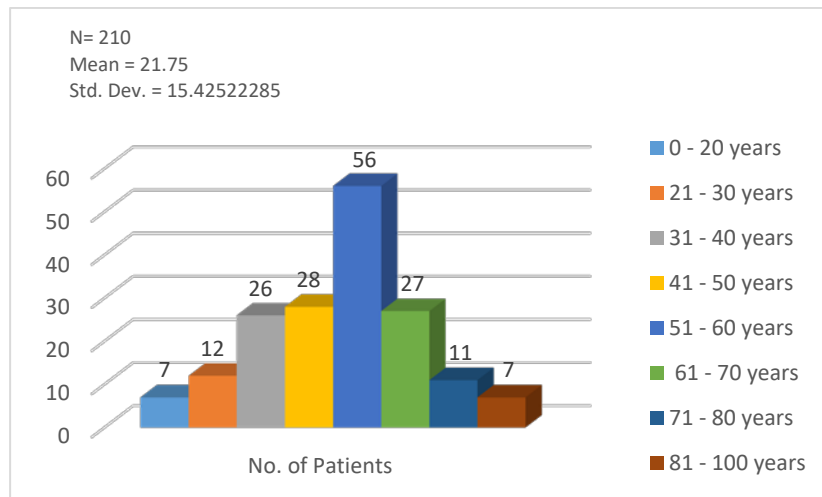


Figure 3: Age Distribution.

The overall lumbosacral angle mean was determined to be 36.5° (range 34-38°). The study shows an increase in the lumbosacral angle with age up to 31-40 year group. Then a fairly constant angle from 40 years. The average lumbosacral angle is shown in Figure 4; age range 21-30 recorded the highest average LSA.

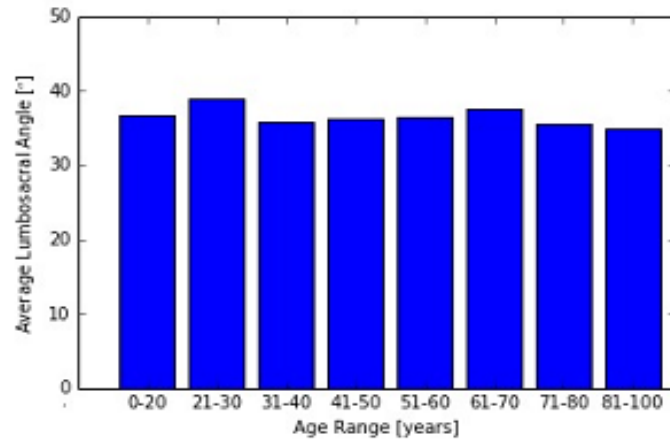


Figure 4: Derived Average Lumbosacral Angle of Age Group

Figure 5 shows the calculated average shear and compressive forces. The age group 0-20 and 21-30 recorded the lowest shear force. The shear forces then increase from age 31-40 as a result of more stresses on the lumbar spine. On the other hand, age group 0-20 recorded the lowest compressive force. The compressive force tend to increase significantly at age 21-30. The compressive force then tend to decrease slightly and increase again. This is as a result of the body aging hence the work rate of the spine tend to decrease. That is the spine is not able to fully support or carry the weight exerting on it thereby increasing the compression in the lumbar region.

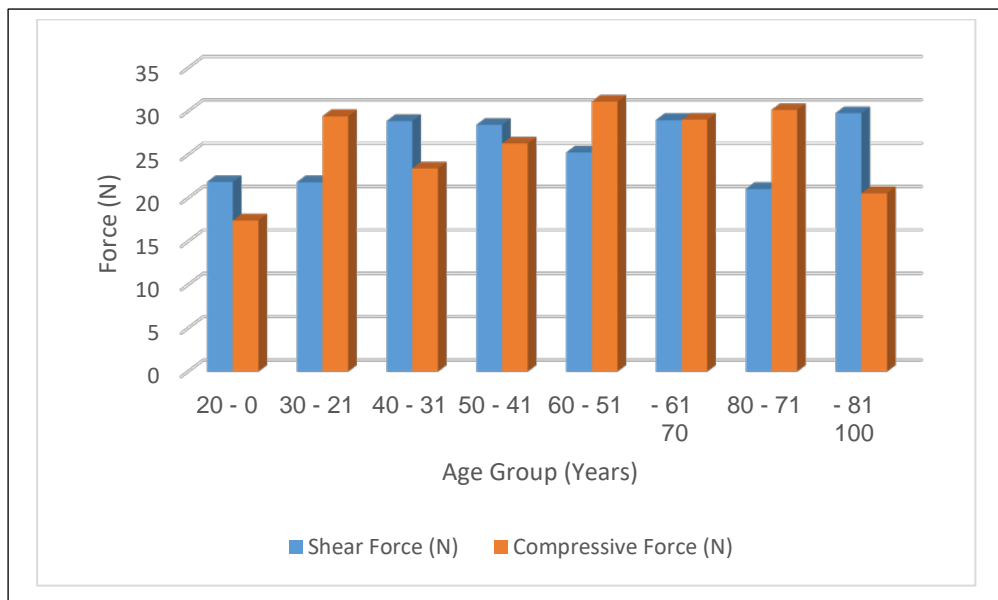


Figure 5: Chart of average shear and compressive forces according to age groups.

4. Discussion

The mean lumbosacral angle of 36.5 was higher than that of the Caucasian population which were found to be between 34° to 44°. The mean angle value of the Nigerians by N. Onyemaechi and F. O. Okpala [5, 8] were also

higher than the Caucasians. Other studies have it that the LSA has a racial variation being lower in Asians and higher in Caucasians which may be attributed to the difference in stature of the different races as well as the predominant occupation.

The highest average LSA was recorded within the 21-30 years range. This is accounted for in people especially women who slouch when walking. A study [1] of paediatric radiographs of age below 14 years observed an average LSA of 35.8 (10.3), lower than that of our paediatric age range. Since most data are on the adult population and there is very little data available on paediatric LSA hence the mean value obtained could not be compared with literature values.

Movements in the spine results in various forces acting on the lumbar spine and sacrum. The forces are torsion, tensile, bending moment, compressive and shear forces. This study consider the compression and shear forces, being the components acting perpendicular to the mid plane and parallel to the disc respectively.

The age group 0-20 and 21-30 recorded the lowest shear force. This is because in this age group there is less stress on the spine. Younger spines (less than 30years) may be more susceptible to shear forces due to more elastic disc and incomplete ossification of the neural arc. The shear forces then increase from age 31-40 as a result of more stresses on the lumbar spine. These were age ranges which consist of mostly farmers which could be attributed to the bending processes in their occupation and religious practices, and reported at the hospital with low back pain. The lumbar spine do experience significant shear force during performance of certain lifting, pulling and pushing activities. Reports by M. S. Azar and his colleagues [2] indicates no association of LSA with the incidence of low back pain. However S. Sarikaya and his colleagues [3] results showed that the nature of the occupation may have influenced the LSA of miners but not a determinant for low back pain. D. Evcik and his colleagues [4] evaluated the Lumbar Lordosis in acute and chronic low back pain patients and observed that changes in lumbar lordosis angles may affect the diagnosis and treatment in LBP patients. The proper lifting technique allows for a neutral, lordotic spine posture which lessens the shear force on the spine.

On the other hand, age group 0-20 recorded the lowest compressive force. The compressive force tend to increase significantly at age 21-30. The compressive force then tend to decrease slightly and increase again. This is as a result of the body aging hence the work rate of the spine tend to decrease. At that critical age, the spine is not able to fully support or carry the weight exerted on it thereby increasing the compression in the lumbar region. Though the larger cross-sectional area of the lumbar vertebrae supports more body weight and accommodate greater compressive force, the incidence of low back pain is higher when an individual is subjected to greater compressive forces during the workday.

5. Conclusion

This study has established the average mean lumbosacral angle. This indicates that the patients analysed were victims suffering from lower back pain since their mean average lumbosacral angle is out of the normal range which is 20° - 30° as reported by Tubbs and his colleagues (2007). The compressive force which acts downwards on the spine is largely responsible for disc herniation and is a good predictor of lower back pain.

The shear force creates the internal deformation of the spine. In a greater percentage of individuals, both the compressive and shear force on the lumbar spine is either increasing or decreasing with respect to the ages of the individual. The lumbosacral angle has been an inherent cause of lower back pain. An increase in the lumbosacral angle causes an increase in lumbar lordosis, hence increasing the shearing force at the lumbar region.

6. Recommendation

A baseline study of lumbosacral angle in the general populace of those without lower back pain is recommended. It should include study of normal physiologic aging of the spine and its related soft tissues, and how this may relate to the pathophysiology of low back pain. Moreover, study of the role of occupational factors in the development, prognosis, and recovery from low back pain should be considered.

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Conflicts of interest

There are no conflicts of interest.

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