ANALYSIS OF LUMBOSACRAL ANGLE, BIO-DATA AND THEIR RELATIONSHIP WITH LOW BACK PAIN

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DECLARATION

I hereby declare that this thesis '**ANALYSIS OF LUMBOSACRAL ANGLE, BIO-DATA AND THEIR RELATIONSHIP WITH LOW BACK PAIN**' is my own work towards the award of Master of Philosophy Degree in Computer Engineering and that to the best of knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

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DEDICATION

This project is dedicated to the Almighty God, my lovely mother Mrs. Pauline Abrafi Oppong, my good father Mr. David Opoku, my helpful twin sister Mrs. Edna Akwaboah, my strong father figure Mr. Tahiru Kwame Camara, my prayerful grandmother Madam Matilda Obeng – Apau, my resourceful uncles; Mr. Frank Amakye and Dr. Eric Kwakye Acheampong and to all those who helped to make this project a success.

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The Almighty God bless you all! Amen.

ABSTRACT

Many researchers believe that lumbosacral angle is one parameter that is of importance in evaluating the possible etiology of lower or low back pain syndrome. There is paucity of data on the lumbosacral angle of the lumbosacral spine in Ghana and other African countries. Most of the data in use in research and medical practice are based on other races but there are anthropometric differences in races. Therefore, the study sought to bring out an empirical data on the pattern of low back pain (LBP) in relation to Lumbosacral Angle (LSA) in our study population and also investigate the association between LBP, LSA, age, gender and weight. Lateral views of the lumbosacral spine radiographs of 177 Ghanaian subjects from the St. John of God Hospital at Duayaw-Nkwanta were studied. The demographics and anthropometric measurements of the subjects such as age, gender and weight were recorded. The LSA was measured using the Ferguson's orthogonal method with the Micro Dicom Viewer software. The researcher employed the descriptive as well as the regressional survey. The findings from the study indicated that the population were dominated by females who constituted 70.1% of the study population as against males who also constituted 29.9%. In terms of age, majority of the participants were between the ages of 40 to 59 years as against the least that were between the ages of 0 to 19 years. The results showed that 41.8% of the sample did not have low back pain as against 58.2% who had low back pain. The mean LSA value for the normal controls was 14.5º with SD ± 1.32º. This can value can be recognised as the normal LSA for our population in from the study. A positive significant relationship was established between LSA and Low Back Pain. This simply means that an increase in LSA leads to 2.5 % increase in probability or risk of low back pain. Findings from the study showed that an increase in age leads to 41.8 % increase in the probability of having low back pain. Weight was found to positively correlate to low back pain. An increase in weight leads to 1.6% increase in the probable result of low back pain. This relationship was predicted to be significant. The study showed that there is a positive and significant relationship between LSA, age, weight and low back pain. The probability of pain of the lower back among males was also found to be 33.1% less than the probability that will be incurred by females and it is also not a significant relationship. In conclusion the mean angle values and variables may form the reference values for the Ghanaian population.

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LIST OF ABBREVIATIONS

KNUST	-	Kwame Nkrumah University of Science and Technology
LBP	-	Low Back Pain
SPSS	-	Statistical Package for Social Sciences
YLD	-	Years of Life Disabled
DALY	-	Disability Adjusted Life Year
WHO	-	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of study

An important health issue of great interest is low back pain. This is due to the cost associated with its diagnosis and treatment and also the loss of the active workforce (Caglayan *et al*., 2014). It is a very common problem and causes much morbidity and socioeconomic loss in the society. Low back pain (LBP) is one of the commonest problem most individuals are faced with at some stage in their lives and studies have shown that an overwhelming number of individuals have an experience of such pain at least once in their lifetime and seek care for it. Statistically about 80% of adults have suffered LBP at particular points in their lifetime (Kelsey, 1980, Nachemson, 1976). This means that majority of the workforce of any country is affected. A Global Burden of Disease study ranked LBP as highest in terms of disability (YLDs), and sixth in terms of overall burden of disability adjusted life years (DALYs) (Hoy *et al.*, 2014).

A study on the prevalence of low back pain on patients radiological reports in Ghana showed that LBP is more prevalent in females than in males and it is increases with age peaking at the age range of 51-60 years. Non Specific Cause recorded much prevalence among the causes of LBP, followed by Nerve Root Affections and then the Red Flags (Kyei *et al.*, 2015).

Low back pain cannot be placed as a disease or any sort of diagnostic entity (Ehrlich, 2003). It is rather a symptom that may occur from a variety of different processes and therefore has many underlying reasons. The pain experienced has many common causes including diseases or injuries to the bones, muscles, and or nerves of the spine. Abnormalities affecting organs within the abdominal, pelvic or chest regions can also give rise to pain that may be felt in the back.

The human spine is of great interest to clinicians and researchers due to its vital role in housing and protecting the spinal cord as well as providing a framework for supporting the trunk. It comprises the cervical, thoracic, lumbar, sacral and coccygeal regions. Pain can begin suddenly due to an accident or can develop with time mainly as a result of aging or age-related changes of the vertebral column. The regions of the vertebral column where the greatest degree of permissible movements occur are cervical and lumbar regions and they are found to be the most frequent sites of pains that are disabling in nature.

The lumbar segment of the vertebral column is of primary interest because it is the most weight-bearing part of the human spine and a considerable amount of movement also occurs in this region (Standring, 2014). Owing to its weight-bearing function, it is a common site for degenerative diseases. The anterior convexity of the lumbar spine in the midsagittal plane is the lumbar lordotic curve. Of all the methods in use to quantify the lordotic curves, radiography still remains the gold standard and measurements can accurately be done in a supine lateral lumbosacral spine radiograph (Okpala, 2014).

One clinically important radiographic angle related to the lordotic curves is the lumbosacral angle (LSA) which is of importance in the management of patients with disorders of the lower back which may be affected with conditions such as inflammation, degeneration and others (Okpala, 2018).

1.2 Problem Statement

The lumbosacral angle is the angle formed between the long axis of the lumbar vertebrae and the sacrum. The weight borne by the cervical and thoracic vertebrae is transmitted to the lumbosacral spine. The lumbosacral joint also permits flexion, extension and rotation movements. It is thus subject to subluxation and frequent injuries and therefore important in assessment of back pain and in traumatic medicine. Many researchers believe that the determination of the lumbosacral angle is one parameter that is of importance in evaluating the possible etiology of low back pain syndrome. It is therefore hypothesized that the degeneration of the lumbosacral disc may be related to its angle of inclination in the human subject.

Considering the variation in socio-economic conditions, cultural practices and anthropometric data among the Ghanaian populations and Western populations, it is possible that the lumbosacral angles Ghanaians will differ from their western counterparts.

For example Ghanaians travel long journeys on poor roads with multiple deep potholes using vehicles that have poor suspension systems and hard seats that lack ergonomic designs. These conditions are expected to increase pressure on the lumbar vertebrae and exacerbate normal age-related degenerative changes. It is also notable that several Ghanaian cultural and socio cultural practices involve activities that require individuals to bend over. For example, the use of short hoes and cutlasses is still the predominant method among rural farmers and city labourers engaged in menial jobs.

Most Ghanaians especially in their childhood years have been exposed to sweeping with short brooms either in school or as part of house chores. Ghanaian mothers are also fond of carrying babies on their backs which increases the load imposed on their spine. Other chores that may subject the spine to stress and increased loading include, carrying load on the head, bending over to fetch water from wells and reservoirs as well as carrying bucket of water on the head. All these activities are expected to increase pressure on the lumbar vertebrae and aggravate normal age-related degenerative changes, leading to lower back pain as shown in Figure 1.1.

Figure 1.1: Pain in the lower back region of the spine (Stevenson, 2017)

Various studies (Nachemson, 1975, Adams, 2004, Wong and Lee, 2004) have examined the relationship between biomechanical changes in the lumbar spine and back pain. However to the best of the researcher's knowledge, there has been no study undertaken to investigate the pattern and causes of lower back pain in relation to the lumbosacral angle among Ghanaians. 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 study therefore seeks to bring out an empirical data of the pattern and causes of lower back pain in relation to the lumbosacral angle.

1.3 Research Questions

1. What is the normal LSA for the Ghanaian populace?
2. What is the state of individual's radiographs with and without low back pain?
3. What is the relationship between Lumbosacral Angle (LSA) and low back pain (LBP) taking into consideration the influence of age and weight?

1.4 Statement of Objectives

This section presents the general as well as the specific objectives of the study.

1.4.1 General Objectives

The principal objective of the research is to investigate the relationship between Lumbosacral Angle (LSA) and low back pain (LBP) using archived radiologic data from the St. John of God Hospital in Duayaw-Nkwanta, in the Ahafo region of Ghana.

1.4.2 Specific Objectives

To achieve the general objective, the following objectives were set:

1. To determine the LSA for each radiograph.
2. To sort the data of radiographs from individuals with and without low back pain.
3. To analyze the relationship between Lumbosacral Angle (LSA) and low back pain (LBP) taking into consideration the influence of age and weight.

1.5 Justification of research

Knowledge on and understanding of the biomechanics of the lumbar spine and various pain causing mechanisms has continually advanced in the past few decades. However, definite answers to some of the basic questions are still elusive. Therefore adequate morphometric knowledge of the lumbar vertebra and discs is relevant for clinical and research purposes. Inadequate baseline information on lumbar sacral angles among Ghanaians as well as the need to understand the pattern of disc degeneration among Ghanaians has necessitated the need for this study. The LSA in the Ghanaian context is still unknown and its relationship with low back pain are the questions the present study sought to address. Understanding the cause of an individual's back pain is the key to proper treatment and hence assist in recovery. Data generated from the proposed study will provide basic information upon which other studies may be conducted to explore aetiology of lumbar vertebral dysfunction among Ghanaians.

1.6 Scope of the Study

The research investigates the relationship between lumbosacral angle and low back pain. The lumbosacral angle was taken as an indicator because it has been utilized as an indicative parameter for assessing low back pain. The study is designed to cover relevant data collected on the lumbosacral angle and low back pain, together with other specifically related data. The study does not however cover all the variables likely to influence low back pain among the people and hence limited to lumbosacral angle as it is the main concern of the study.

1.7 Organization of the Study

Organization of this research work was sectioned into five chapters including chapter one which comprises of the introduction. Thus chapter one is made up of the background of the study, problem statement, objectives of research, research hypothesis, the scope of the study, and the organization of the study. The review of related literature is captured in chapter two whiles the chapter three looks at the methodology of how the research was structured and the collection of the relevant data. Chapter four presents the data analysis, presentation and discussion. The terminal chapter consist of summary, conclusion and recommendations of the work.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Several factors can cause pains of the lower back and this is partly caused by intensifying sedentary or inactive lifestyle. Another underlying factor to this pain is the unavoidable injury induced by accident or trauma.to the back (CoachR, 2017). The wear and tear of the structures of the spine as a result of any or all of these factors contribute to lower back pains and the associated injuries. Therefore, low back pain presents itself as a complex and multi-faceted problem. Also the anatomy of the human spine will be reviewed in order to fully grasp the concept of pains concerned with the lower back and the relationship between them.

2.2 The Human Spine

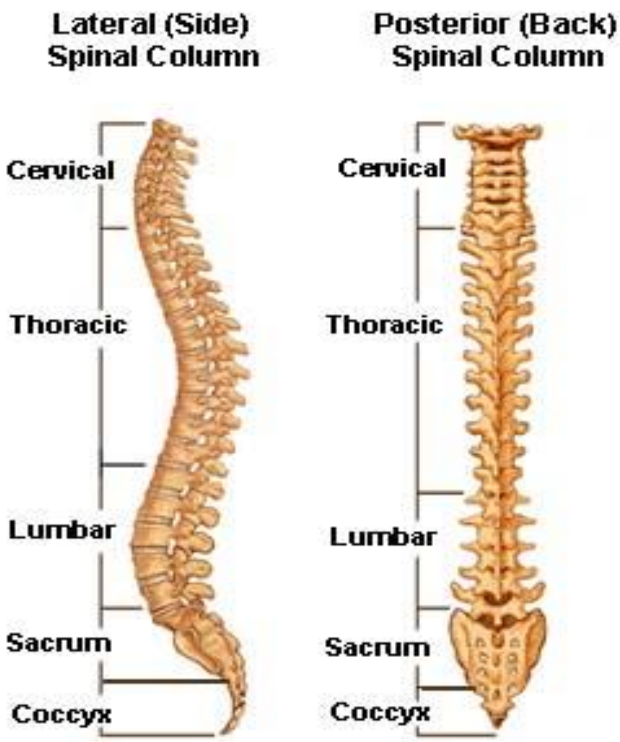
The spine is the central skeletal pillar of the human body, located in the dorsal region of the body. The vertebral column of an adult human is made up of thirty-three (33) vertebrae of which there are seven (7), twelve (12) and five (5) vertebrae matched with the cervical, thoracic and lumbar regions of the spine respectively. The remaining five (5) sacral vertebrae are fused together to form the sacrum, and four (4) Coccygeal vertebrae with the lower three (3) commonly fused forms the coccyx (Snell, 2008). The vertebrae from the cervical region to the lumbar region are articulating and the nine in the sacrum and coccyx are fused and therefore non- articulating. Therefore, there are five major regions of the spine as illustrated in Figure 2.1(a). The total number of vertebrae is subjected to frequent variations and numbers being reported between 32 and 35 bones (Standring, 2015).

The morphology of the vertebral column is influenced by mechanical and environmental factors externally and internally by factors which are metabolic, genetic and hormonal. All these affect the ability of the spine to react to the dynamic forces such as compression, traction and shear expressed in daily living. These dynamic forces can differ in magnitude and are greatly influenced by locomotion, occupation and posture (Standring, 2015).

The adult in a standing position has the following lateral view of the vertebral column with the regional curves: the cervical region is posteriorly concave, the thoracic region is posteriorly convex, and the lumbar region is posteriorly concave and the sacral region posteriorly convex. These four curvatures are illustrated in Figure 2.1(b). However in the foetus, the spine has one continuous anterior concavity (Snell, 2008).

The full length of the vertebral column in the average adult male and female measures approximately 70 cm and 60 cm respectively. Along the vertebral column, the vertebrae become progressively larger from the cervical to the lumbar region, as they must support increasingly greater weight (Marieb and Hoehn, 2010). The cervical vertebrae constitute about 8% of the overall body length, with 20%,12%, 12% with the thoracic, lumbar and sacrococcygeal regions having these values respectively (Standring, 2015). In the nonaligned upright posture, the entire spine is approximately one-third of the body height (Keller *et al*., 2005).

The size of the vertebrae that is in the vertebral column increases progressively from the cervical to the sacral level and then becomes increasingly smaller toward the head of the coccyx. As the column descends, successive vertebrae bear an increasing amount of the weight of the body. This accounts for the changes in size of vertebrae in the vertebral column.



(a) **(b**

Figure 2.1: The vertebral column showing the lateral and posterior views (Snell, 2008)

According to Keller *et al.* (2005), compressive load on the intervertebral disc increases progressively from the cervical spine to the lumbar spine. Their study reported a compression load of 15.2%, 61.9% and 65.1% of body weight for the thoracic, cervical, and lumbar segments of the vertebral spine respectively. The body weight is further transmitted inferiorly to the sacrum and moves to the Sacroiliac joints through to the pelvic girdles and then from there to the lower limbs (Snell, 2008, Moore *et al.,* 2013)

The individual vertebrae that make up the vertebral column are separated by resilient fibro-cartilaginous intervertebral discs which make the column flexible(Snell, 2008, Standring, 2015, Moore *et al.,* 2013). The intervertebral disc contributes to about a quarter of the length of the vertebral column in young adults. Very little movement occurs between two adjacent vertebrae. However, a combination of the individual movements between adjacent vertebrae and intervertebral discs provide appreciable movement in the spine (Moore *et al.,* 2013).

Flexibility of the vertebral column is facilitated and controlled by the articulation of the thoracic, cervical, lumbar and first sacral vertebrae (1st 25 vertebrae) at the zygapophysial joint. The joint is the synovial joint sandwiching the superior and inferior articular processes (Moore *et al.,* 2013).

The functions of the vertebral column are to provide attachment for muscles, protect the spinal cord, nerves and the covering meninges (Snell, 2008). It also provides support to the trunk as well as serves as a site for haematopoiesis (Standring, 2015). Furthermore, it bears the body's weight and transmits it to the lower limbs (Snell, 2008).

2.3 The Vertebrae

The vertebrae basically serve as the support column for be sustaining the weight carried by the head, neck and trunk and eventually transfer this weight to the appendicular skeleton of the body's lower limb. Protection of the spinal cord, aid in maintenance of an erect body position as and when standing or sitting are also the functionalities performed by the vertebrae. The vertebra is made up of the body, arch and articular process. Vertebrae show regional variations in size and other characteristics, that notwithstanding, their basic structure remains the same. Figure 2.2, shows that a typical vertebra has two fundamental parts: an anterior rounded body and a posterior vertebral arch (Moore *et al.,* 2013). Enclosed by the vertebral arch and body, is a cavity called the vertebral foramen (Figure 2.2). The spinal cord and the roots of the spinal nerves and the covering meninges all lie within the foramen of the vertebra. The formation of the vertebral arch is by two pairs of pedicles and laminae. It also supports seven processes; four articular, two transverse and one spinous. The single spinous process is also called the neural spine.

Articulation of the vertebral bodies together forms a strong pillar which acts as support for our heads and trunks. The vertebral foramina consequently create a carnal for protecting the spinal cord. Every vertebrae pair has two openings or apertures on either side called intervertebral foramina for carrying the spinal nerves and vessels.

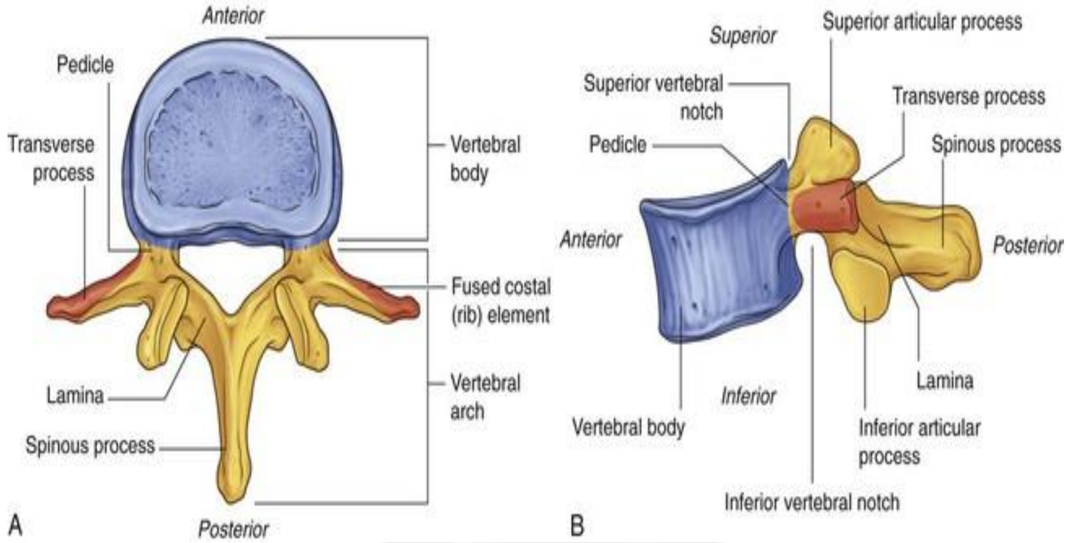


Figure 2.2: Structure of a Typical Vertebra (MedicineHack, 2011)

Located posteriorly to the body are a pair of transverse processes on the left and the right and a spinous process which protrudes from the back. The spinous processes of the cervical and lumbar regions are mostly felt through the skin.

Acting up as restrictions on the range of possible movements are the superior and inferior articular facets found in each vertebra. Pars interarticularis, a thin segment of the neural arch joins these facets.

2.3.1 Lumbar Vertebrae

The largest vertebrae are the five lumbar vertebrae found between the thoracic and the sacral regions of the vertebral column. There are five lumbar vertebrae usually designated as L1, L2, L3, L4 and L5 in descending order along the vertebral column with an articulating disc between adjacent vertebrae. They present neither foramina transversaria nor costal facets. They support the weight of the upper body which increases inferiorly within the vertebral column. The lumbar vertebrae have large bodies (Figure 2.3) which bears the increasing weight imposed on them by the upper part of the body.

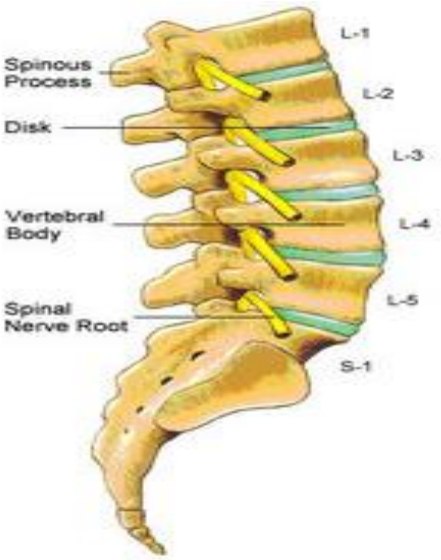


Figure 2.3: The lumbar spine (Corewalking, 2016)

The bodies of a typical lumbar and thoracic vertebrae differ in thickness with the lumbar part being thicker than that of the thoracic vertebra. The surfaces, both superior and inferior, appear oval in shape instead of heart shaped. The lumbar vertebrae body is kidney shaped (Figure 2.4), and the pedicles and laminae are short and thick. These vertebrae bear the most weight. Their spinous processes are massive providing a surface area for lower back muscular attachment. This strengthens or changes the curve of the lumbar spine. Pars interarticulus is the name given to the part of the lamina between the superior and inferior articular processes and is likely to cause injury in some people, leading to spondylolisthesis. A mammary process projects posterior ward from the superior articular process. The long and thin transverse process corresponds to a rib and an additional process may project inferior ward from its root. The quadrilateral spinous processes project backwards horizontally. The fifth lumbar vertebra, presents itself as usually the largest and mainly has the responsibility for the formation of the lumbosacral angle between the lumbar part of the column and the sacrum.

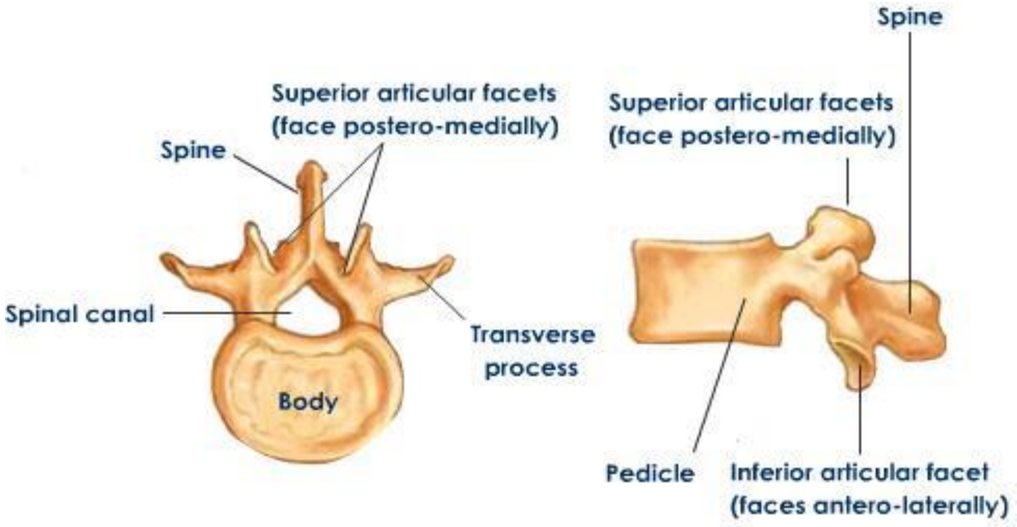


Figure 2.4: Structure of a lumbar vertebra (Tutorvista, 2016)

2.3.2 Sacral Vertebrae

The Sacrum is a large, bony triangular shaped structure found between the lumbar and coccygeal parts of the caudal spinal axis (Figure 2.5). It bears resemblance to an inverted triangle. However, it has a concave inner and a convex outer surface. The Sacrum revolve and rotates superiorly (above) with the fifth lumbar vertebra (L5). It is positioned inferiorly (below) with the coccyx and the bilateral iliac bones at the sacroiliac joints. When the spine is examined from a lateral position notice is made of the sacrum projecting posteriorly leading to the formation of the lumbosacral angle which subjects its articulation to shearing forces.

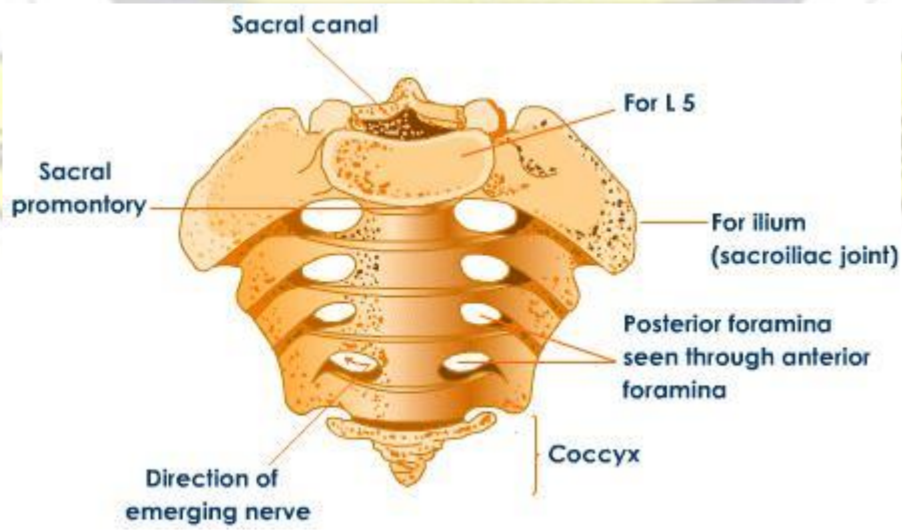


Figure 2.5: The Sacrum bone (Tutorvista, 2016)

Five vertebrae form the sacrum, joined together at the anterior and posterior ends. Its spinous processes are fused together to form the median Sacral crest projecting caudally towards the sacral hiatus (Figure 2.6). The S5 level of the sacrum has a defect in its posterior wall called the sacral hiatus. The vertebral body of S1 has a wide structural body that contains the greatest density of trabeculae with a cruciate pattern of arrangement making it the largest. The design of S1 comes with a protruding anterosuperior lip of bony structure known as the sacra promontory. This aids in support during axial loading.

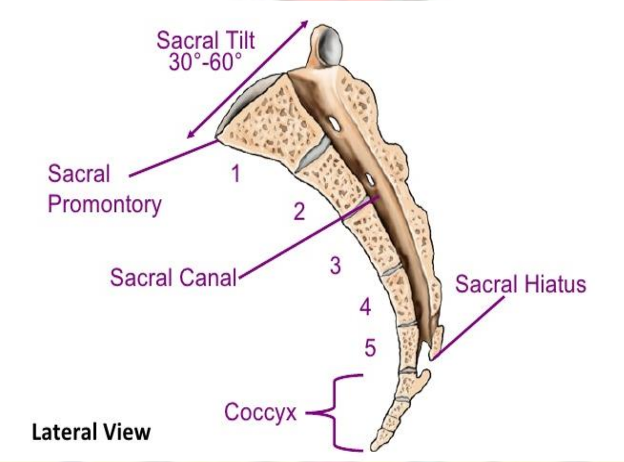


Figure 2.6: Lateral view of the Sacrum (Surange, 2010)

The caudal continuation of the spinal canal of the lumbar is the sacral canal. It is made up of the meninges, the lower portion of the cauda equine, filum terminale, fibrous and fatty tissue. The end of the sacral hiatus is called the epidural space. Transmission of the ventral and dorsal rami of the sacral nerve roots (S1-S4) is carried out by the four pairs of foramina with openings on the anterior and posterior surfaces of the sacrum respectively.

The paired blocks of the bone are the lateral masses located lateral to the sacral foramina. Laterally located also to the vertebral body of S1 is the winged-shaped bone; the sacral ala. The sacral alae display less or small trabecular density according to histological study of it.

2.3.3 Coccyx

The vertebrae, usually four, located below the sacrum are unevenly fused by joints and or disc ligaments in the adult to form the bony structure known as coccyx (Figure 2.7). It is similar in shape to a miniature sacrum. Formed as a triangular arrangement of bones, it is found at the bottom portion of the vertebral column below the sacrum. The common term given to it is tailbone because it represents a vestigial tail. Novel findings coming out now have it that the coccyx is not one solid bone, but there is some articulation between the vertebrae made possible by fibrous joints and ligaments. The connection of the coccyx with the sacrum is through the sacrococcygeal joint. In the motion of the pelvis, hips and the legs, the coccyx usually moves a little forward or backwards. The coccyx also supports and balance the body better in the sitting and standing stance of a person by rotating the pelvic bones including the coccyx slightly outward and inward. There is distribution of weight between the bottom portions of the two ischiums and the tailbone, providing balance and stability when a person is seated. The coccyx functions as a connecting point for many of the pelvic floor muscles. These muscles are important for anal support and assist in defecation, support the vagina in females for sexual function and help in movements such as walking, running and motion of the legs.

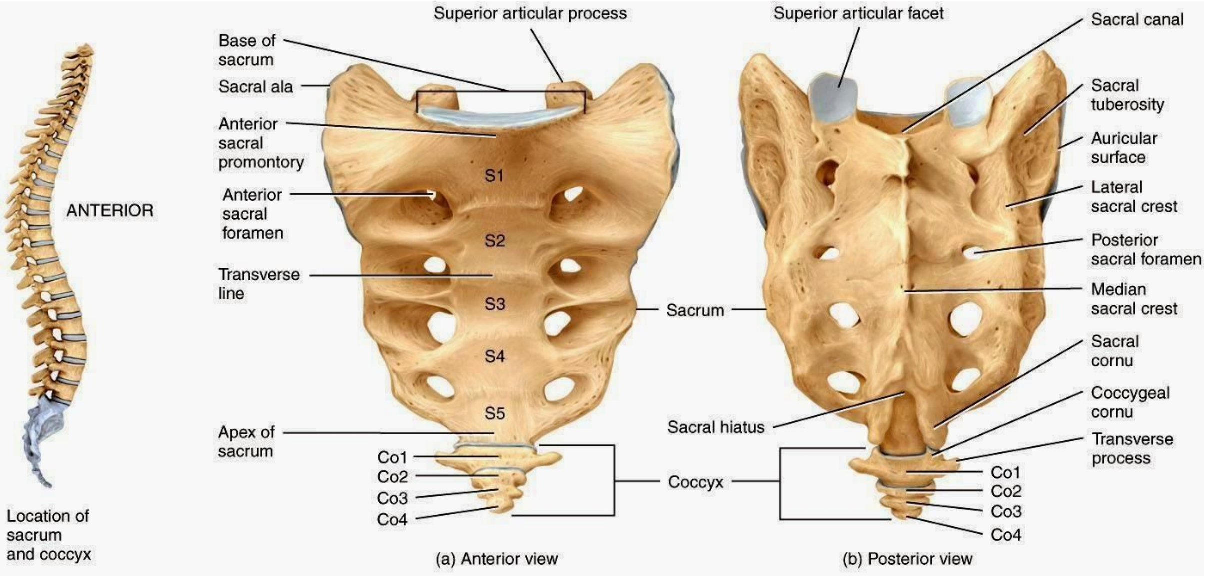


Figure 2.7: Anterior and Posterior views of the sacrum and coccyx (Dayseye, 2016)

2.4 Intervertebral Discs

Intervertebral discs are found between the articulating surfaces of adjacent vertebrae (Figure 2.8).They are usually located between the intervertebral spaces of the second cervical vertebra (C2) through to the first sacral vertebra (S1). They unite the vertebrae into a continuous semi-rigid column. The total length of the vertebral column comprises 20-25% of the intervertebral discs (Snell, 2008, Moore *et al.*, 2013).

According to Urban *et al.* (2000), about one-third of the entire length of the vertebral column is occupied by the intervertebral discs. The three major compositions of the intervertebral discs are water, collagens and proteoglycan aggregations. The discs are semi-elastic and their elasticity permits the movement of vertebrae over each other (Snell, 2008). They have a resilient nature that allows them to function as shock absorbers. The resilience in the discs is, however, gradually lost with advancing age (Snell, 2008). Each intervertebral disc has an outer fibrous part referred to as the annulus fibrosus, which has more collagen constituent compared to water and aggregating glycoproteins (Urban *et al.*, 2000). The central portion of the intervertebral disc is gelatinous and is called the nucleus pulposus. It contains a greater proportion of water and proteoglycans than collagen.

A fibrous ring called the annulus fibrosus consists of concentric lamellae of fibrocartilage. It forms the circumferential periphery of the intervertebral disc. The fibres insert into the epiphyseal rims on the outer margins of the articular surfaces of the vertebral bodies. The fibres forming each concentric lamella run obliquely between adjacent vertebral bodies and their inclination is reversed in alternate sheets (Snell, 2008). This arrangement allows movement between adjacent vertebrae as well as provide a strong bond between them (Moore *et al.,* 2013). The more exterior fibres are strongly fastened to the head-end and tail-end longitudinal ligaments of the vertebral column (Snell, 2008).

In the central core of the intervertebral disc is the nucleus pulposus which is made up of notochodal cells. It exhibits the most dramatic degenerative changes with advancing age (Urban *et al.,* 2000). It is made up of about 88% water at birth and is more cartilaginous than fibrous (Moore *et al.,* 2013). In foetus and infants, the nucleus has actively mitotic as well as biosynthetically active notochordal cells.

As an individual age, the density of notochordal cells decreases together with the proportion of living cells that may be found among them and is replaced by cells that are chondrocytic in appearance but are of unknown origin (Urban *et al.,* 2000). These cells with chondrocytic appearance although they continue to synthesise proteoglycans also synthesise significant amounts of collagen. This results in the nucleus pulposus becoming stiffer and less hydrated thereby losing its transparent appearance. Eventually, clefts and fissures begin to form within the disc. From this point, the nucleus may continue to degenerate until it can no more fulfil its mechanical responsibility (Urban *et al.,* 2000).

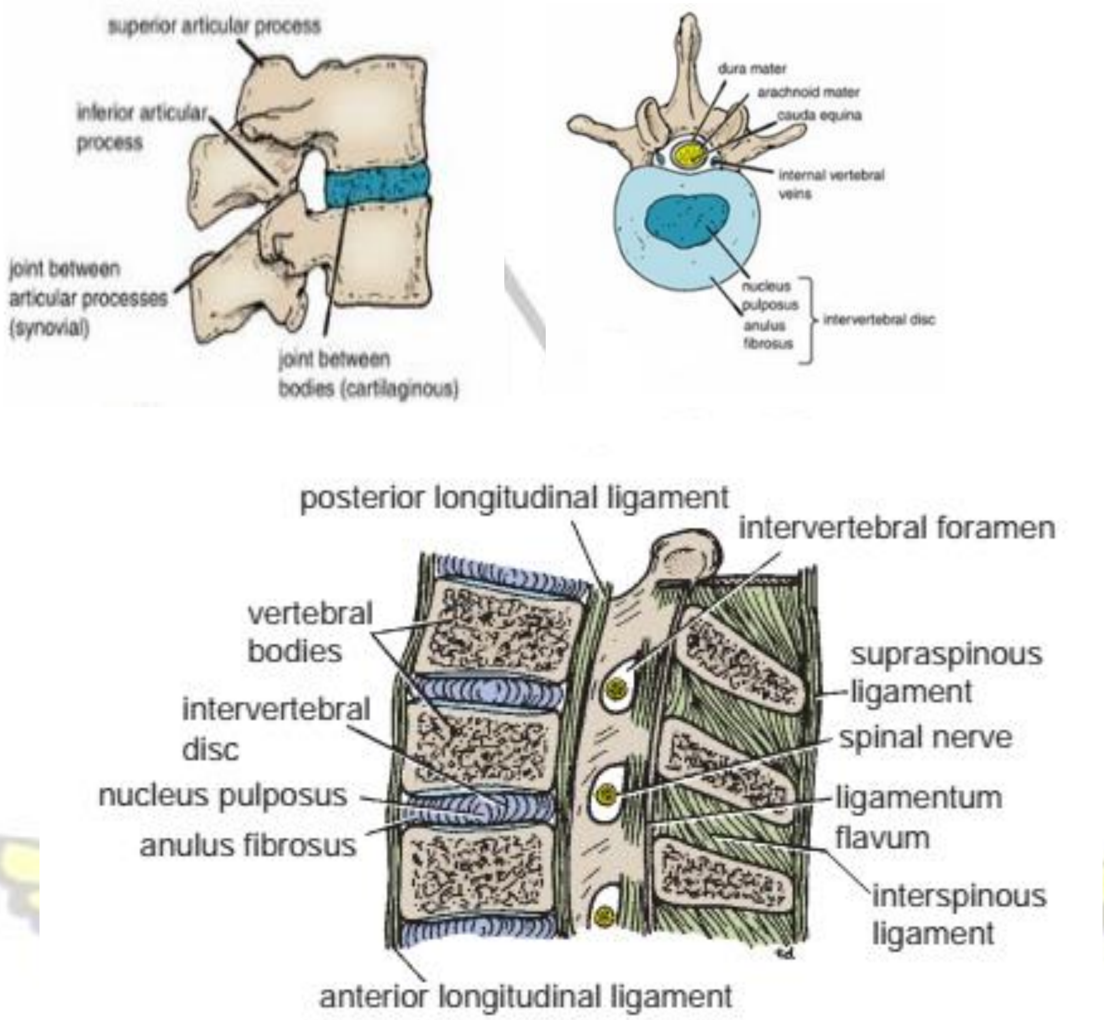


Figure 2.8 Sagittal section of the lumbar part of the vertebral column showing intervertebral discs and ligaments (Snell, 2008)

The nucleus pulposus is not centred but more posteriorly placed. This is due to the fact that the annulus fibrosus lamellae are thinner in thickness and less numerous at the posterior side compared to the anterior and lateral sides. The nucleus pulposus receives its nourishment through diffusion in the annulus fibrosus of blood vessels and the vertebral body thus making it avascular (Moore *et al.*, 2013). The semifluid nature of the nucleus pulposus makes it flexible and resilient. This allows the disc to change shape and also allows a vertebra to sway forward or backward on another during flexion and extension of the column (Snell, 2008).

The discs serve as shock absorbers against vertical forces exerted on them by the body. An unexpected build-up in the compression force on the vertebral column results in the flattening out of the semi-fluid nucleus pulposus. The surrounding annulus fibrosus accommodates the outward thrust of the nucleus pulposus during compression. Sometimes, the outward thrust of the nucleus pulposus may be too great for the annulus fibrosus. When this occurs, the nucleus may herniate into the vertebral canal. Further protrusion may cause compression in the spinal nerve roots or even the spinal cord(Snell, 2008). Disc herniation may be classified as protrusions, extrusions, and sequestrations (Fardon and Milette, 2001, Ohshima *et al.*, 1993). When stretched or tensed as occurs during hanging and suspension of the body, the nucleus pulposus thins up in thickness. During what is known as anterior flexion, the lateral flexion and the extension of the vertebral column, compression occurs all together in the same disc. When these movements are performed and also during rotational movements, the turgid nucleus pulposus serves as a semifluid fulcrum (Moore *et al.*, 2013).

The thickness of intervertebral discs varies at different segments of the vertebral column. The discs are relatively thicker in the lumbar and cervical regions however their thickness is more prominent in the lumbar region. Those in the cervical and lumbar regions present themselves as thicker anteriorly but are uniform throughout the thoracic region. The varying shapes of the intervertebral disc contribute to secondary curvatures of the vertebral column (Moore *et al.*, 2013).

The nucleus pulposus shows regressive changes quite early. With advanced age, the fluid content of the nucleus pulposus decreases and is replaced by fibrocartilage. There is also degeneration in the collagen fibre of the annulus fibrosus. As a result of this, the annulus cannot always contain the nucleus pulposus under stress. The discs are thin and less elastic during old age making it difficult to distinguish between the nucleus and the annulus (Snell, 2008, Friberg, 1948). These changes are considered to lie within the framework of normal physiologic changes rather than being pathologic.

2.5 Muscles of the Back Region

Back muscles have two principal groupings; superficial and deep. Movements of the spine and maintenance of posture are the responsibility of the deep muscles. The superficial muscles are in charge of the movements of the shoulder blades.

Sometimes, para spinal muscles which the collective name given to deep muscles form a thick mass on both sides of the spine and extend from the lower portion of the skull to the sacrum. This mass has well distinct yet overlapping muscles of varying lengths, attached to the spinous or transverse processes of different vertebrae. The muscles individually are thought of as strings. When a string is pulled, contraction of a muscle occurs which causes one or more vertebrae to turn on the vertebra below. The muscles work in relation by extending thus a backward bend and causing a rotation of the spine. The muscles of the abdomen accomplish the forward bending or flexion. Maintenance of posture is also carried out by the superficial muscles of the back by keeping the vertebra or spine erect against gravity.

The fascia (fibrous covering) of the deep muscles form thick sheets with the lumbar fascia in the lower back. This fibrous coverings or sheets function as attachments for other muscles especially those of the abdominal wall.

The superficial muscles are found overlying the deep muscles of the back region. The most superficial muscles are the trapezius found in the upper back. Its structure appears to be a large flat muscle which projects like a hood over the back of the neck and the upper back. Below the trapezius are these two muscles, the levator scapulae and rhomboid. They originate from the cervical and/or thoracic spine and insert on the scapula. These muscles in various combination act together to create movement of the scapulae with examples in action such as shrugging and bracing of the shoulders back.

A superficial muscle which is large in appearance, the Latissimus dorsi covers the mid and low parts of the back. It begins on the lower thoracic spine and lumbar fascia, and inserts on the upper end of the humerus. Some of the shoulder movements are the responsibility of the Latissimus dorsi.

Some muscle category work together to extend the vertebral column and thus maintain their good posture, one referred to as the erector spinae. Nerves called the spinal nerve innervate them and many of these muscles are small and are therefore more prone to damage.

The superficial erector spinae muscles are located deep to the latissimus dorsi and the trapezius and dividing into three groups. They look as if they are one muscle when viewed from the lumbar and sacral regions below because they appear as non-distinct.

2.6 Imaging of the Lumbar Spine

Imaging techniques applied to the spine are essential for diagnosing spinal pathologies. Its use has been increasingly employed in diagnosis of acute low back aches and sciatica (Boden *et al.*, 1990). Computed Tomography (CT) has improved radiological examination of fractures in the vertebral column, particularly in the determination of the degree of compression of the spinal cord (Merritt and Rowland, 1989). Magnetic Resonance Imaging provides improved resolution of soft tissue structures and as such facilitates more accurate diagnosis of degenerative disc disease (Heithoff, 1988). Conventional radiographs are usually used when visualising high contrast structures such as bone. Radiographic images of the vertebral column are usually taken in the anteroposterior and lateral views (Merritt and Rowland, 1989).

2.7 The Lumbosacral Angle

This is the angle formed between the long axis of the fifth lumbar vertebra and the sacrum. The determination of the lumbosacral angle is one parameter that is of importance in evaluating the possible aetiology of low back pain syndromes. From literature, the term lumbosacral angle is measured in many different ways. The most frequently used measurement is that described by Ferguson (1934). He measured the angle formed between the plane of the superior surface of S1 and compared it to the horizontal plane as seen in Figure 2.9.

Using the technique of Ferguson (1934), the patient lies sideways with the long axis of the spine parallel to the long axis of the roentgenographic table, thus allowing the bottom of the film to be employed as the reference line, with the angle being the lumbosacral angle. There have been several studies to verify these values by Splithoff (1953), Von Lackum (1924), and Mitchell (1934). Splithoff (1953) measured the angle in 100 normal subjects using the lateral recumbent position, and found the largest number of angles in normal to be 40º - 44º; however, other than a bar graph, he did not state what range of measurements might be expected in a normal population. Von Lackum (1924) dissected the intact pelvis and lower lumbosacral spine in 30 cadavers and found the average angle to be 42.5º. Mitchell (1934) measured the angle in twenty-eight people and found the averaging angle to be 41º. However, he failed to mention the method by which the roentgenograms were made.

Using the positioning method of Ferguson (1934) can introduce some error in angle measurement. This is because the technician is responsible for trying to position the long axis of the patient's S-curved spine parallel to the long axis of the roentgenographic table in order to make the measurement of the lumbosacral angle valid.

The use of upright lateral spot roentgenograms would obviate this source of error. In a busy radiology department, the standing lateral spot roentgenogram of the lower lumbar spine is most frequently used, not only to evaluate the lumbosacral angle, but also to determine slippage in cases of spondylolisthesis, or degenerative disease.

According to a study by Hellems Jr. and Keats (1971) on the determination of the lumbosacral angle in the upright position, measurements were performed on 319 normal males ranging in age from 17-58 years, who had lumbosacral spine roentgenograms made as part of a routine pre-employment examination. The mean was 41.1º with a standard deviation of 7.7º

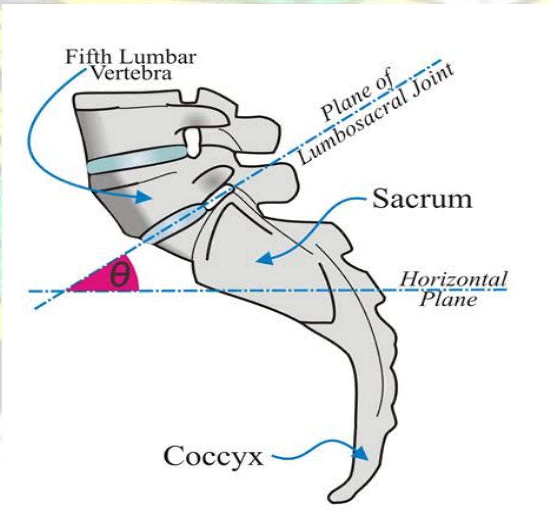


Figure 2.9: Ferguson's normal lumbosacral angle

Another study by Abitbol (1987) of the lumbosacral angle of 131 children whose age ranged from birth to 5 years revealed that the LSA increases from an average of 20º to an average of 70º and remains static thereafter. According to him, the results show that the formation of the LSA has no relation to increasing age, weight, or height neither does obstetrical requirements have any major responsibility in its formation. Rather it emerges that the progressive acquisition of erect posture and the ontogeny of bipedal locomotion has a relation to the development of the LSA.

2.8 Disorders of the Vertebral Column

Some of the disorders of the spine may be occurring infrequently if the fusing of the laminae is not well furbished and consequently a cleft is left in the arches of the vertebrae. The spinal membrane comprises of dura mata and arachnoid mata, and generally the spinal cord itself protrudes through this cleft leading to the malformation known as spina bifida. This is a common condition found in the lumbosacral region, but it may occur in the cervical or thoracic region, or the arches throughout the whole length of the canal and may remain incomplete.

Kyphosis, lordosis, retrolistheis and scoliosis are some of the abnormal curvature of the spine which sometimes occur in individuals. Kyphosis describes an extreme posterior curvature found in the thoracic region of most people. It creates what we normally call humpback or dowager's hump observed mostly in osteoporotic conditions.

Lordosis is an exaggerated curvature of the lumbar region, "swayback". Pregnant women also commonly experience temporary lordosis. Retrolisthesis as termed, describes the posterior displacement of a vertebral body with respect to the adjacent vertebral segment to a degree less than luxation (dislocation).

A very predominant ailment is the lateral curvature called scoliosis found in the spine and occurs in 5% of the population. It is found mostly in females than in males and may result from unequal growth of two sides of one or more vertebrae. Pulmonary atelectasis which is incomplete or whole deflation of one or more lobes of the lungs as we see mostly in asthma or pneumothorax can also cause such condition.

2.9 Causes of Low Back Pain

The causes of pain to lower back can be split into different faces. Much more, there are numerous structures in the spine that can produce pain. However, most of the lower back pains are attributed to mechanical causes resulting from obesity, pregnancy, and job-related movements like stooping, bending and other stressful postures. Additional contributions are construction works, jack hammering, truck driving and sand blasting activities.

Some examples of mechanical causes of low back pain includes sprains and strains, degeneration of intervertebral discs, ruptured or herniated discs, sciatica, radiculopathy, spondylolisthesis, traumatic injuries, spinal stenosis and skeletal irregularities are.

Low back pain in several cases is associated with spondylosis, a term making reference to the general degeneration of the spine which is in relation to normal wear and tear that occurs in the joints, discs, and bones of the spine as people age.

Low back pain is rarely related to critical conditions, but when these conditions do occur, they demand immediate medical attention. Serious underlying conditions include infections which are not a common cause of back pain but they can cause pains when they involve the vertebrae, a condition called osteomyelitis.

Tumours are relatively a low cause of back pain. However, they occasionally grow as a result of cancer that has spread from elsewhere in the body. Other underlying conditions that may result in pain in the lower back is cauda equina syndromeis. This is a serious health complication though it sparingly occurs. When the disc material is pushed into the spinal canal and it compresses the bundle of lumbar and sacral nerve roots, the result is a loss of bladder and bowel control. Permanent neurological damage may result if this syndrome is left untreated.

Large vessels supplying blood to the abdomen, pelvis and legs can become abnormally enlarged leading to the occurrence of *abdominal aortic aneurysms*. A sign of back pain can be indication of the enlargement of the *aneurysm* and this needs assessment before rupture. The presence of kidney stones can cause pain which are usually sharp on one side of the lower back

Other minor conditions that are indicators for low back pain in people include arthritis, osteoarthritis and rheumatoid arthritis which are inflammatory diseases of the joints. Another source of back pain is spondylitis also known as spondyloarthritis or spondyloarthropathy. This is an inflammation of the vertebrae in which painful fractures of the vertebrae caused by a metabolic bone disease called osteoporosis causes a continuous decrease in bone density and strength.

Another underlying cause of pain is endometriosis and fibromyalgia. They cause widespread muscle pain linked to the back and the legs and extreme fatigue.

These several causes of low back pain can be put distinctively into three divisions; chronic, acute and sub-acute low back pain depending on symptoms duration.

2.9.1 Acute and Sub- Acute Low Back Pain

Lower back pain with a duration of less than 4 weeks is termed as an acute lower back pain. There are multiple reasons which potentially can lead to acute low back pain. Muscles sprains, sprains of ligaments and inflammation of the tendons especially in lumbar region are some of the most common causes. And sometimes, spinal causes can occur and simply heal in a quick time expenditure. Sub-acute lower back pain refers to one which spans a period of a month to three months.

2.9.2 Chronic Low Back Pain

Chronic lower back pain lasts for close to 12 weeks and more. That is about a month and more. There are several different possible causes to chronic lower back pains. A common cause is the discogenic lower back pain where there is occurrence of a tear from the nucleus pulposus and extends out to the outer third or two-thirds of the annulus fibrosus. This allow proteins with inflammatory features to move out to the nerve fibres and this can irritate those fibres and cause pain. Facet joint pain is the second most common cause of chronic lower back pain. The facet joints are synovial joints that bear similarities with the other synovial joints in the body. Another term given to these facet joints are the zygapophyseal joints. They can be damaged in so many different ways. The capsule of the joint can be torn and the cartilage can wear too and these changes can lead to inflammation within the joint which causing pain. The third most common cause of chronic lower back pain is the sacroiliac (SI) joint. The sacroiliac joint can become very painful because of altered biomechanics, trauma, and degenerative changes. The pains ultimately come because of the inflammation within the joints.

Spondylolisthesis is another cause of chronic lower back where the bones have slipped in relation to one another. This slippage can induce irritations and inflammations, which can lead to pain. Inflammation of the nerves exiting the spine leads to lumbar radiculopathy. A number of reasons lead to this occurrence. A herniated disc can cause inflammation around a nerve root. Bony spinal stenosis can also lead to inflammation around the nerve root. Lumbar radiculopathies typically cause buttock and leg pain but not low back pain, per se. However, low back pain and lumbar radiculopathies often coexist because the same arthritic facet joint that develops a bone spur and causes low back pain may also create for animal stenosis and inflame a nerve root leading to a lumbar radiculopathy.

2.9.3 Region of Pain

Additionally, the categorization of the low back pain is not based on only duration, but may also be described as:

- Localized: For a localized pain, palpation or pressing a specific surface area of the lower back by the physician leads to discomfort and one may feel soreness in that area.
- Diffuse: Pain that is described as diffused originates from deep tissue layers and spreads over a large area.
- Radicular: is as a result of an irritation in the root of nerves and spread out from the affected area. Sciatica is an example of such pain.
- Referred: is pain perceived in the lower back caused by inflammation or a disease elsewhere located in the kidneys or structures close to the lower back including the bladder, uterus, intestines, appendix, ovaries or the testes.

2.9.4 Diagnosing Low Back Pain

The diagnosis of LBP is mainly based on reported symptoms. History of medical and physical examinations normally identify serious conditions that may be causing the pain. During the diagnosis and monitoring stages, the healthcare professional will ask about the onset, site, and severity of the pain; duration of symptoms and any stampedes in locomotion.

Along with a thorough back examination, neurological tests are performed to ascertain the possible causes of the pain. Appropriate treatment is thus given. The more positive results a patient presents the more likely the diagnosis of LBP. The cause of chronic lower back pain is often difficult to determine even after examination under scrutiny.

Imaging tests are not warranted in most cases but under certain circumstances, imaging may be ordered to rule out specific causes of pain, including tumours and spinal stenosis. Imaging techniques such as X-rays, Computerized Tomography (CT), Myelograms, Discography, Magnetic Resonance Imaging (MRI), Electrodiagnostics, bone scans, ultrasound imaging and blood tests and many more are used. However, these techniques are patient dependent and the site of pain.

One of the foremost imaging techniques to look out for broken bones or injured vertebra is the X-ray. It shows if there are any abnormalities or fractures to the bony structures and any misalignment of the vertebrae. Conventional X-rays do not give visibility of tissues such as muscles, ligaments or even bulging discs.

Spinal structures that cannot be seen on conventional x-rays can make use of the computerized tomography (CT) for visibility. Most of these structure such as spinal stenosis, disc rupture and even tumours can be seen on CT scans. The use of a computerized system allows the CT scan to create three-dimensional images from series two-dimensional images.

An innovation of X-rays and CT scans diagnostic imaging modalities is the myelograms. The procedure deals with the injection of a contrast dye into the spinal canal. This allows the spinal cord or any nerve compression resulting from fractures or disc herniation as will be displayed on the screens.

When there is failure of other diagnostic procedures, the discography may be used to detect the cause of pain. Discography has to do with injecting a contrast dye into a spinal disc that may be cause of the low back pain. Injured areas show on CT scans after the injection. The effect therefore is reoccurrence of symptoms for that suspected spinal disc. Discography provides additional information in cases where individuals are to take into account lumbar surgery or unending pain with conventional treatment.

Magnetic resonance imaging (MRI) another imaging modality generates images using a magnetic force instead of radiation. Additional features of MRI scans in comparison to X-ray is its ability to produce images of soft tissues such as muscles, ligaments, tendons, and blood vessels. MRI function can be necessitated assuming there are suspicions of any infection, inflammation, tumour, disc herniation or rupture. A condition that requires prompt surgical treatment can be identified using the non-invasive MRI. Most times there is no need for an MRI scan especially during the early stages of low back pain unless there are red alerts in the history or physical exam of the person.

Electrodiagnostics are procedures that are mainly used to rule in or out lumbar radiculopathy upon the onset of experiencing low back pain in a person. The methods include electromyography (EMG), nerve conduction studies (NCS), and evoked potential (EP) studies. These procedures are either performed as stand-alone or alongside others. Imaging and scans of bones are used to detect and monitor infection, fracture, or disorders in the bone. A small amount of radioactive material is injected into the bloodstream and will gather particularly in areas with some abnormality in the bones. Target areas of irregular bone metabolism or abnormal blood flow are identified from images generated from scanners

Ultrasound scanning or sonography involves the usage of high-frequency sound waves to obtain images of internal organs. The echoes of the sound wave are recorded and output as a real-time visual image. Ultrasound imaging can display images of fractured ligaments, muscles, tendons, and other soft tissue masses in the lower back.

Blood tests are not often use to diagnose the cause of back pain. However, they may be ordered to look for indications of inflammation, infection, and or the presence of arthritis. This procedure is only considered in some applications. Other possible tests include erythrocyte sedimentation, C-reactive protein and full blood count. People with ankylosing spondylitis or reactive arthritis and HLA-B27 as a genetic marker in the blood can be detected during blood tests.

2.10 Empirical Review

Evcik and Yücel (2003), report on lumber lordosis in acute and chronic low back pain showed that there were 50 patients with chronic low back pain and 50 with acute low back pain. There was some significant correlation between the value of the sacral and lumber extension in chronic low back pain patients according to the study as the former was found to be greater than the latter. However, no statistical difference or correlation was fine tuned in lumbosacral and sacral horizontal angles and spinal mobility of the two sets. The study finally conclude that chronic low back pain affects the lower lumber vertebra and limits the peak range for lumber extension. It employed the correlation and regression analysis approach in arriving at these findings.

Okpala (2014) on lumbosacral angle on normal lateral supine lumbosacral radiographs of 274 Nigerians of south east region established normal lordosis and the possible values at which to consider hypo-lordosis (below 15 degrees) and hyper-lordosis (above 75 degrees) in the population under study. The study also established the development of lumbar lordosis cases at spinal maturity, and that in the measurement of the normal lumber lordosis, the retrospective approach is a credible alternative to the prospective method. The data was analysed using the SPSS statistics version 17.0. The study also employed the descriptive approach in analysing the data.

In a study by Mahadik *et al*. (2015) on the correlation of lumbosacral angle with core muscle endurance in chronic low back pain patients, found that core muscle endurance was reduced in patients with chronic low back pangs. The study also found a negative correlation between core muscle endurance and lumbosacral angle. The study adopted the cross-sectional study design. The study also adopted the descriptive statistical analysis approach in analysing the data.

Some studies by Nakipoglu *et al.* (2008) on the biomechanics of the lumbosacral region in females with acute and chronic low back pain constituted about 50% of the acute low back pain and 73.3% of the chronic low back pain patient groups. A statistically significant difference achieved between the two groups considering some factors. They include their ages, genders and the stability of their lumber. There were no statistical variations regarding LSA and segmental lordosis angles between the acute and chronic low back pain patients. A sample of 60 participants were grouped as acute low back pain with 30 subjects in each group. Analysis was done based on the randomised controlled evaluation design.

Kyei *et al.* (2015) studied on the prevalence of low back pain on patients radiological reports and found that low back pain affects both men and women but more prevalent in women than men. Non-specific cause of low back pain was the prevalent cause and spondylosis was the most prevalent among the non-specific cause. Its prevalence was also in all age groups and in both sexes. The study employed the quantitative and cross sectional design and was used with a framework for the radiological reports recorded. Convenient sampling technique was used to select 540 radiological reports of patients who were 18 years and above. The SPSS version 18.0 was used in the data analysis. This study also adopted descriptive statistics of frequency distributions, bar charts and percentages in presenting the results.

CHAPTER THREE

METHODOLOGY

3.0 Study Design

The design that is adopted for this study is exploratory. This strategy is adopted to bring to light the relations of a given phenomenon by considering the effects of peculiar customs, processes, among others.

3.1 Study Site

Data was obtained from the Radiology Unit of St. John of God Hospital in Duayaw- Nkwanta in the Ahafo Region of Ghana. The hospital is a major health facility in Ghana with about 500 bed capacity and a daily patient attendance of about 200. The hospital has an excellent orthopaedic centre and is rated among the top three in Ghana. The Radiology Unit employs the Direct Digital radiography systems. This involves the usage of active matrix flat panels consisting of a detection layer deposited over an active matrix array of thin film transistors and photodiodes. With DR the image is converted to digital data in real-time and is available for review within seconds. These features made this health facility a good choice for collection of data for the study. Patients are referred to this unit from other health centres for lumbar spine imaging. The X-ray unit averagely attends to about 120 patients a day out of which an average of 60 are lumbar cases.

3.2 Study Population

The target population were men and women whose X-ray images had been taken from January 2016 to April, 2016. The specified time duration of a quarter of one year was due to the fact that the X-ray at the study site had a limited capacity with respect to how many patients' radiologic data the system could save in records. Periodically, old records of patients were deleted to make room for new data. Old images were then backed-up onto a Picture Archiving and Communication System (PACS). However, images stored on the PAC system did not have weight information of patients. This information was only available in the database of the medical stores of the hospital. Images belonging to Ghanaian patients were sorted out using the names and unique identity numbers obtained from the records available.

3.2.1 Inclusion Criteria

There were some criteria put in place to get the appropriate images for the study and these included:

- X-Ray Images which stated Ghanaian nationality from the available records were considered for the study.
- Images whose indication for X-Ray imaging did not include any condition (such as tumours, trauma, fractures) that could potentially affect the shape and dimensions of the lumbar sacral junction.
- Images that were clear enough and as well as clearly shown intervertebral disc features on lumbar images required for lordotic angle measurements.

3.2.2 Exclusion Criteria

The following criteria was used to get the inappropriate images from the lot retrieved. These are:

- Indications for X-Ray imaging that were due to trauma, fracture or any other condition that could affect structure measurements.
- Images with severe localised vertebrae deformation.
- Images with vertebral fractures, spinal metastases or evidence of spinal surgery.

- Images that were not clear which made it difficult to identify the landmarks for LSA measurements.

3.3 Materials

A search through patient records for lumbar X-ray images, revealed three hundred and forty-seven (347) names on the X-ray machine. Out of this, 59 images could not be retrieved from the PACS. Thus 288 images were retrieved, out of which only 177 were valid for LSA measurements.

Each image was copied onto a flash drive using the Micro Dicom version 0.9.1 (Build 918) 64 bit. The Micro Dicom is a viewer software (an imaging application for viewing medical images), which is used at the study centre to manage images stored in the PACS. The images copied onto the flash drive did not have the Micro Dicom software automatically packaged with it to enable viewing of the images directly from the flash drive, therefore it had to be installed on the computer being used. The software had an inbuilt ruler with calibrations, which was used for LSA measurements. The software supported magnification of images without changing the dimensions measured with the ruler. Magnification was used to enable clear visualisation of vertebral landmarks.

3.4 Procedure

A search was done on the X-ray machine at the Radiology unit of the St. John of God hospital to obtain information on all patients that had taken a lumbar x-ray image at the centre. The search phrase used was “lumbar”. The search returned 347 names of patients. These patients had undergone x-ray examination within January, 2016 and April, 2016.

From the search, a list was compiled taking note of patient’s ID, age, and weight. The list was used to retrieve images from the PACS, which is an online database where all images taken at the Hospital are stored. Forty images out of the list compiled could not be retrieved from the PACS server. The images were missing from the database. In all, 222 images were retrieved. The images were transferred onto a flash drive using the Micro Dicom software so they could be viewed at a convenient time on any available computer.

Information concerning their age, weight and occupation was retrieved from the medical stores with the assistance of a personnel at the store. Patients' records were grouped according to unique identity numbers and year. The data was then recorded or typed and organised using Microsoft Excel.

Patient images were grouped according to age and sex. Age classification was based on a modification of WHO's age classification (World Health Organization, 2013). The present study combined WHO's classification for infancy, childhood and adolescent and grouped them to collectively span the ages of 0-19 years. According to World Health Organization (2013), adulthood spans the ages of 20- 59 years whiles age 60 years and above are classified as elderly. For the purpose of this study, adulthood was divided into early adulthood (20-39 years) and late adulthood (40-59 years). Age 60 years and above were maintained as elderly. Sex was classified as male or female.

3.5 LSA Measurements

LSA measurements were performed on lateral radiographic images of the lumbar spine using the Micro Dicom software. The images were opened from the folders and the lateral images were selected for lumbosacral angle measurements to be carried out. The mid-sagittal images were located by looking for the presence of a clear demarcation of the spinal cord and a clear view of the spinous processes posterior to the spinal cord.

In measuring the lumbosacral angle, Ferguson’s technique of measurement was adopted and modified. Firstly, the technique of measurement was applied to the base of the 5th Lumbar vertebrae, L5; this measured the angle of inclination of the base of L5. To use Ferguson’s method of measurement, an arbitrary straight horizontal line was drawn below L5. From that line, an inclined line was projected from the end of the horizontal line anterior to that particular spine region. This projected inclined line is tangential to the base of L5. The value for the angle of inclination of the base of L5 was then recorded (Figure 3.1).

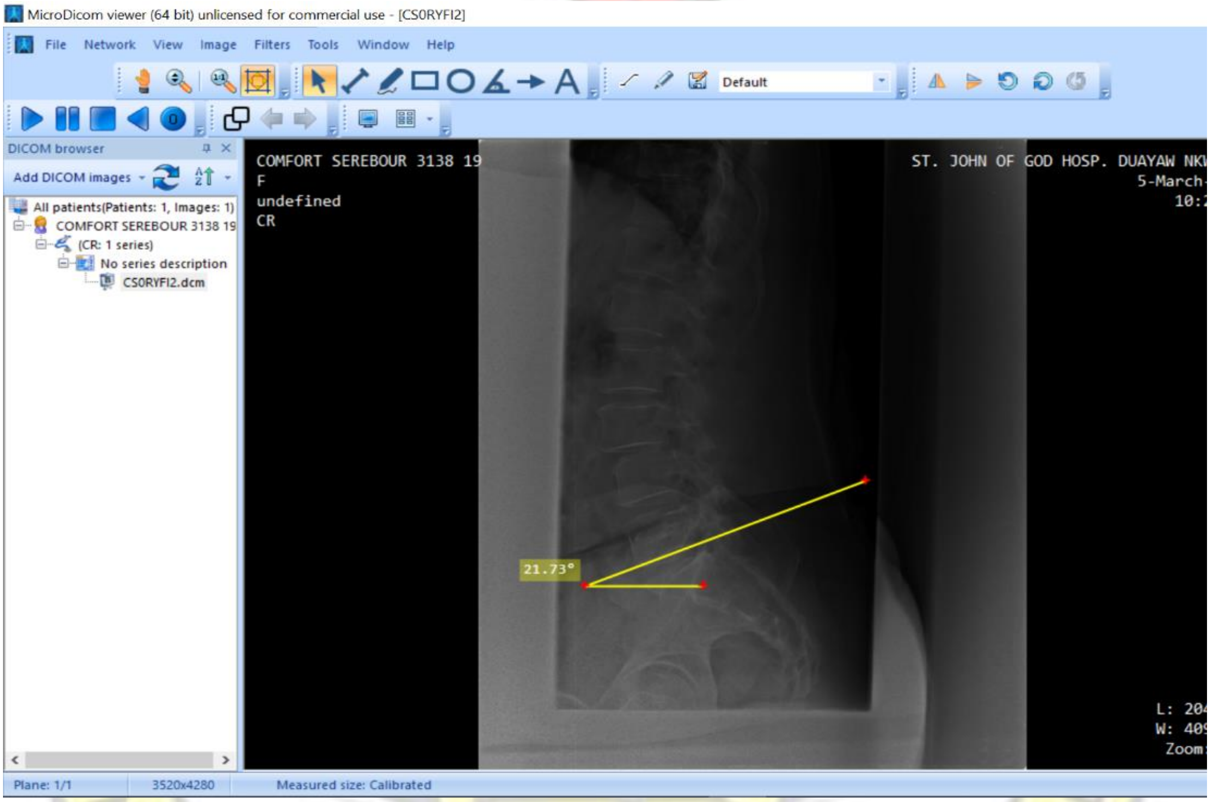


Figure 3.1 Measurement of Lumbosacral Angle using Ferguson's technique (Step I)

Secondly, Ferguson’s method again was applied to the sacrum to measure the angle of inclination of the top surface of the sacral vertebrae specifically the first of the fused sacral vertebrae denoted as S1 (Figure 3.2).

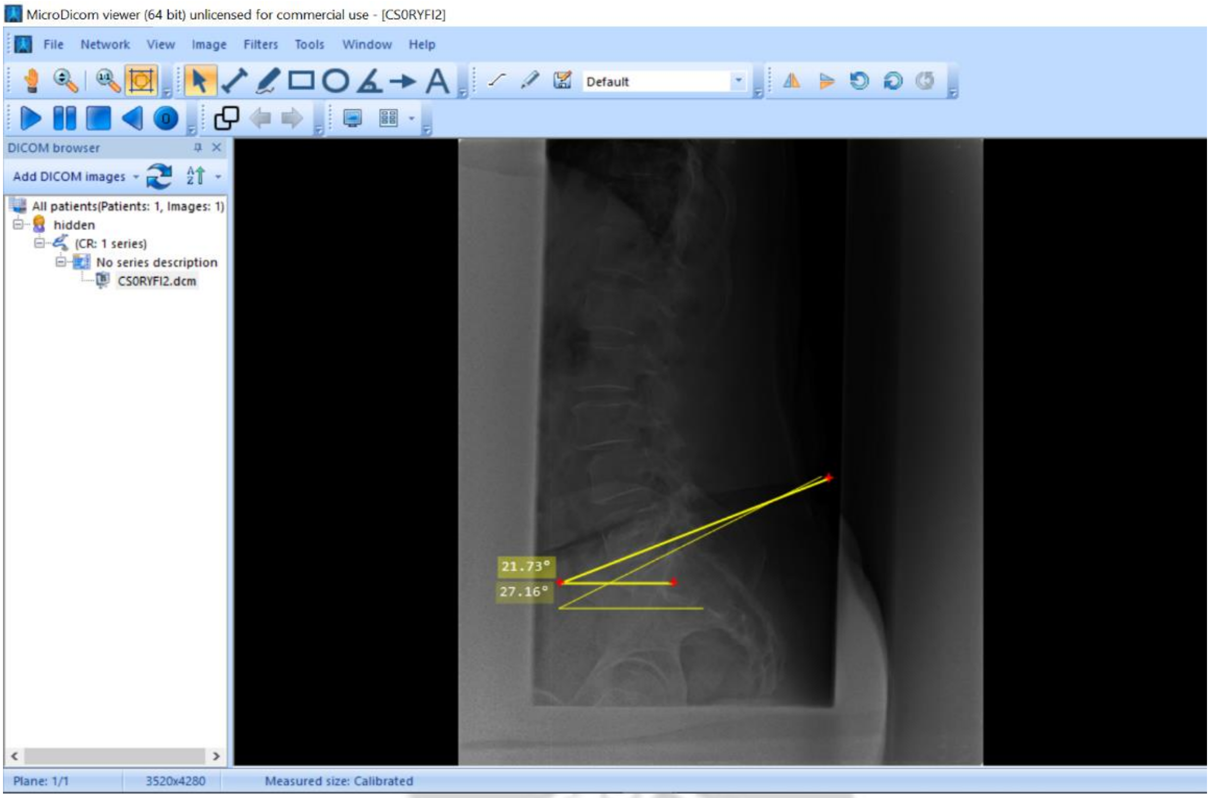


Figure 3.2 Measurement of Lumbosacral Angle using Ferguson's technique (Step2)

The inclined line drawn for both L5 and S1 was such that they intersected as illustrated in Figure 3.2 above.

Finally, the lumbosacral angle was obtained by measuring the angle between the two inclining lines drawn for L5 and S1 respectively in Figure 3.3.

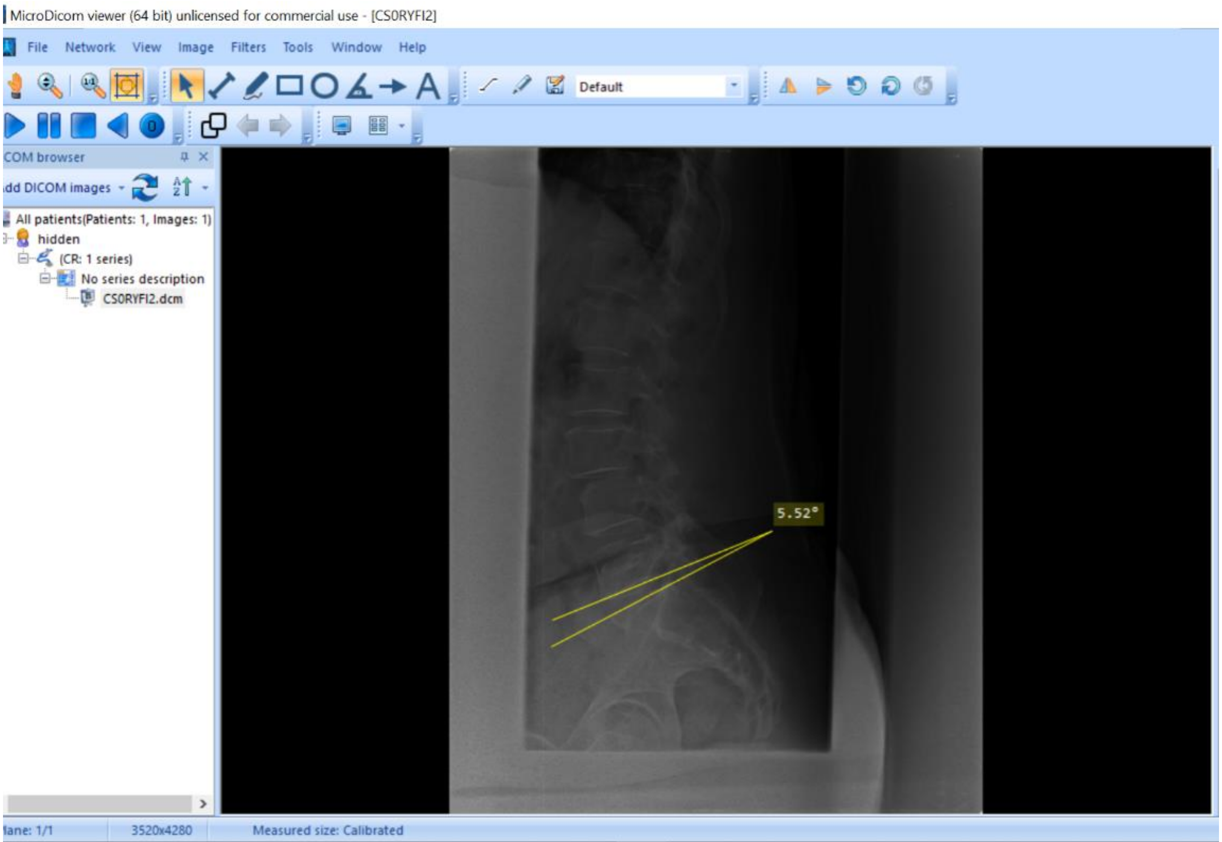


Figure 3.3 Measurement of Lumbosacral Angle using Ferguson's technique (Step 3)

Each measurement was done three times for each lumbosacral junction and the average recorded. All measurements were carried out by the principal researcher. Series of training sessions were undertaken with a radiographer, who is a clinician as well. This continued until he was satisfied the principal researcher was competent to carry out all LSA measurements accurately. Test for reliability of all measurements was, however, done by the principal researcher and the radiographer.

3.6 Data Handling

Both raw and analysed data were kept on a password protected laptop to safeguard the data from unauthorised access. All images transferred onto the flash drive was kept in a locked cabinet to ensure adequate safe-guarding of patient data. Confidentiality of patient information was ensured, by limiting access to patients' images as well as all confidential information pertaining to these images to only the principal researcher, my supervisor and the radiographer who supervised the classification of these images.

3.7 Statistical Analysis

Results obtained from the measurements of LSA were analysed using the students t-test. Descriptive statistics of means, standard deviations, minimum and maximum values were used to summarise lumbosacral angle data. Frequencies and percentages were used to summarise data as well as graphs and tables were used to summarize data where applicable. Each lumbosacral angle was considered as a single statistical unit.

A correlation matrix was used to determine if there was a correlation between LSA measurements and age, weight and occupation variables. Sex differences in LSAs were analysed using independent t-tests.

The study then used the regression analysis to establish the relationship between low back pain and lumbosacral angle.

3.8 Ethical Issues

Permission was also obtained from the central administration of the St. John of God Hospital as well as the head of Radiology Unit at the hospital to allow collection of data from their facility. Confidentiality of patient information was ensured at all times by safe guarding patient information on a password protected computer.

3.9 Model Specification

To be able to arrive at the relationship between Lumbosacral Angle (LSA) and low back pain (LBP), the study specifies a probit model as advocated for by Hausman and Wise (1978) in such a study. The Probit model is specified as a result of the nature of the dependent variable which is binary in nature (i.e. 1 = Low back pain and 0 = No Low back pain).

$LBP_i = \beta_0 + \beta_1 LSA_i + \beta_2 Weight_i + \beta_3 Age_i + \beta_4 Gender_i + e_i$ 3.1

Where: LBP_i represents Low Back Pain; LSA_i represents Lumbosacral Angle; $Weight_i$ represents weight; Age_i represents age; $Gender_i$ represents gender; β's are the coefficients obtained from the regressional analysis and e_i - represents the error term.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Gender of Respondents

From Figure 4.1 it is realised that 53 male patients represented 29.9% of the respondents, while 124 female patients represented 70.1% of the respondents. This means that majority of the patients who sought medical services were females.

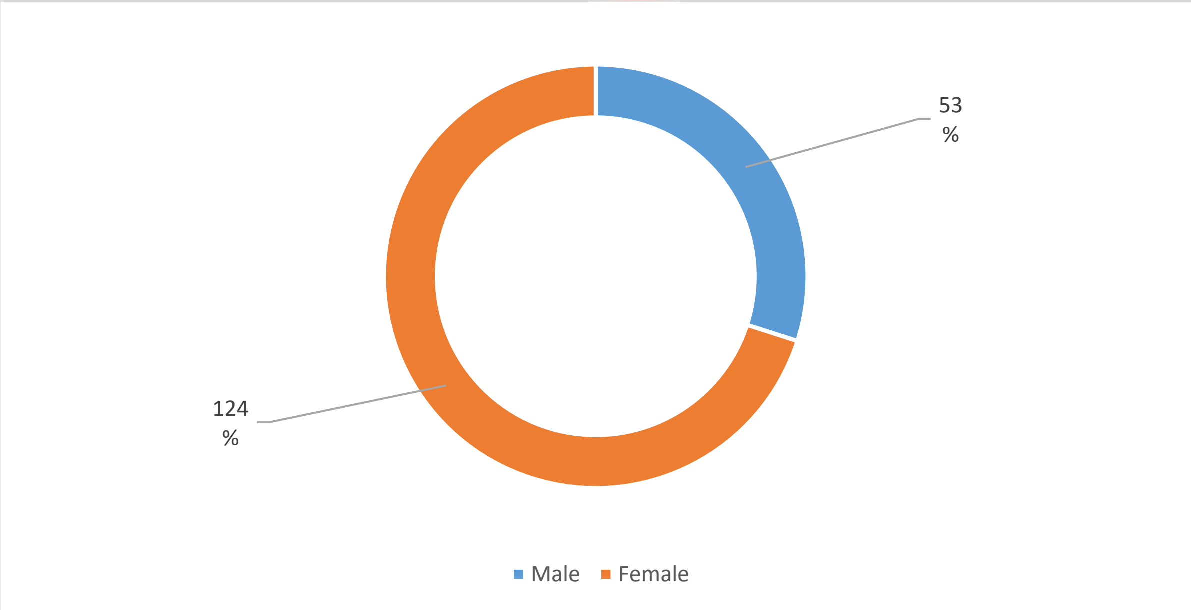


Figure 4.1: Gender of Respondents

4.2 Frequency distribution of Age

It is evident from Table 4.1 that majority of the respondents, 82 patients representing 46.3% were between the ages of 40 to 59 years whiles the minority of 7 patients also representing 4.0% were between the ages of 0 to 19 years. 42 patients also representing 23.7% were between the ages of 60 to 79 years whiles 37 patients representing 21.9% were between the ages of 20 to 39 years. 9 patients on the other hand representing 5.1% were also between the ages of 80 to 89 years. This means that majority of the samples for the study were between the ages of 40 to 59 years.

Table 4.1: Frequency distribution of Age

Age Group	Frequency	Percentage (%)
0-19	7	4.0
20-39	37	20.9
40-59	82	46.3
60-79	42	23.7
80-99	9	5.1
Total	**177**	**100.00**

4.3 Frequency distribution of Low Back Pain

From Table 4.2 it was evident that 74 patients representing 41.8% of the sample population had no low back pain as against 103 patients representing 58.2% which reported with low back pain. This means that majority of the population had low back pain.

Table 4.2: Frequency distribution of Low back Pain

Low Back Pain	Frequency	Percentage (%)
Yes	103	58.2
No	74	41.8
Total	177	100

4.4 Mean LSA

From Table 4.3, it is seen that patients without low back pain who represent the healthy normal controls had an average LSA of 17.59º whiles those with low back pain had an LSA of 14.05º. The test of differences between the controls and those with low back pain LSAs showed that there is not much a significant variation between the LSAs, with a p-value of 0.925. This is contrary to the observations of Nakipoglu et al. (2008), who found a statistical differences between the two groups.

Table 4.3: Mean distribution of Low back Pain and LSA

Variable	**N**	**Mean LSA**
Low Back Pain	103	14.05º
No Low Back Pain	74	17.59º
Total	177	

t = 0.094, p-value=0.925

4.5 Mean LSA according to Age group for Low Back Pain

From Table 4.4, it is evident that on average, majority of the sample population of those with low back pain between the age group of 0-19 years had a mean LSA of 18.49º. On average the minority of the samples between the ages of 80 to 99 years had a mean LSA of 13.24º. Those between the ages of 20 to 39 years and 60 to 79 years on average received a mean LSA of 15.60º and 13.08º respectively. There was not much a significant difference between the mean ages of samples in terms of LSA (all p-values were greater than 0.05).This contradicts the views of Nakipoglu et al. (2008), who found a statistical difference between the two groups in terms of age.

Table 4.4: Mean distribution of Age group and LSA for Low back Pain

Age Groups	**Mean LSA**		**t-test**	**P-Value**
0-19(1)	18.49º	1 versus 2	0.358	0.725
20-39(2)	15.60º	2 versus 3	0.781	0.438
40-59(3)	13.89º	3 versus 4	0.399	0.691
60-79(4)	13.08º	4 versus 5	-0.045	0.965
80-99(5)	13.24º	1 versus 5	0.662	0.529

Conclusion: In all *P*>0.05

4.6 Mean LSA according to Age group for No Low Back Pain

From Table 4.5, it is evident that on average, majority of the sample population of those with low back pain between the age group of 0-19 years had a mean LSA of 13.48º. On average the minority of the samples between the ages of 80 to 99 years had a mean LSA of 18.79º. Those between the ages of 20 to 39 years and 60 to 79 years on average received a mean LSA of 17.83º and 17.49º respectively. There was not much a significant difference between the mean ages of samples in terms of LSA (all p-values were greater than 0.05).This contradicts the views of Nakipoglu et al. (2008), who found a statistical difference between the two groups in terms of age.

Table 4.5: Mean distribution of Age group and LSA for No Low Back Pain

Age Groups	Mean LSA		t-test	P-Value
0-19(1)	13.48º	1 versus 2	-0.791	0.432
20-39(2)	17.83º	2 versus 3	-1.75	0.861
40-59(3)	18.38º	3 versus 4	0.524	0.603
60-79(4)	17.49º	4 versus 5	-0.274	0.791
80-99(5)	18.79º	1 versus 5	-0.443	0.676
			Conclusion: In all *P*>0.05	

4.7 Mean Low back pain according to Gender

When it comes to those with low back pain it was realised that females had a mean value of 0.56 as against males who had a mean value of 0.62. This simply means that on average males experience low back pain than females. There was however not much a significant variation in results between the mean values for males and females (t =0.174; p-value 0.862), meaning there is no significant difference between low back pain among males and females as shown in Table 4.6.

Table 4.6: Low back pain according to Gender

Gender	Number (N)	Mean LBP	t-test	p-value
Female	52	0.56	0.715	0.476
Male	22	0.62		
Total	74			

4.8 Descriptive Statistics of variables

According to Table 4.7, age had a mean value of 51.04, with a least value of 13 years and a greatest value of 93 years. The mean value of 51.04 means that the average age of the sample is 51 years.

LSA had a mean value of 66.04º, with a minimum value of 2º and a maximum value ∞º. The mean value of 66.04º meant that on average the LSA of the samples for the study was 66º.

Weight on the other hand had a mean value of 15.53 kg with a minimum value of 26 kg and a maximum value of 109 kg. The mean value of 15.53 kg meant that the average weight of the sample was 16 kg.

Table 4.7: Descriptive Statistics of Variables

Variable	Mean	SD	Min	Max
Age	51.04	16.86	13	93
LSA	66.34	9.48	2	∞
Weight	15.53	14.20	26	109

4.9 Correlation Analysis of variables.

Table 4.8 reports the correlation coefficients of LSA and low back pain of the selected samples. The correlation among variables is considered strong if it exceeds a value. This is according to Green et al. (1988). And a value of 0.9 was proposed to be the standard for correlating these variables. More so, we see a correlation coefficient of less than 0.9 among all the variables as anticipated, indicating that multicollinearity among the variables is absent.

Table 4.8: Correlation Analysis of variables

Variable	LBP	LSA	Age	Weight
LBP	1.000			
LSA	0.186*	1.000		
Age	0.289**	-0.107	1.000	
Weight	0.150*	0.071	0.002	1.00

**** = Significant |at 1%, * = Significant |at 5%**

From Table 4.8, it is realised there a correlation coefficient of 0.186 existing between LSA and low back pain. This however, gives a positive relationship. Age is positive and it's related to low back pain with the coefficient of correlation to be 0.289. This link is strong since it is significant at 1%. Weight is also positively related with low back pain with a correlation coefficient of 0.150 as shown and this is a significant relationship.

4.10 Regression Analysis of the relationship between Lumbosacral Angle (LSA) and low back pain (LBP)

Since the dependent variable (i.e., low back pain) appears binary in nature, there would result in predicted probabilities less than zero or greater than one as the ordinary least squares (OLS) approach for modelling the binary dependent variable is not appropriate as the linear model. In addition, a flaw of the linear model is that it does not allow us to consider the nonlinear nature of the effect of independent variables on the binary dependent variable.

Therefore, in estimating relationship between Lumbosacral Angle and low back pain, a probit model is used since the dependent variable appears in a binary form.

Table 4.9 presents a probit regression of relationship between Lumbosacral Angle (LSA) and low back pain (LBP).

The model diagnostics indicate the predictive ability of the model at 64.77% implying that the model predicts up to 64.77% low back pain probability. The statistic had a pseudo R^2 of 0.1237. This Wald chi-square has a probability of 0.0000 indicating the pseudo R-squared and Wald chi-square are significant at 1%, implying all the variables together explain Low back pain. The Doornik-Hansen test of normality was performed on the probit estimates of the model which shows that the error term was normally distributed given the probability of 0.1280 and hence the confirmation of probit and not a logit model.

Table 4.9: Probit regression of the relationship between Lumbosacral Angle (LSA) and low back pain (LBP)

	Coefficient	**Std. Error**	**Z**	$p > (z)$
LSA	0.025*	0.010	2.29	0.022
Age	0.418**	0.116	3.61	0.000
Weight	0.016	0.007	2.30	0.021
Male	-0.331	0.221	-1.49	0.135
Con	-1.253	0.693	-1.81	0.071

Pseudo R-Squaredv=0.1180, P>Chi2=0.0000, ** = Significant at 1%, * = Significant at 5%
Doornik-Hansen: Prob>Chi2=0.1280

Source: Field Survey, 2017

4.10.1 Relationship between Lumbosacral Angle (LSA) and low back pain (LBP)

From Table 4.1 it is realized that between LSA and low back pain there is a positive relationship. This relationship is a significant one as such and it simply means that an increase in LSA leads to 2.5% increase in probability of low back pain.

4.10.2 Relationship between Age and low back pain (LBP)

From inferences, there is a positive and significant relationship between age and low back pain. The coefficient of 0.418 implies that an increase in age leads to 41.8% increase in the probability of low back pain.

4.10.3 Relationship between Weight and low back pain (LBP)

Weight as mentioned is also positively related to low back pain. Thus an increase in weight leads to 1.6% increase in the probability of low back pain. However, this relationship is not significant.

4.10.4 Relationship between Gender and low back pain (LBP)

The probability of pain of the lower back among males is 0.331 less than the probability that will be incurred by females in the lower back and it is also not a significant relationship. This is in line with the study by Kyei et al. (2015) that low back pain affect both men and women but more prevalent in women than men.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter summarizes the findings, conclusion and recommendations from the study. The conclusion is made based on the findings from the study while suggesting appropriate recommendations to be made to address the raised concerns.

5.2 Summary of Major Findings

The study sought to find out the relationship between Lumbosacral Angle (LSA) and Low back pain (LBP).

The researcher employed the descriptive as well as the regression survey design. The findings from the study indicated that the respondents are dominated males who constituted 70.1% as against female who also constituted 29.9%. In terms of age, majority of the sample were between the ages of 40 to 59 years as against the least that were between the ages of 0 to 19 years.

The study has shown that 41.8% of the sample of the population had no low back pain as against 58.2% who were detected to have low back pain.

In terms of LSA according to gender for the population without back pain, it was found that, the mean LSA for males were 18.68º and that of females is 17.13º. Regarding Mean LSA according to age majority of the samples, the lowest age of 0 to 19 years received a mean value of 18.49º whiles the highest age of 80 to 99 years received a mean value of 13.24º. However, there were no huge variations between the mean ages in terms of LSA.

Regarding the mean low back pain according to age groups, the study establishes that those within the least age group of 0 to 19 years received a mean LBP of 0.14 whiles the highest age of 80 to 99 years received a mean LBP of 0.89 and there was significant difference. There was a significant difference in LBP among the samples in the age groups of 20 to 39 years and 40 to 59 years. Apparently there was a significant difference in LBP between the age groups of 60 to 79 years and 80 to 99 years likewise the differences in LBP between the age groups of 0 to 19 years and 80 to 99 years.

The study also found that the mean low back pain of males was 34.45 as against the mean value of low back pain for females as 36.26. This means that on average there is low back pain among females than males. Meaning that on average majority of the females have low back pain since they engage more in activities or tasks that affect the lower back.

With regards to the descriptive statistics of the variables for the study, the result shows that age, LSA and Weight received mean values of 51.04 years, 66.34º and 15.53kg respectively, with standard deviations of 16.86, 9.48 and 14.20 respectively.

The results of the study have shown the absence of multicollinearity as the correlation coefficient was less than 0.9. Thus there was a positive relationship between LSA, age, weight and gender to LBP.

In the study, there is a positive relationship between LSA and low back pain. This relationship is found to be significant. This simply means that an increase in LSA leads to 18.6% increase in probability of low back pain.

The study further shows the existing positive and significant relationship between LSA, age and low back pain. Moreover, an increase in age which leads to 41.8% increase in the probability of low back pain was also determined.

This work also shows that weight is also positively related to low back pain. An increase in weight leads to 1.6% increase in the probability of low back pain. This relationship was found to be significant.

The study establishes a 33.1% less probability of low back pain among males compared to the probability that females will have low back pain and it is not a significant relationship.

5.3 Conclusion

In conclusion the study establishes a positive relationship between LSA and low back pain. This relationship is found to be significant. It further shows a positive and significant relationship existing between age and LSA. It could also be inferred that there is a positive significant relationship between weight and low back pain as well as an insignificant relationship between gender and low back pain.

The researcher must therefore finalize all findings to say that, the relationship from LSA and age to low back pain should not be underestimated. Weight is also a significant factor when looking at low back pain, since it was found to be very significant in the study.

5.4 Recommendations

In a developing country like Ghana, the vibrant and a healthy working force is paramount for its socio-economic development. The burden of chronic illness such as low back has huge financial implication on the economy and as such, measures to mitigate the deleterious consequences of diseases is very much appreciated.

The study found a positive effect of age and weight on the lower back in the development of LBP, therefore it is recommended that the Ghanaian population takes a particular attention to low back pain as their age and weight increases and to avoid certain practices such as use of drugs and alcohol, smoking, no or less body exercise and poor dieting. These practices are likely to cause LBP.

The study was conducted on the relationship between LSA and LBP without taking into account other causative factors affecting low back pain. Further studies should be carried out to determine the causative factors of low back pain among the Ghanaian population. This will also throw more light on the true state of the matter in the country as whole.

This study should also be extended to other imaging centres in other regions of Ghana since the dynamics are likely change. This will provide a broader view on lordotic angle measurements among Ghanaians.

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APPENDICES

Below is a table containing the control samples (patients without low back pain) used for this study and their corresponding, gender, weight, age, L5 angles, S1 angles and lumbosacral angles.

NO	PATIENT ID	GENDER	WEIGHT (Kg)	AGE (yrs)	L5 BOTTOM INCLINED ANGLE	S1 INCLINED ANGLE	L/S ANGLE
1	4410/16	Female	52.0	27	5.27	13.34	18.48
2	4453/16	Female	79.0	54	7.66	21.34	13.61
3	2981/16	Female	49.0	17	7.51	14.23	6.45
4	4947/16	Female	46.0	43	16.36	32.07	15.34
5	4058/16	Female	58.0	64	14.51	21.77	7.28
6	4691/16	Female	46.0	15	16.82	49.27	33.81
7	2698/16	Male	26.0	13	13.04	28.22	14.82
8	1328/16	Female	57.0	50	31.50	46.51	17.43
9	396/16	Female	59.0	48	24.70	31.49	7.08
10	4694/16	Female	83.0	29	28.49	43.85	15.25
11	5328/16	Male	78.0	53	8.89	50.00	41.47
12	2142/16	Female	68.0	57	22.26	70.27	48.17
13	1789/16	Female	45.0	21	18.16	40.41	22.08
14	5885/16	Female	61.0	44	51.13	56.20	4.98
15	754/16	Female	56.0	14	38.57	40.33	2.00
16	4307/16	Female	60.0	60	3.87	19.12	15.42
17	3190/16	Female	65.0	51	24.75	59.57	34.61
18	3317/16	Male	60.0	19	7.43	21.77	14.62

19	932/16	Male	71.0	53	7.95	24.40	16.86
20	945/16	Male	109.0	29	9.97	24.39	14.57
21	6693/16	Male	62.0	20	33.86	48.90	15.75
22	2807/16	Female	75.0	56	16.04	32.59	16.47
23	1392/16	Female	77.0	54	2.78	12.90	10.37
24	4665/16	Female	70.0	57	17.64	27.39	9.53
25	1662/16	Female	58.0	48	28.85	66.29	36.65
26	2488/16	Female	50.0	24	20.63	26.57	5.92
27	4458/16	Male	70.0	49	6.42	35.65	29.82
28	6575/16	Female	70.0	68	18.75	35.71	17.12
29	181/16	Male	52.0	25	28.13	39.85	12.05
30	3297/16	Female	62.0	46	11.79	7.87	19.05
31	357/16	Female	47.0	26	10.16	31.25	21.44
32	5863/16	Female	54.0	53	33.28	41.00	8.12
33	5558/16	Female	92.0	62	15.86	38.06	22.35
34	5551/16	Female	57.0	59	26.25	30.29	4.45
35	4964/16	Male	82.0	42	11.53	35.81	24.18
36	5796/16	Female	66.0	48	24.50	53.28	28.21
37	4290/16	Female	86.0	55	13.92	25.92	12.21
38	3629/16	Female	71.0	65	4.12	7.69	3.82
39	6155/16	Female	72.0	32	31.11	69.5	38.63
40	4034/16	Female	55.0	62	27.95	41.45	13.75
41	4939/16	Female	73.0	44	23.24	43.20	19.70
42	5472/15	Female	42.0	58	16.07	27.34	12.00

43	2235/15	Female	60.0	30	21.60	32.46	10.83
44	2520/16	Female	82.0	32	35.39	63.15	27.50
45	237/16	Female	59.0	60	20.49	41.73	21.42
46	3102/16	Male	65.0	36	12.23	20.34	7.86
47	4041/16	Female	80.0	55	9.49	28.40	18.94
48	5600/16	Female	59.0	60	7.02	23.91	16.73
49	5238/16	Male	51.0	33	12.38	29.87	17.18
50	4181/16	Male	57.0	21	26.93	46.81	19.55
51	403/16	Female	50.0	19	19.43	24.39	9.16
52	6470/16	Female	70.0	40	12.70	28.34	15.69
53	3721/16	Male	56.0	59	27.57	45.49	17.70
54	5168/16	Male	75.0	49	17.71	40.96	24.09
55	3806/16	Female	56.0	21	32.12	42.85	10.85
56	149/16	Female	66.0	34	30.92	37.76	7.04
57	1838/16	Female	75.0	53	27.50	36.37	9.09
58	4033/16	Female	64.0	38	25.58	33.69	7.46
59	4775/16	Male	62.0	48	7.05	23.92	17.12
60	4471/16	Female	68.0	34	15.23	34.97	19.4
61	16773/15	Male	80.0	55	9.74	22.75	13.49
62	3152/16	Female	59.0	50	10.98	21.75	11.08
63	5410/16	Male	92.0	58	3.85	6.10	9.86
64	5263/16	Female	62.0	57	16.62	53.73	37.59
65	1758/16	Female	71.0	38	21.75	71.92	50.10
66	4340/16	Male	48.0	38	18.03	51.34	33.27

67	436/16	Female	71.0	49	13.39	25.05	14.49
68	4037/16	Female	49.0	73	10.39	25.05	14.49
69	3726/15	Female	55.0	87	17.65	36.43	18.79
70	6135/16	Male	54.0	57	22.3	54.25	32.57
71	6240/16	Female	58.0	53	15.79	21.96	6.11
72	6264/16	Female	68.0	52	12.41	32.75	19.83
73	1265/16	Male	64.0	26	19.42	20.52	1.97
74	4055/16	Female	67.0	44	28.42	22.77	14.62

Below is a table containing the sample of patients reported with low back pain used for this study and their corresponding, gender, weight, age, L5 angles, S1 angles and lumbosacral angles.

NO.	Patient ID	GENDER	WEIGHT (Kg)	AGE(yrs)	L5 BOTTOM INCLINED ANGLE	S1 INCLINED ANGLE	L/S ANGLE
1	5991/16	Female	65.0	32	20.58	48.73	28.41
2	2918/16	Female	82.0	44	25.09	10.75	14.71
3	5023/16	Female	55.0	82	9.85	24.41	14.53
4	5340/16	Female	54.0	70	36.77	51.72	14.67
5	2813/16	Female	86.0	60	51.38	53.45	2.22
6	773/16	Female	88.0	58	27.88	50.85	22.72
7	933/16	Female	80.0	51	25.41	14.41	10.73
8	4031/16	Female	59.0	54	8.63	23.49	14.83
9	3127/16	Male	76.0	63	39.89	45.61	6.00
10	888/16	Female	49.0	50	20.73	30.38	9.81
11	5302/16	Female	56.0	67	20.24	43.45	23.01
12	6527/16	Female	79.0	70	35.51	50.33	14.78
13	6555/16	Female	59.0	59	16.70	35.59	18.72
14	6312/16	Male	62.0	61	21.61	37.34	16.16
15	3787/16	Male	60.0	81	29.98	45.61	16.12
16	2273/16	Male	94.0	66	5.73	26.84	21.10
17	236/16	Female	57.0	78	29.98	38.91	8.96
18	5608/16	Female	72.0	55	1.83	18.07	15.69
19	5402/16	Female	50.0	68	30.19	30.27	∞

20	230/16	Female	80.0	54	17.50	33.04	15.47
21	4859/16	Female	63.0	49	12.56	60.52	48.11
22	7358/15	Male	105.0	32	21.74	34.76	12.19
23	4393/16	Male	56.0	32	37.14	43.31	6.42
24	5569/16	Male	92.0	39	18.54	32.81	13.77
25	6726/16	Male	56.0	55	23.37	28.40	4.83
26	6207/16	Female	58.0	46	13.99	26.02	11.84
27	2914/15	Female	53.0	80	35.52	37.41	1.74
28	4489/16	Male	55.0	29	23.70	37.40	13.42
29	4030/16	Female	74.0	40	13.78	34.43	20.86
30	101/16	Female	87.0	82	46.99	73.28	26.03
31	240/16	Female	80.0	78	39.43	39.01	23.87
32	1304/16	Female	60.0	53	8.27	19.00	10.82
33	4757/16	Female	73.0	63	26.48	49.93	20.18
34	3105/16	Female	54.0	58	16.18	22.29	6.19
35	4263/16	Female	56.0	48	23.45	32.66	9.42
36	6336/16	Male	66.0	59	39.36	53.20	13.42
37	1150/16	Female	65.0	65	33.04	37.69	5.27
38	6284/16	Male	61.0	47	27.44	38.11	10.80
39	2423/16	Male	96.0	0	16.25	44.02	27.96
40	5354/16	Male	57.0	81	30.75	47.60	17.27
41	5277/16	Female	62.0	62	17.73	64.83	47.10
42	418/16	Female	92.0	32	18.17	27.91	9.79
43	135/16	Female	84.0	45	23.79	37.87	14.28

44	5143/16	Male	40.0	82	7.53	18.62	10.89
45	2299/16	Male	75.0	58	27.66	52.50	24.48
46	4061/16	Female	68.0	53	32.74	31.40	1.54
47	6472/16	Female	75.0	65	25.95	32.13	6.33
48	85/16	Female	52.0	37	46.42	60.55	14.11
49	782/16	Female	65.0	67	23.79	45.33	21.39
50	3465/16	Male	55.0	24	25.63	38.18	11.87
51	5256/16	Male	70.0	59	19.73	28.94	9.10
52	6665/16	Male	104.0	40	7.94	24.04	16.42
53	1915/16	Female	57.0	74	33.18	33.90	∞
54	3299/16	Female	69.0	56	13.74	24..40	10.64
55	6229/16	Female	82.0	56	1.80	12.15	10.54
56	3699/16	Male	86.0	63	12.58	18.50	6.40
57	5217/16	Male	47.0	63	28.57	32.11	3.75
58	2645/16	Female	58.0	78	15.91	18.62	2.49
59	5858/16	Male	58.0	42	29.62	48.89	19.75
60	2653/16	Female	72.0	55	26.64	36.27	9.56
61	6335/16	Male	56.0	57	26.83	38.55	11.79
62	1289/16	Male	60.0	60	17.32	30.21	13.06
63	3149/16	Female	68.0	37	20.94	26.35	5.46
64	3719/16	Female	60.0	36	15.45	42.24	25.31
65	1792/16	Male	71.0	74	5.23	8.80	14.39
66	4800/16	Female	76.0	55	18.59	31.47	12.98
67	5036/16	Female	47.0	76	38.28	35.91	∞

68	5313/16	Female	107.0	56	25.76	33.12	7.31
69	1448/16	Female	56.0	63	19.30	22.00	2.84
70	4474/16	Female	73.0	40	13.30	30.35	17.14
71	5426/15	Female	60.0	68	24.64	28.90	4.16
72	4118/16	Female	81.0	55	16.41	23..86	7.42
73	966/15	Female	50.0	79	43.17	47.14	3.74
74	6550/16	Female	86.0	51	14.87	32.19	18.09
75	2219/15	Female	67.0	46	11.57	24.70	13.11
76	1299/16	Male	31.0	13	27.00	46.00	18.49
77	5265/16	Female	57.0	61	13.67	21.66	8.07
78	4164/16	Female	70.0	55	6.23	18.66	12.67
79	2289/16	Female	62.0	48	14.28	21.47	7.11
80	2838/16	Male	67.0	33	4.33	9.95	6.13
81	698/16	Male	70.5	55	15.40	22..49	7.26
82	4742/16	Female	80.0	65	33.20	65.50	31.96
83	725/16	Male	75.0	32	8.96	27.05	18.05
84	2569/16	Male	56.0	58	40.35	49.75	9.56
85	1291/16	Female	89.0	59	12.68	25.22	12.93
86	7880/16	Male	84.0	71	15.41	28.80	13.59
87	6056/16	Male	72.0	52	13.87	37.06	23.00
88	5493/16	Female	71.0	67	34.92	42.77	7.89
89	5091/16	Female	82.0	48	22.83	0.44	22.39
90	3268/16	Male	67.0	35	16.89	50.52	33.60
91	4382/16	Female	80.0	58	26.33	31.25	4.37

92	2402/16	Female	75.0	39	7.77	27.89	21.00
93	30785/15	Female	101.0	33	14.27	26.09	12.18
94	3194/16	Female	52.0	51	27.28	9.81	17.66
95	766/16	Female	65.0	62	23.57	35.54	13.03
96	5926/16	Female	52.0	80	26.41	40.69	14.05
97	3166/15	Female	66.0	61	15.22	25.42	10.23
98	2176/16	Male	60.0	50	15.37	30.26	15.12
99	559/16	Male	65.0	39	15.37	30.26	15.12
100	4899/16	Female	70.4	51	31.72	31.76	∞
101	2796/16	Male	46.0	93	0.57	5.59	5.31
102	4956/16	Female	57.0	50	28.82	47.33	18.43
103	5204/16	Female	77.0	69	25.67	37.45	11.32