Sudan University of Sciences & Technology

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Study of Normal Sudanese Cervical and Lumbar Curvature Angle Using Cobb Method in CT Imaging

دراسة زاوية انحناء الفقرات العنقية والقطنية الطبيعية باستخدام طريقة كوب لدي السودانين بالتصوير بالاشعة المقطعية المحوسبة

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بسم الله الرحمن الرحيم

الله لا إله إلا هو الحي القيوم لا تأخذه سنة ولا نوم له ما في
السموٰت وما في الأرض من ذا الذي يشفع عنده إلا بإذنه يعلم
ما بين أيديهم وما خلفهم ولا يحيطون بشيء من علمه إلا بما شاء
وسع كرسيه السموٰت والأرض ولا يؤوده حفظهما وهو العلي العظيم

صدق الله العظيم

سورة البقرة(255)

Dedication

To my parent

To my brothers

To my wife

To my friends

To everyone whom

Gave me a bit of wise advice

Acknowledgement

I wish to thank all those who helped me. Without them, I could not have completed this project.

This research could not have been written without Prof/Dr/ Caroline Edward Ayad, who not only served as my supervisor but also encouraged me.

To my colleague Mogahid M.A Zidan in Al-Zytouna Specialized Hospital and Mutasim Mahdi Hassan in Royal Care Hospital to helped me and I gave them my great thanks

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List of abbreviations

	abbreviations
CT	Computed Tomography
CAT	Computerized Axial Tomography
MSCT	Multi-slice Computed Tomography
PACs	picture archiving and communication system
C1-7	The cervical vertebrae
T1-12	The thoracic vertebrae
L1-5	The lumbar vertebrae
S1-5	The sacral vertebrae
Co 1- 4	The coccygeal vertebrae
MPR	Multi-planar Reconstruction

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Abstract

The purpose of this study was to standardize the normal values as reference for Cobb angle of cervical and lumbar vertebrae in normal Sudanese subjects using Computerized Tomography (CT).

This study was done at Al-Zytouna specialized hospital and Royal Care hospital from august 2015 to June 2018.

The sample (A) 200 lateral scouts CT scan of lumbar spine were obtained from (107males, 93 females).their ages were ranged from (21-80) years old, the sample (B) 90 lateral scouts CT scan of cervical spine were obtained from (66 males, 24 females).their ages were ranged from(22-60) years old. Toshiba CT scan machine was used with KV120- MA10 -50.

The Cobb angles were measured from L1 to L5 for both gender and correlated to their ages. The mean Cobb angle of lumbar vertebral in male was (30.59^0) and in female was (35.65^0).There was differences in Cobb angle of lumbar spine between males and females. The mean Cobb angles of lumbar vertebrae in males were found to be (4.77^0), (4.80^0), (4.64^0), (4.99^0), (7.16^0) and in females (5.42^0), (5.34^0), (5.28^0) (5.66^0), (8.05^0) for L1, L2, L3, L4 and L5 respectively. There were significant differences in the Cobb angle of lumbar spine between both genders at p=0.000.

The mean Cobb angle of cervical vertebral in males were found to be (5.42^0), (5.08^0), (5.01^0) and in females (4.45^0), (4.27^0), (4.09^0) for C3, C4, and C5 respectively. There were significant differences in Cobb angle of cervical spine between the both genders at p=0.000.

The mean Cobb angle end plate of the cervical and lumbar vertebrae differs significantly from males and females' Sudanese subjects.

ملخص الدراسة

الهدف من هذه الدراسة هو توحيد القيم الطبيعية كمرجع لزاوية العمود الفقري العنقي والقطني في السودانين باستخدام الاشعة المقطعية.

أجريت هذه الدراسة في مستشفى الزيتونة التخصصي ومستشفى رويال كير في الفترة من أغسطس 2015 إلى يونيو 2018.

عينة (أ) من 200 مريض وكان عدد الذكور107 و عدد الاناث 93 و تتراوح اعمارهم بين 21-80 سنة وعينة (ب) من 90 مريض وكان عدد الذكور66 و عدد الاناث 24 و تتراوح اعمارهم بين 22-60 سنة و تم استخدام جهاز اشعة مقطعية 64 شريحة و120 كيلوفولت و 10-50 مللي امبير.

تم قياس زوايا كوب من L1 إلى L5 لكل من الجنسين وارتباطها بأعمارهم. كانت متوسطات العمود الفقري للفقرات القطنية في الذكور (30.59^0) وفي الإناث (35.65^0) .كانت هناك اختلافات في زاوية كووب للعمود الفقري القطني بين الذكور والإناث. و متوسط زوايا كووب للفقرات القطنية في الذكور (4.77^0) ، (4.80^0) ، (4.64^0) ، (4.99^0) ، (7.16^0) ، وفي الإناث (5.42^0) ، (5.34^0) ، (5.28^0) (5.66^0) (8.05^0) لـ L1 و L2 و L3 و L4 و L5 على التوالي. هناك فروق ذات دلالة إحصائية في زاوية كووب من العمود الفقري القطني بين الجنسين في p = 0.000.

اظهرت النتائج متوسط زاوية كوب في العمود الفقري العنقي في الذكور (5.42^0) ، (5.08^0) ، (5.01^0) ، وفي الإناث (4.45^0) ، (4.27^0) ، (4.09^0) ل C3، C4 ، و C5 على التوالي. كانت هناك فروق ذات دلالة إحصائية في زاوية كووب من العمود الفقري العنقي بين الجنسين عند P = 0.000.

من خلال النتائج وجد ان هنالك اختلاف في لوحة نهاية زاوية كووب للفقرات العنقية القطنية بين الذكور والاناث في السودانين.

Chapter One

Introduction

Chapter One

Introduction

1-1 Introduction:-

The spine is an anatomical structure of repetitive motion and large compressive forces and therefore will be of high risk of degenerative changes. (Whitmarsh.T et.al, 2012)

The vertebral column called the spine, back bone, or spinal column, makes up about two-fifths of the total height and is composed of a series of bones called vertebrae. The vertebral column, the sternum, and the ribs form the skeleton of the trunk of the body. The vertebral column consists of bone and connective tissue. (Tortora and Derrickson, 2017)

The spinal cord that it surrounds and protects consists of nervous and connective tissues. At about 71 cm (28 in.) in an average adult male and about 61 cm (24 in.) in an average adult female, the vertebral column functions as a strong, flexible rod with elements that can move forward, backward , sideways and rotate. In addition to enclosing and protecting the spinal cord, it supports the head and serves as a point of attachment for the ribs, pelvic girdle, muscles of the back and upper limbs. The total number of vertebrae during early development is 33.As a child grows several vertebrae in the sacral and coccygeal regions fuse. As a result, the adult vertebral column typically contains 26 vertebrae. These are distributed as follows: seven cervical vertebrae in the neck region, twelve thoracic vertebrae posterior to the thoracic cavity, five lumbar vertebrae supporting the lower back, one sacrum consisting of five fused sacral vertebrae and one coccyx usually consisting of four fused coccygeal vertebrae.

The cervical, thoracic and lumbar vertebrae are movable, but the sacrum and coccyx are not. (Tortora and Derrickson, 2017)

The vertebral endplate is a thin layer of dense, subchondral bone adjacent to the intervertebral disc, which tends to be thinnest in the central region and thickest towards the periphery. (Edwards W.T et al, 2001)

Evaluation of bone morphology is important; the shape changes associated with normal aging are still under debate. There is no consensus on whether a mild wedging of the vertebral body is the result of a continuous remodeling with the advancing age or due to fractures. To be able to diagnose morphological changes, the normal should be well known. (Whitmarsh T et.al, 2012)

Computed tomography (CT), computerized axial tomography (CAT) an imaging method in which a cross-sectional image of the structures in a body plane is reconstructed by a computer program from the x-ray absorption of beams projected through the body in the image plane. (Kuettner and Flohr, 2006)

Spine CT are commonly requested for a herniated disc or narrowing of the spinal canal, also called spinal stenosis, but the most frequent use of spinal CT is to get a better look at spinal column damage in patients who have been injured. (Edwards.WT et al, 2001)

Computed Tomography is accepted as the imaging modality of choice in most skeletal diseases when structural or spatial information of the affected bones and articulations is needed. A special advantage of CT is its capability of a fast whole body examination that offers diagnostic information about all organ systems. When using the MSCT technique for whole-body evaluation, no additional CT examination is needed for musculoskeletal diagnosis in many cases. (Kuettner and Flohr, 2006)

The currently, the accepted measure for clinical assessment of spinal curve is the Cobb angle. The Cobb angle is measured on plane radiographs by drawing a line through the superior endplate of the superior end vertebra of spinal curve, and another line through the inferior endplate of the inferior-most vertebra of the same spinal curve, and then measuring the angle between these lines .Clinically, many Cobb measurements are still performed manually using pencil and ruler on hardcopy X-ray films, but PACs systems (computer networks) are increasingly used which allow manual Cobb measurements to be performed digitally by clinicians on the computer screen. As well as being used to assess scoliosis in the coronal plane, the Cobb angle is used on sagittal plane radiographs to assess thoracic kyphosis and lumbar lordosis. (Dougherty.G et al, 2011)

1-2 Problem of the study:

In conventional radiograph, the spinal curvature recognizes by using manual measurements but this method is not accurate. There for this study is a trial to find out to assess the curvature depending on CT measurements.

1-3 Objectives:

1-3-1General objective:-

To evaluate the vertebral curvature by evaluation the end plates.

1-3-2 Specific objective:-

1- To measure the superior and inferior end plates angles in normal cervical and lumbar vertebral.
2- To assess the finding related to age, gender, weight and body mass index (BMI).
3- To measure the vertebral body height (C3-C5 and L1-L5).
4- To find out the normal index to reach for the standardized normal finding.

1-4 Over view of study:-

Chapter one: consisted of the introduction, problem of the study, objectives, methodology of the research.

Chapter two: included literature review, anatomy, pathology, computed tomography (CT), Cobb technique.

Chapter three: included materials and methods.

Chapter four: included result presentation.

Chapter five: included discussion, conclusion & recommendations.

Chapter Two

Literature review

Chapter two

Theoretical background

2-1-1 Anatomy of the vertebral column:

The vertebral column, also called the spine, back bone, or spinal column, makes up about two-fifths of your total height and is composed of a series of bones called vertebrae. (Tortora and Derrickson, 2017)

The vertebral column, the sternum, and the ribs form the skeleton of the trunk of the body. The vertebral column consists of bone and connective tissue figure(2-1) .

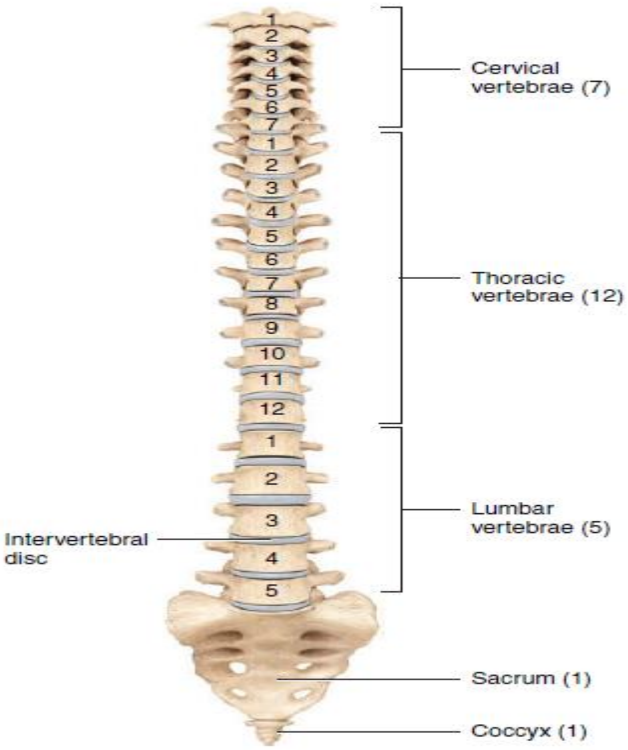

Figure (2-1): The anterior view showing regions of the vertebral column (Tortora and Derrickson, 2017)

The spinal cord that it surrounds and protects consists of nervous and connective tissues. At about 71 cm (28 in.) in an average adult male and about 61 cm (24 in.) in an average adult female, the vertebral column functions as a strong, flexible rod with elements that can move forward, backward, a sideways and rotate. In addition to enclosing and protecting the spinal cord, it supports the head and serves as a point of attachment for the ribs, pelvic girdle, muscles of the back and upper limbs. The total number of vertebrae during early development is 33.As a child grows several vertebrae in the sacral and coccygeal regions fuse. As a result, the adult vertebral column typically contains 26 vertebrae (Figure 2-1). These are distributed as follows: seven cervical vertebrae in the neck region, twelve thoracic vertebrae posterior to the thoracic Cavity, five lumbar vertebrae supporting the lower back, one sacrum consisting of five fused sacral vertebrae, one coccyx usually consisting of four fused coccygeal vertebrae. The cervical, thoracic, lumbar vertebrae are movable but the sacrum and coccyx are not. (Tortora and Derrickson, 2017)

2-1-2 Normal Curves of the Vertebral Column:

When viewed from the anterior or posterior, a normal adult vertebral column appears straight. But when viewed from the side, it shows four slight bends called normal curves (Figure 2-2).

Relative to the front of the body, the cervical and lumbar curves are convex (bulging out); the thoracic and sacral curves are concave (Cupping in). The curves of the vertebral column increase its strength, help maintain balance in the upright position, absorb shocks during walking, and help protect the vertebrae from fracture.

The fetus has a single anteriorly concave curve throughout the length of the entire vertebral column .At about the third month after birth, when an infant begins to hold its head erect; the anteriorly convex cervical curve develops. Later, when the child sits up, stands, and walks, the anteriorly convex lumbar curve develops. (Tortora and Derrickson, 2017)

The thoracic and sacral curves are called primary curves because they retain the original curvature of the embryonic vertebral column. The cervical and lumbar curves are known as secondary curves because they begin to form later, several months after birth. All curves are fully developed by age 10. However, secondary curves may be progressively lost in old age.

Various conditions may exaggerate the normal curves of the vertebral column, or the column may acquire a lateral bend, resulting in abnormal curves of the vertebral column. Three such abnormal curves-kyphosis, lordosis,and scoliosis. (Tortora and Derrickson, 2017)

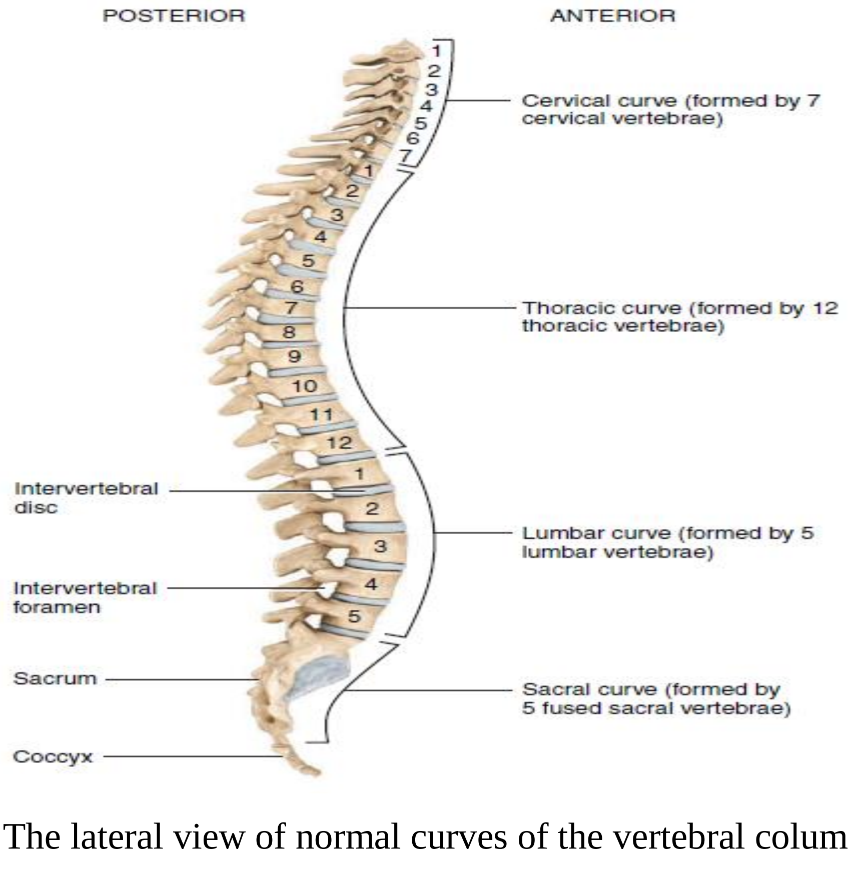

Figure (2-2): The lateral view of normal curves of the vertebral column. (Tortora and Derrickson, 2017)

2-1-3 Intervertebral Discs:

Intervertebral discs are found between the bodies of adjacent vertebrae from the second cervical vertebra to the sacrum (Figure 2-3) and account for about 25% of the height of the vertebral column. Each disc has an outer fibrous ring consisting of fibrocartilage called the annulus fibrosus and an inner soft, pulpy, highly elastic substance called the nucleus pulposus .

The superior and inferior surfaces of the disc consist of a thin plate of hyaline cartilage. The discs form strong joints, permit various movements of the vertebral column, and absorb vertical shock. Under compression, they flatten and broaden.

During the course of a day the discs compress and lose water from their cartilage so that we are a bit shorter at night. While we are sleeping there is less compression and rehydration occurs, so that we are taller when we awaken in the morning. With age, the nucleus pulposus hardens and becomes less elastic. Decrease in vertebral height with age results from bone loss in the vertebral bodies and not a decrease in thickness of the intervertebral discs. Since intervertebral discs are a vascular, the annulus fibrosus and nucleus pulposus rely on blood vessels from the bodies of vertebrae to obtain oxygen and nutrients and remove wastes. Certain stretching exercises decompress discs and increase general blood circulation, both of which speed up the uptake of oxygen and nutrients by discs and the removal of wastes. (Tortora and Derrickson, 2017)

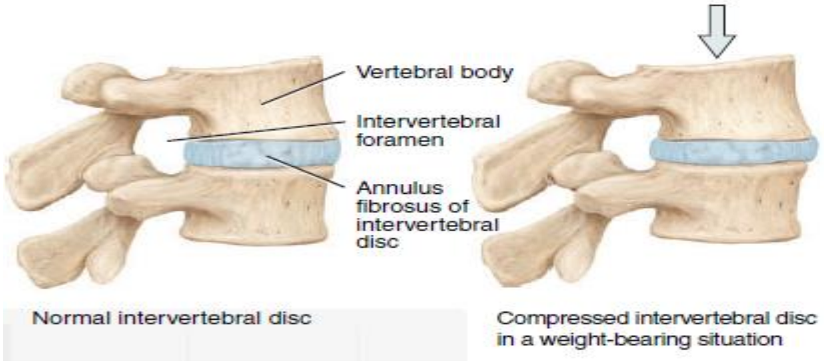

Figure (2-3): The lateral view of the intervertebral disc. (Tortora and Derrickson, 2017)

2-1-4 Parts of a Typical Vertebra:

Vertebrae in different regions of the spinal column vary in size, shape, and detail, but they are similar enough (Figure 2-4).Vertebrae typically consist of a vertebral body, a vertebral arch, and several processes. (Tortora and Derrickson, 2017)

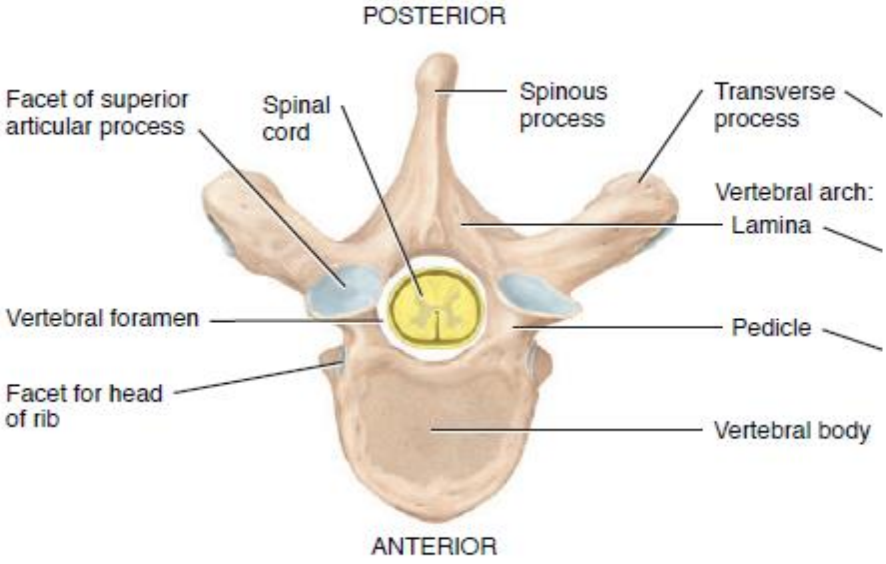

Figure (2-4): The superior view of a typical vertebra. (Tortora and Derrickson, 2017)

2-1-5 Vertebral Body:

The vertebral body, the thick, disc-shaped anterior portion, is the weight-bearing part of a vertebra. Its superior and inferior surfaces are roughened for the attachment of cartilaginous intervertebral discs.

The anterior and lateral surfaces contain nutrient foramina, openings through which blood vessels deliver nutrients and oxygen and remove carbon dioxide and wastes from bone tissue (Figure 2-5). (Tortora and Derrickson, 2017)

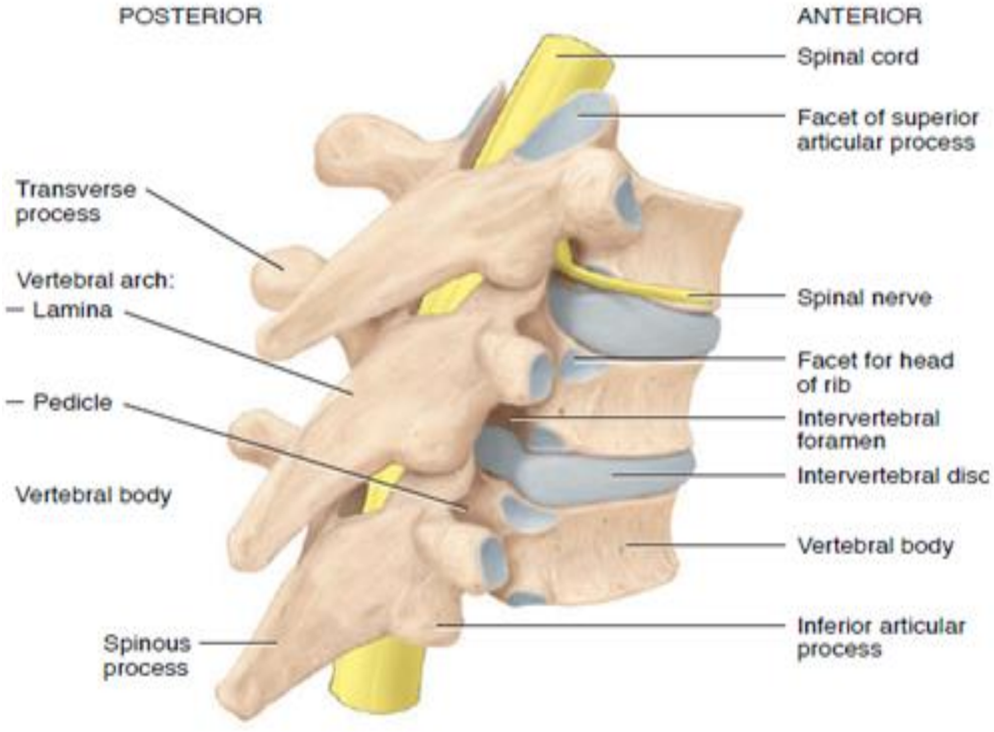

Figure (2-5): The right posterolateral view of articulated vertebrae. (Tortora and Derrickson, 2017)

2-1-6 Vertebral Arch:

Two short, thick processes, the pedicles, project posteriorly from the vertebral body and then unite with the flat laminae (thin layers) to form the vertebral arch. The vertebral arch extends posteriorly from the body of the vertebra; together, the vertebral body and the vertebral arch surround the spinal cord by forming the vertebral foramen. The vertebral foramen contains the spinal cord, adipose tissue, areolar connective tissue, and blood vessels. Collectively, the vertebral foramina of all vertebrae form the vertebral (spinal) canal. The pedicles exhibit superior and inferior indentations called vertebral notches. When the vertebral notches are stacked on top of one another, they form an opening between adjoining vertebrae on both sides of the column. Each opening, called an intervertebral foramen, permits the passage of single spinal nerve carrying information to and from the spinal cord. (Tortora and Derrickson, 2017)

2-1-7 Processes:

Seven processes arise from the vertebral arch. At the point where a lamina and pedicle join, a transverse process extends laterally on each side. A single spinous process (spine) projects posteriorly from the junction of the laminae. These three processes serve as points of attachment for muscles. The remaining four processes form joints with other vertebrae above or below. The two superior articular processes of a vertebra articulate (form joints) with the two inferior articular processes of the vertebra immediately above them. In turn, the two inferior articular processes of that vertebra articulate with the two superior articular processes of the vertebra immediately below them, and so on. The articulating surfaces of the articular processes, which are referred to as facets, are covered with hyaline cartilage. The articulations formed between the vertebral bodies and articular facets of successive vertebrae are termed intervertebral joints. (Tortora and Derrickson, 2017)

2-1-8 Age-related Changes in the Vertebral Column:

With advancing age the vertebral column undergoes changes that are characteristic of the skeletal system in general. These changes include reduction in the mass and density of the bone along with a reduction in the collagen-to-mineral content within the bone, changes that make the bones more brittle and susceptible to damage.

The articular surfaces, those surfaces where neighboring bones move against one another, lose their covering cartilage as they age; in their place rough bony growths form that lead to arthritic conditions.

In the vertebral column, bony growths around the intervertebral discs, called osteophytes, can lead to a narrowing (stenosis) of the vertebral canal. This narrowing can lead to compression of spinal nerves and the spinal cord, which can manifest as pain and decreased muscle function in the back and lower limbs. (Tortora and Derrickson, 2017)

2-1-9 Regions of the Vertebral Column:

The vertebral column is beginning superiorly and moving inferiorly. The regions are the cervical, thoracic, lumbar, sacral, and coccygeal. Note that vertebrae in each region are numbered in sequence, from superior to inferior. (Tortora and Derrickson, 2017)

2-1-9-1 cervical vertebrae:

The bodies of the cervical vertebrae (C1–C7) are smaller than all other vertebrae except those that form the coccyx (Figure 2-6).

Their vertebral arches, however, are larger. All cervical vertebrae have three foramina: one vertebral foramen and two transverse foramina (Figure 2-7). The vertebral foramina of cervical vertebrae are the largest in the spinal column because they house the cervical enlargement of the spinal cord. Each cervical transverse process contains a transverse foramen through which the vertebral artery and its accompanying vein and nerve fibers pass. (Tortora and Derrickson, 2017)

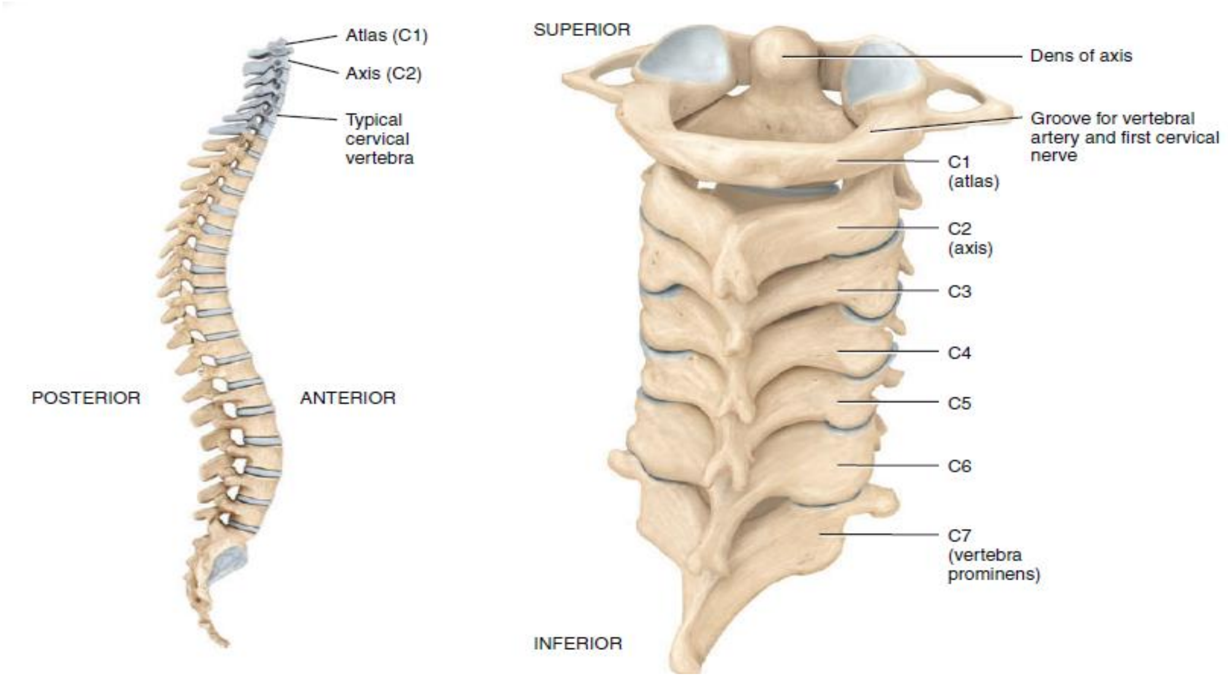

Figure (2-6): The regions of the vertebral column and cervical region. (Tortora and Derrickson, 2017)

The spinous processes of C2 through C6 are often bifid—that is, they branch into two small projections at the tips (Figure 2-7.c).

The first two cervical vertebrae differ considerably from the others. The atlas (C1) is the first cervical vertebra inferior to the skull (Figure 2-7.b). The atlas is a ring of bone with anterior and posterior arches and large lateral masses. It lacks a body and a spinous process. The superior surfaces of the lateral masses, called superior articular facets, are concave. They articulate with the occipital condyles of the occipital bone to form the paired atlanto-occipital joints.

The inferior surfaces of the lateral masses, the inferior articular facets, articulate with the second cervical vertebra. The transverse processes and transverse foramina of the atlas are quite large. The second cervical vertebra (C2), the axis (Figure 2-8), does have a vertebral body. A peglike process called the dens or odontoid process projects superiorly through the anterior portion of the vertebral foramen of the atlas. The dens makes a pivot on which the atlas and head rotate. This arrangement permits side to-side movement of the head.

The articulation formed between the anterior arch of the atlas and dens of the axis, and between their articular facets, is called the atlanto-axial joint. In some instances of trauma, the dens of the axis may be driven into the medulla oblongata of the brain. (Tortora and Derrickson, 2017)

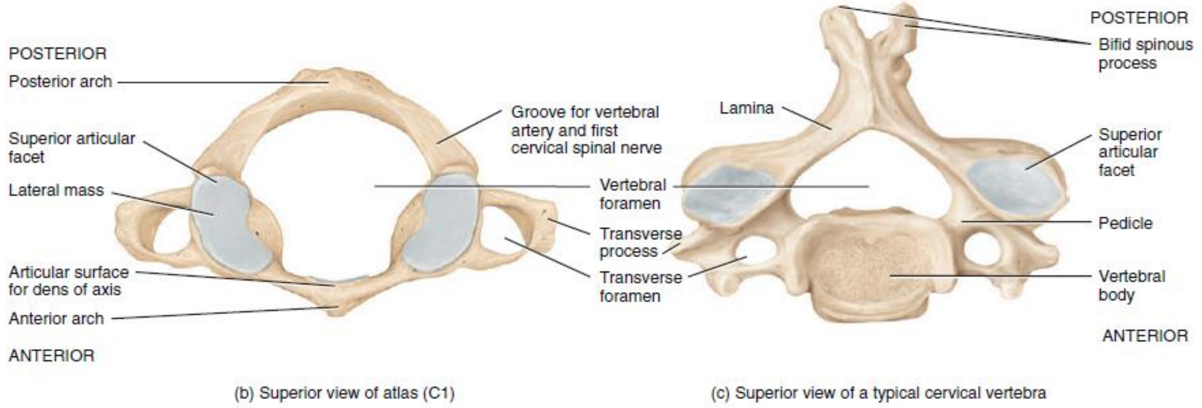

Figure (2-7): (b) First cervical vertebra, or Atlas, (c) 3-7 cervical vertebrae. (Tortora and Derrickson, 2017)

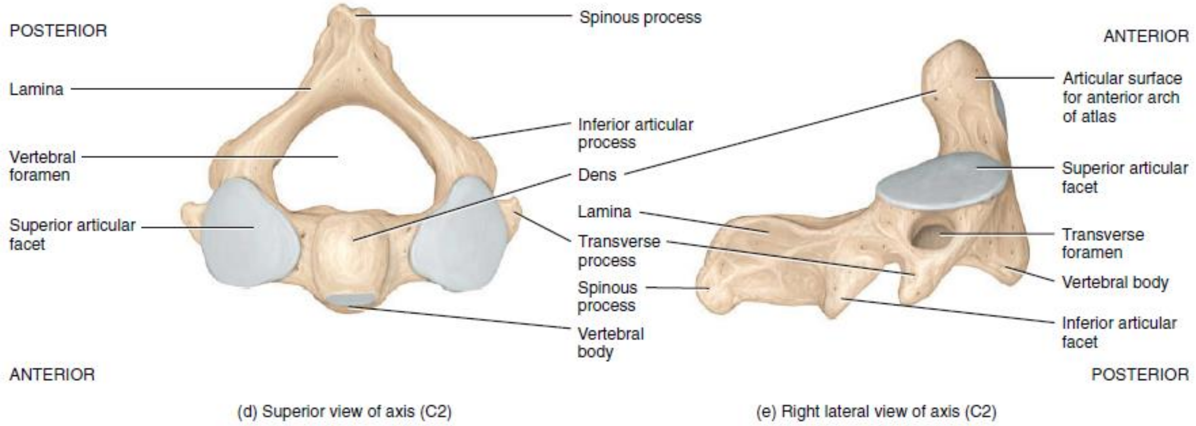

Figure (2-8): The second cervical vertebra (d), or axis (e). (Tortora and Derrickson, 2017)

The third through sixth cervical vertebrae (C3–C6), represented by the vertebra in figure (2-7), correspond to the structural pattern of the typical cervical vertebra previously described. The seventh cervical vertebra (C7), called the vertebra prominens, is somewhat different (Figure 2-6). It has a large, non-bifid spinous process that may be seen and felt at the base of the neck, but otherwise is typical. (Tortora and Derrickson, 2017)

2-1-9-2 Thoracic vertebrae:

Thoracic vertebrae (T1–T12; Figure 2-9) are considerably larger and stronger than cervical vertebrae. In addition, the spinous processes on T1 through T10 are long, laterally flattened, and directed inferiorly. In contrast, the spinous processes on T11and T12 are shorter, broader, and directed more posteriorly.

Compared to cervical vertebrae, thoracic vertebrae also have longer and larger transverse processes. They are easily identified by their costal facets which are articular surfaces for the ribs. The feature of the thoracic vertebrae that distinguishes them from other vertebrae is that they articulate with the ribs. Except for T11 and T12, the transverse processes of thoracic vertebrae have costal facets that articulate with the tubercles of the ribs. Additionally, the vertebral bodies of thoracic vertebrae have articular surfaces that form articulations with the heads of the ribs Figure (2-9). The articular surfaces on the vertebral bodies are called either facets or demifacets. A facet is formed when the head of a rib articulates with the body of one vertebra. A demifacet is formed when the head of a rib articulates with two adjacent vertebral bodies. In Figure (2-9), on each side of the vertebral body T1 has a superior facet for the first rib and an inferior demifacet for the second rib. On each side of the vertebral body of T2–T8, there is a superior demifacet and an inferior demifacet as ribs two through nine articulate with two vertebrae, and T10–T12 have a facet on each side of the vertebral body for ribs 10–12. These articulations between the thoracic vertebrae and ribs, called vertebrocostal joints, are distinguishing features of thoracic vertebrae. Movements of the thoracic region are limited by the attachment of the ribs to the sternum. (Tortora and Derrickson, 2017)

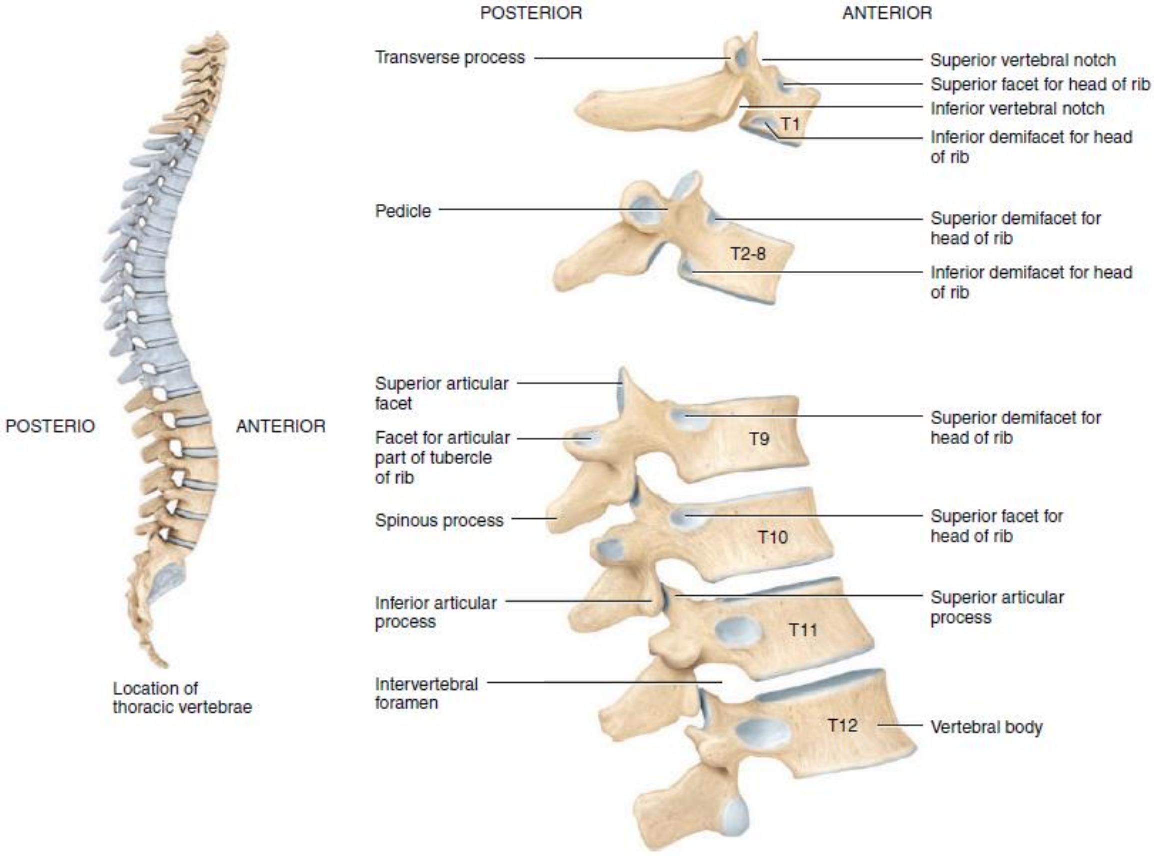

Figure (2-9): The regions of the vertebral column and thoracic region. (Tortora and Derrickson, 2017)

2-1-9-3 The lumbar vertebrae:

The lumbar vertebrae (L1–L5) are the largest and strongest of the unfused bones in the vertebral column (Figure 2-10) because the amount of body weight supported by the vertebrae increases toward the inferior end of the backbone, their variousprojections are short and thick. The superior articular processes are directed medially instead of superiorly, and the inferior articular processes are directed laterally instead of inferiorly.The spinous processes are quadrilateral in shape, are thick and broad, and project nearly straight posteriorly. The spinous processes are well adapted for the attachment of the large back muscles. (Tortora and Derrickson, 2017)

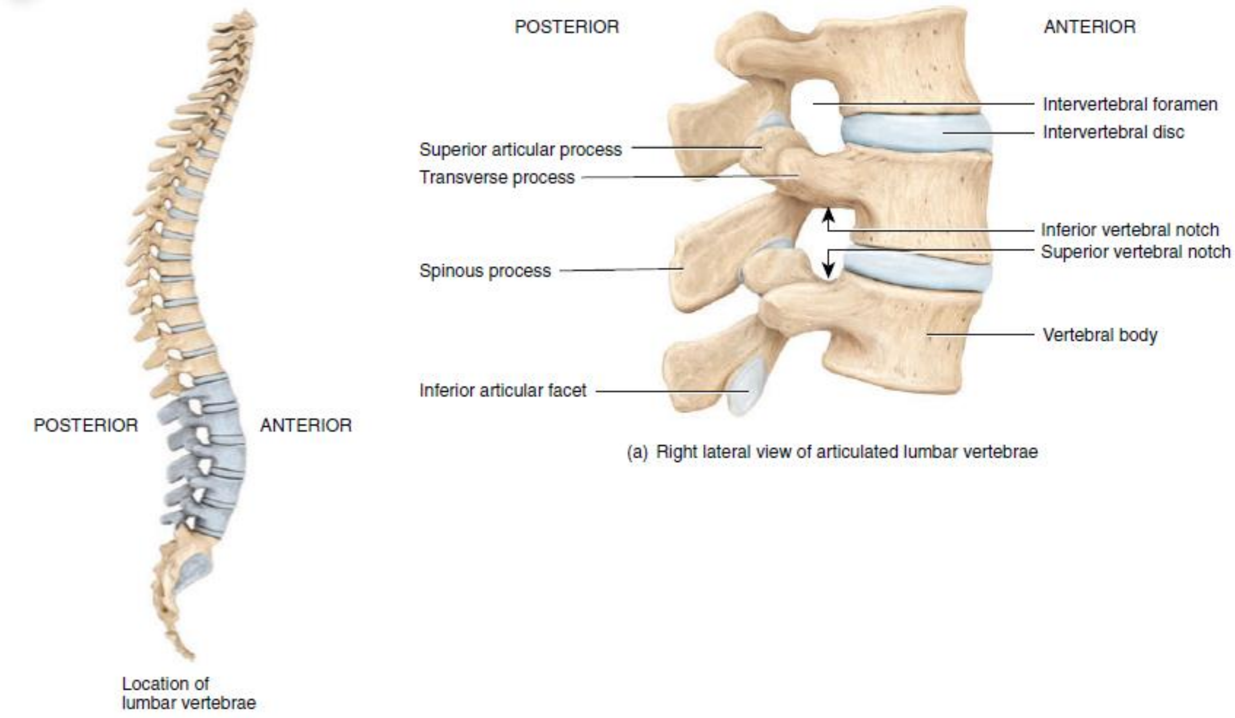

Figure (2-10): The regions of the vertebral column and lumbar region. (Tortora and Derrickson, 2017)

2-1-9-4 The sacrum:

The sacrum is a triangular bone formed by the union of five sacral vertebrae (S1–S5) (Figure 2-11). The sacral vertebrae begin to fuse in individuals between 16 and 18 years of age, a process usually completed by age 30. Positioned at the posterior portion of the pelvic cavity medial to the two hip bones, the sacrum serves as a strong foundation for the pelvic girdle. The female sacrum is shorter, wider, and more curved between S2 andS3 than the male sacrum.

The concave anterior side of the sacrum faces the pelvic cavity. It is smooth and contains four transverse lines that mark the joining of the sacral vertebral bodies (Figure 2-11). At the ends of these lines are four pairs of anterior sacral foramina. The lateral portion of the superior surface of the sacrum contains a smooth surface called the sacral ala, which is formed by the fused transverse processes of the first sacral vertebra (S1). (Tortora and Derrickson, 2017)

The convex, posterior surface of the sacrum contains a median sacral crest, the fused spinous processes of the upper sacral vertebrae; a lateral sacral crest, the fused transverse processes of the sacral vertebrae; and four pairs of posterior sacral foramina (Figure 2-11). These foramina connect with anterior sacral foramina to allow passage of nerves and blood vessels. The sacral canal is a continuation of the vertebral cavity. The laminae of thefifth sacral vertebra, and sometimes the fourth, fail to meet. This leaves an inferior entrance to the vertebral canal called the sacral hiatus on either side of the sacral hiatus is a sacral cornu (plural is cornua), an inferior articular process of the fifth sacral vertebra. They are connected by ligaments to the coccyx. (Tortora and Derrickson, 2017)

The narrow inferior portion of the sacrum is known as the apex. The broad superior portion of the sacrum is called the base. The anteriorly projecting border of the base, called the sacral promontory, is one of the points used for measurements of the pelvis. On both lateral surfaces the sacrum has a large ear-shaped auricular surface that articulates with the ilium of each hip bone to form the sacroiliac joint (Figure 2-11).

Posterior to the auricular surface is a roughened surface, the sacral tuberosity, which contains depressions for the attachment of ligaments. The sacral tuberosity unites with the hip bones to form the sacroiliac joints. The superior articular processes of the sacrum articulate with the inferior articular processes of the fifth lumbar vertebra, and the base of the sacrum articulates with the body of the fifth lumbar vertebra to form the lumbosacral joint. (Tortora and Derrickson, 2017)

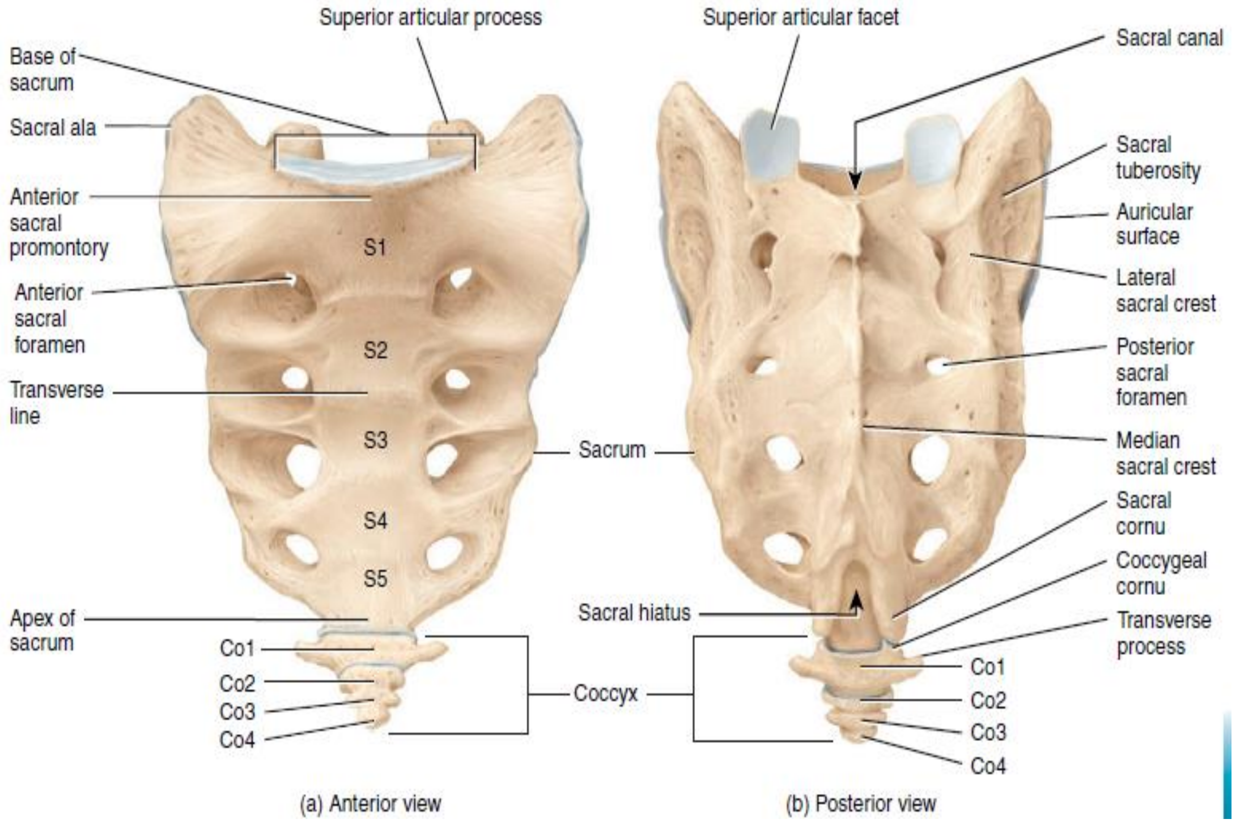

Figure (2-11): The sacral region and coccyx region. (Tortora and Derrickson, 2017)

2-1-9-5 The coccyx:

The coccyx, like the sacrum, is triangular in shape. It is formed by the fusion of usually four coccygeal vertebrae, indicated in (Figure 2-11) as Co1–Co4. The coccygeal vertebrae fuse somewhat later than the sacral vertebrae, between the ages of 20 and 30. The dorsal surface of the body of the coccyx contains two long coccygeal cornua that are connected by ligaments to the sacral cornua. The coccygeal cornua are the pedicles and superior articular processes of the first coccygeal vertebra. They are on the lateral surfaces of the coccyx, formed by a series of transverse processes; the first pair is the largest. The coccyx articulates superiorly with the apex of the sacrum. In females, the coccyx points inferiorly to allow the passage of a baby during birth; in males, it points anteriorly.

(Tortora and Derrickson, 2017)

2.2 Pathology:

2-2-1Scoliosis:

Scoliosis is an abnormal lateral curvature of the vertebral column (Fig. 2-12). A true scoliosis involves not only the curvature (right- or left-sided) but also a rotational element of one vertebra upon another. The commonest types of scoliosis are those for which we have little understanding about how or why they occur and are termed idiopathic scoliosis. These are never present at birth and tend to occur in either the infantile, juvenile, adolescent age groups. The vertebral bodies and posterior elements (pedicles and laminae) are normal in these patients. When a scoliosis is present from birth (congenital scoliosis) it is usually associated with other developmental abnormalities. In these patients, there is a strong association with other abnormalities of the chest wall, genitourinary tract, and heart disease. This group of patients needs careful evaluation by many specialists. A rare but important group of scoliosis is that in which the muscle is abnormal. The abnormal muscle does not retain the normal alignment of the vertebral column, and curvature develops as a result. Other disorders that can produce scoliosis include bone tumors, spinal cord tumors, and localized disc protrusions. (Drake.R.L et al, 2015)

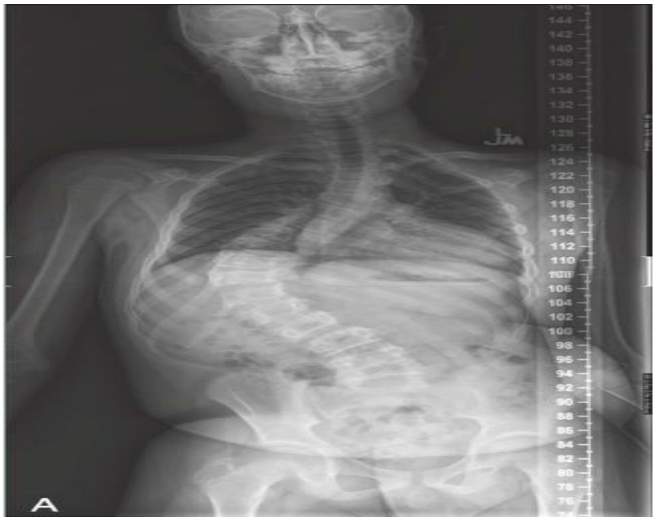

Figure (2-12): The scoliosis in lumbar region. (Drake.R.L et al, 2015

2-2-2Kyphosis:

Kyphosis is abnormal curvature of the vertebral column in the thoracic region, producing a “hunchback” deformity. This condition occurs in certain disease states, the most dramatic of which is usually secondary to tuberculosis infection of a thoracic vertebral body, where the kyphosis becomes angulated at the site of the lesion. This produces the gibbus deformity, a deformity that was prevalent before the use of anti tuberculous medication. (Drake.R.L et al, 2015)

2-2-3 Lordosis:

Lordosis is abnormal curvature of the vertebral column in the lumbar region, producing a swayback deformity. (Drake.R.L et al, 2015)

2-2-4 Fractures of the vertebral column:

Fractures of the vertebral column often involve C1, C2, C4–T7, and T12–L2. Cervical or lumbar fractures usually result from a flexion–compression type of injury such as might be sustained in landing on the feet or buttocks after a fall or having a weight fall on the shoulders.

Cervical vertebrae may be fractured or dislodged by a fall on the head with acute flexion of the neck, as might happen on diving into shallow water or being thrown from a horse. Spinal cord or spinal nerve damage may occur as a result of fractures of the vertebral column if the fractures compromise the foramina. (Drake.R.L et al, 2015)

2-2-5 Spina bifida:

Spina bifida is a disorder in which the two sides of vertebral arches, usually in lower vertebrae, fail to fuse during development, resulting in an “open” vertebral canal.There are two types of spina bifida. The commonest type is spina bifida occulta, in which there is a defect in the vertebral arch of L5 or S1. This defect occurs in as many as 10% of individuals and results in failure of the posterior arch to fuse in the midline. The more severe form of spina bifida involves complete failure of fusion of the posterior arch at the lumbosacral junction, with a large outpouching of the meninges. This may contain cerebrospinal fluid (a meningocele) or a portion of the spinal cord (a myelomeningocele). These abnormalities may result in a variety of neurological deficits, including problems with walking and bladder function. (Drake.R.L et al, 2015)

2-2-6 Herniation of intervertebral discs:

The disc between the vertebrae is made up of a central portion (the nucleus pulposus) and a complex series of fibrous rings (anulus fibrosus). A tear can occur within the anulus fibrosus through which the material of the nucleus pulposus can track. After a period of time, this material may track into the vertebral canal or into the intervertebral foramen to impinge on neural structures.

This is a common cause of back pain. A disc may protrude posteriorly to directly impinge on the cord or the roots of the lumbar nerves, depending on the level, or may protrude posterolateralty adjacent to the pedicle and impinge on the descending root. In cervical regions of the vertebral column, cervical disc protrusions often become ossified and are termed disc osteophyte bars. (Drake.R.L et al, 2015)

2-2-7 spondylosis:

The term spondylosis implies a loss of mechanical integrity of intervertebral disc, leading to instability of the affected segment and, later on, nerve root or cord compression symptoms caused by stenosis in either the intervertebral foramen or the spinal canal .Although spondylosis appears most obviously in the cervical spine because of its mobility, it may occur in other areas of the spine, especially the lower lumbar spine. The condition begins with intervertebral disc degeneration, which can occur as a result of damage to the disc or poor nutrition. A state of poor nutrition may result from changes at the cartilaginous end plate between the disc and the vertebral body, resulting in lack of nutritional interchange. (Magee, D.J .et al.2015)

2-2-8 The vertebrae and cancer:

The vertebrae are common sites for metastatic disease (secondary spread of cancer cells). When cancer cells grow within the vertebral bodies and the posterior elements, they destroy the mechanical properties of the bone A minor injury' therefore lead to vertebral collapse. Importantly, vertebrae that contain extensive metastatic disease may extrude fragments of tumor into the vertebral canal.compressing nerves and the spinal cord. (Drake.R.L et al, 2015)

2-3 Computed Tomography:

Computed Tomography is accepted as the imaging modality of choice in most skeletal diseases when structural or spatial information of the affected bones and articulations is needed. A special advantage of CT is its capability of a fast whole body examination that offers diagnostic information about all organ systems. When using the MSCT technique for whole-body evaluation, no additional CT examination is needed for musculoskeletal diagnosis in many cases. Specific image datasets that fulfill the requirements of musculoskeletal diagnosis can be calculated out of the primary raw dataset. However, best image quality is provided by focused musculoskeletal CT when optimized parameters are also applied for data acquisition. (Kuettner and Flohr, 2006)

2-3-1 Cervical Spine CT:

Patient position is supine and head first, arms parallel to the body, shoulders down, using headrest, remove dental prostheses, necklaces. Orthogonal positioning of the patient's head simplifies the image interpretation. Sagittal and coronal MPR are obligatory. Axially angulated reconstructions perpendicular to the spine are recommended when a detailed evaluation of the intervertbral discs, the vertebral body, or vertebral arch is demanded. Trauma diagnosis includes the injured vertebral body as well as each non injured adjacent segment cranially and caudally for surgical planning. (Kuettner and Flohr, 2006)

2-3-2 Lumbar Spine CT:

Standard patient position is supine and feet first, arms elevated, legs elevated for comfort. A small pitch value (up to 1.0) is recommended for short scan ranges (up to three vertebrae) for increased image quality. The examination of large spine ranges often requires higher pitch values. (Kuettner and Flohr, 2006)

2-4The Cobb Angle:

Currently, the accepted measure for clinical assessment of scoliosis is the Cobb angle. The Cobb angle is measured on plane radiographs by drawing a line through the superior endplate of the superior end vertebra of a scoliosis curve, and another line through the inferior endplate of the inferior-most vertebra of the same scoliotic curve, and then measuring the angle between these lines (Fig. 2-13). Clinically, many Cobb measurements are still performed manually using pencil and ruler on hardcopy X-ray films, but PACs systems (computer networks) are increasingly used which allow manual Cobb measurements to be performed digitally by clinicians on the computer screen. As well as being used to assess scoliosis in the coronal plane, the Cobb angle is used on sagittal plane radiographs to assess thoracic kyphosis and lumbar lordosis. (Dougherty.G et al, 2011)

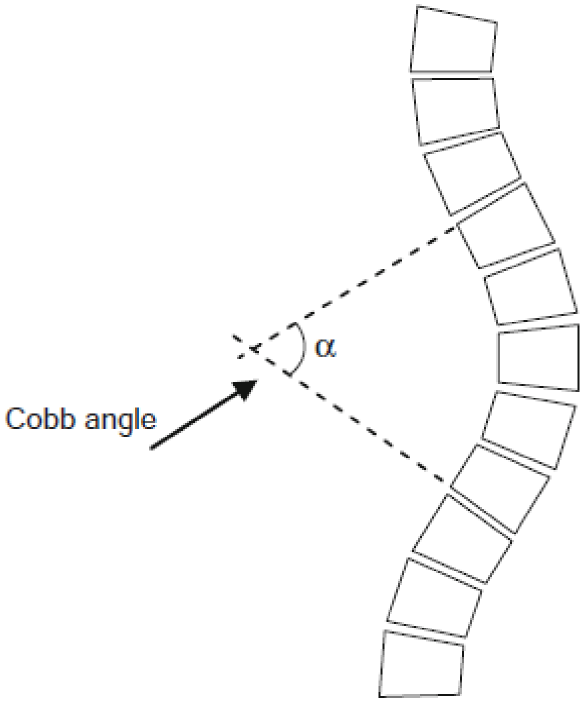

Figure (2-13) The Cobb angle measurement (Dougherty.G et al, 2011)

2-5 previous studies:

In study done by (HONG, J.Y et.al 2010) Ninety lateral lumbar radiographs were collected for the study. The radiographs were divided into normal (Cobb‹10^0), low grade (Cobb 10^0–19^0), high-grade (Cobb C ≥20^0) group to determine the reliability of Cobb L1–S1. (HONG, J.Y et.al, 2010)

In study by (SCHEER, J.K et al. 2013) the most common of which are Cobb angles typically measured from C-1 to C-7or C-2 to C-7. The 4-line method includes drawing a line either parallel to the inferior endplate of C-2 or extending from the anterior tubercle of C-1 to the posterior margin of the spinous process, and another line parallel to the inferior endplate of C-7. Perpendicular lines are then drawn from each of the 2 lines noted above and the angle subtended between the crossings of the perpendicular lines is the cervical curvature angle. In a symptomatic normal volunteer a large percentage (approximately 75%–80%) of cervical standing lordosis is localized to C1–2 and relatively little lordosis exists in the lower cervical levels. (SCHEER, J.K et al. 2013)

In study done by (HAY.O et.at2015) Compared to males, the female spine manifested a statistically significant greater curvature, a caudally located lordotic peak, and greater cranial peak height. As caudal peak height is similar for males and females, the deeper lordosis among females is due partially to the fact that the upper part of the female lumbar curve is positioned more dorsally. (HAY, O et.al, 2015)

In study done by (KOROVESSIS PG et.al 2015) a study conducted using the Cobb angle measurement on plain radiographs (x-rays taken of individuals in a standing position) of an asymptomatic Greek population, demonstrated that thoracic kyphosis and lumbar lordosis (T12-S1, L1-L5) were not sex-related. (KOROVESSIS PG et.al 2015)

In study done by(AYAD, C. E et.al, 2013) showed significant difference at p value 0.05, the end plates angles were affected as the subjects ages increase. The study concluded that the mean Cobb angle end plate differs significantly from males and females Sudanese subjects and it has relation with age and the values differs from what was mentioned in the previous studies. (AYAD, C. E et.al, 2013)

In study done by (MURRIE ,VL.et.al, 2003) the results confirm known observations that lumbar lordosis is more prominent in women ($P < 0.01$) and those with a higher body mass index ($P < 0.04$), we were unable to demonstrate any significant variation in lordosis with age. (MURRIE, VL et.al, 2003)

In study done by (OYAKHIRE, M.O et.al, 2013) the mean (± SD) of the Lumbar lordotic angle was 48.45^0 ± (9.28^0). A statistically significant association was found between Lumbar lordotic angle and age ($P<0.05$). Females had significantly higher Lumbar lordotic angles compared with males ($P<0.05$). (OYAKHIRE, M.O et.al, 2013)

In study done by (Been, E., et.al, 2017) the total cervical lordosis of males and females was similar. Males had smaller upper cervical lordosis (Foramen magnum–C3) and higher lower cervical lordosis (C3–C7) than females. The sum of vertebral body wedging of males and females is kyphotic (anterior height smaller than posterior height).Males had more lordotic intervertebral discs than females. Half of the adults (51%) had lordotic cervical spine, 41% had straight spine, and less than 10% had double curve or kyphotic spine. (Been, E., et.al, 2017)

In study done by (Damasceno, L.H.F, et.al, 2006) the angular value of lumbar lordosis and the role of vertebral bodies and intervertebral discs in its constitution were studied in normal individuals. X-Ray images of lumbar spine were studied in 350 normal and asymptomatic individuals, ages ranging from 18 to 50 years old (average 29.0 years old ± 8.24), being 143 males and 207 females. The lumbosacral (L1S1) and the lumbolumbar (L1L5) curves were measured. A significant difference was seen between males and females for lumbar curvature measurements. Age-related differences were found in lumbar curvature and vertebral bodies measurements. (Damasceno, L.H.F, et.al, 2006)

In study done by (Busche-McGregor, M, et.al, 1981) the lateral lumbar x-ray films of 60 asymptomatic adults ranging in age from 18 to 30 years were analyzed with respect to 19 end-plate angles and the vertebral body heights. The mean, standard deviation and variance for each of the angles and heights measured is reported, and statistical evaluation is made to determine any difference between the male and female lordosis. No significant difference was found, other than the vertebral heights of L1, L3, L4 and L5 which were statistically larger in males. A fairly consistent pattern of vertebral heights was noted with respect to the level of the lumbar spine measured. Differences in the end-plate angles in each segmental region of the lumbar spine were calculated, and the angulation of the curve was found to increase the farther down the lordosis that measurements were taken. (Busche-McGregor.M, et.al, 1981)

Chapter Three

Material and Methods

Chapter Three

Material and methods

3-1 Material:

3-1-1 the sample of the study:

This study was done at Al-Zytouna specialized hospital and Royal Care hospital from august 2015 to June 2018.

The sample (A) 200 lateral scouts CT scan of lumbar spine were obtained from (107males, 93 females).their ages were ranged from (21to80) years old, the sample (B) 90 lateral scouts CT scan of cervical spine were obtained from (66 males, 24 females).their ages were ranged from (22 to 60) years old.

3-1-2 Inclusion criteria:

Patient above 20 years of age, without history of pain in cervical and lumbar vertebrae

3-1-3 Exclusion criteria:

The traumatic cases, any disease of the vertebral column, spinal canal, para vertebral muscles diseases cases were excluded

3-1-4 the machine used:

Toshiba CT 64 slices, the parameters which are used shown in the table below:

Table (3.1) parameters and machine are used

Parameter	Cervical spine	Lumbar spine
Kvp	120	120
MA	10-50	10-50
Slice thickness	2mm	5mm
Beam collimation	0.5*64mm	0.5*64mm
Time per rotation	0.65/0.5mm	0.65/0.5mm

Figure (3-1): Toshiba CT scanner

3-2 Methods:

3-2-1 Technique:

For cervical spine Patients lied on the examination table in supine position with head first and use the headrest with the neck support cushion. Centre the Patient with the light beam indicator making certain his shoulders reach the headrest, isocenter is in Sternal notch.

For lumbar the feet first and hands behind the head and there are bands under his feet and another one under his head and the isocenter is in xphisternal process then scout views were obtained.

In the cervical, the segments measurements were taken by drawing a perpendicular to a line drawn across the superior endplate of the upper-ends of C3, C4, C5 vertebra and the inferior endplate of the lower-end of the same vertebra.

In the lumbar, the segments measurements were taken by drawing a perpendicular to a line drawn across the superior endplate of the upper-ends of L1, L2, L3, L4, L5 vertebra and the inferior endplate of the lower-end of the same vertebra. The global angle measurements were taken by drawing a perpendicular to a line drawn across the superior endplate of the upper-end of L1 and inferior endplate of the lower-end of L5. The vertebral body height of each vertebral obtained and body mass index calculated

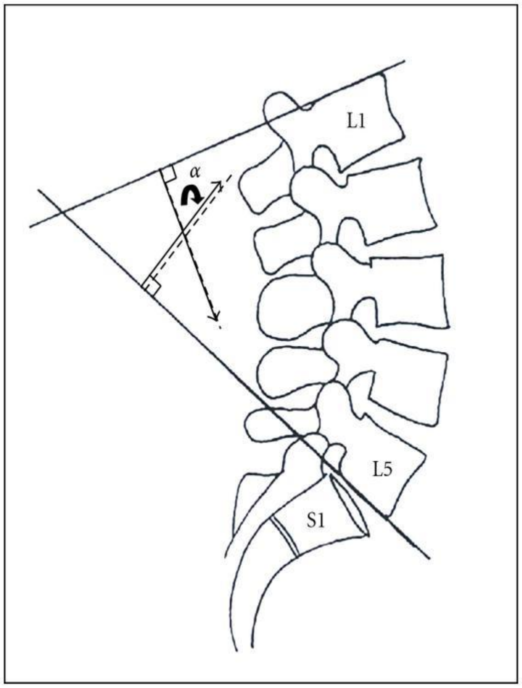

Figure (3-2) The Cobb angle measurement (Damasceno, L.H.F, et.al, 2006)

3-2-2 image interpretation:

All images were studied and the following data were collected from CT images and Cobb angles, vertebral body height were measured by computer program in the CT .CT diagnosis was seen from the radiologist reports.

3-3 Data analysis:

The collected data was analyzed statistically by using SPSS program version 25.

Chapter Four

The result

Chapter Four

The result

4-1 The result:

Table 4.1: Distribution of the sample (A) according to gender

Gender	Frequency	Percent
Female	93	46.5%
Male	107	53.5%
Total	200	100%

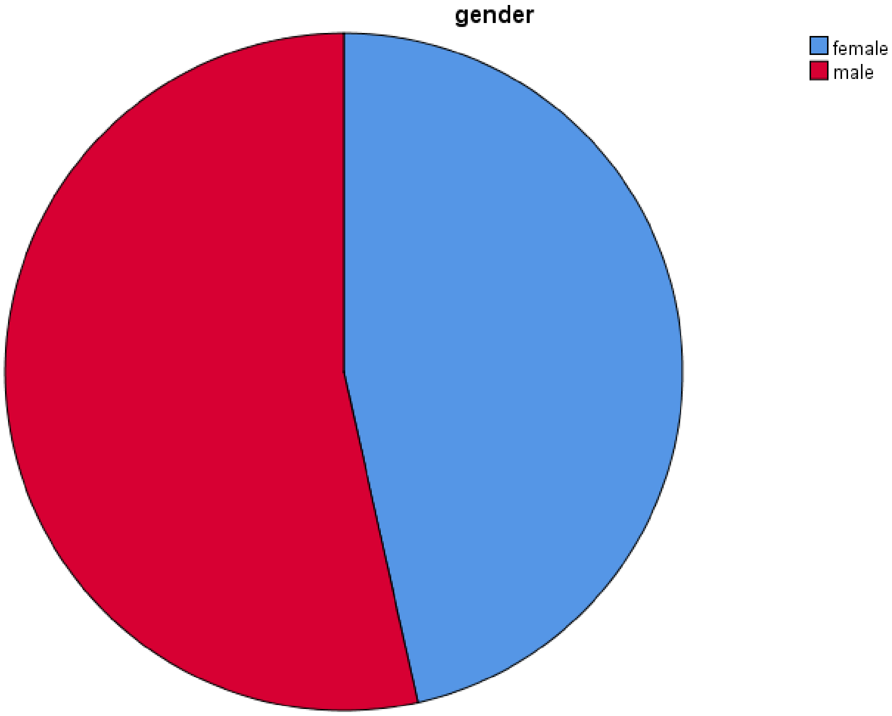

Figure (4-1): Distribution of the sample (A) according to gender

Table 4.2: Distribution of the sample (B) according to gender

Gender	Frequency	Percent
Female	24	26.7%
Male	66	73.3%
Total	90	100%

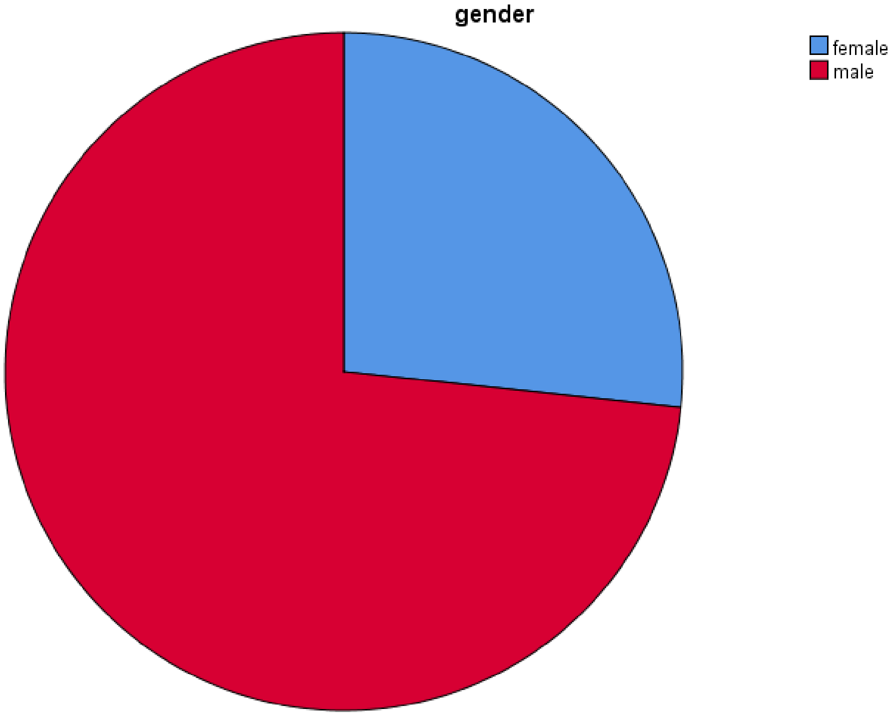

Figure (4-2): Distribution of the sample (B) according to gender

Table 4.3: Results for both gender including age classes, mean and standard deviation of lumbar Cobb angles

Age classes	Gender	L1 Mean± SD	L2 Mean± SD	L3 Mean± SD	L4 Mean± SD	L5 Mean± SD
21-30	Male	5.47±1.5	5.17±1.4	5.06±1.4	5.50±1.7	8.12±2.3
	Female	5.37±1.1	5.4±1.0	5.17±0.9	5.52±0.9	7.4+±2.1
31-40	Male	4.59±1.2	4.86±1.1	4.90±1.3	5.21±1.9	7.04±2.6
	Female	5.36±1.0	5.33±0.8	5.23±0.8	5.56±1.1	7.77±2.3
41-50	Male	4.98±1.7	4.91±1.4	4.67±1.4	5.47±2.4	7.51±3
	Female	5.30±1.0	5.22±0.9	5.25±0.8	5.82±1.4	9.05±4.2
51-60	Male	4.33±0.9	4.34±1.1	3.99±1.0	4.04±1.1	6.34±2.7
	Female	5.57±1.0	5.31±0.8	5.30±0.9	5.85±1.2	8.20±3.0
61-70	Male	4.83±1.7	4.80±1.5	4.95±1.5	5.03±1.8	7.47±2.7
	Female	5.64±0.9	5.49±0.9	5.54±0.9	5.65±1.1	7.50±2.9
71-80	Male	4.25±0.8	4.68±0.6	3.82±0.6	4.13±1	5.86±2.8
	Female	5.20±1.0	5.43±0.5	5.13±0.9	5.46±1.2	8.53±2

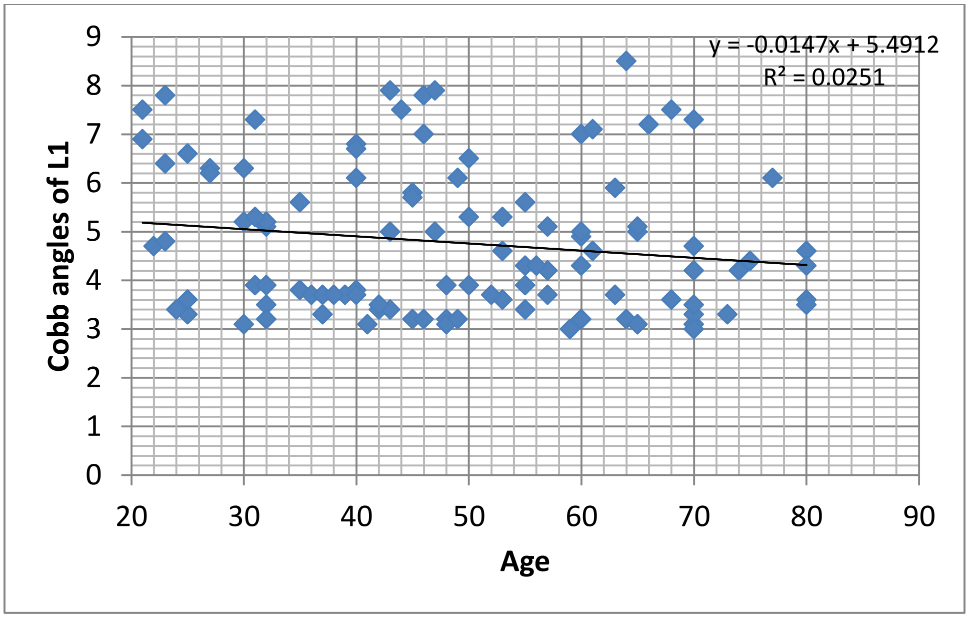

Figure (4-3): Scatter plot diagram shows the linear relationship between Cobb's angle of L1 and Age group for male.

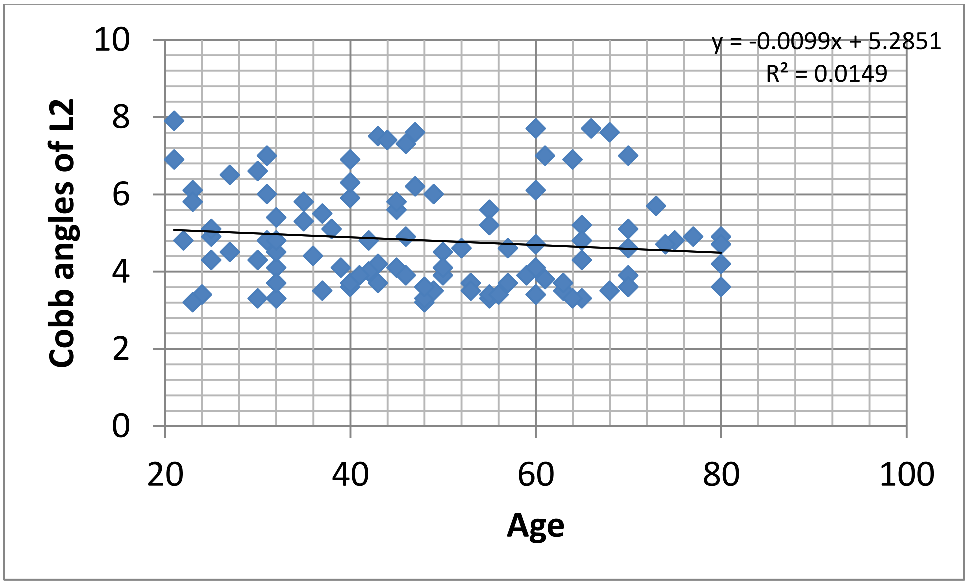

Figure (4-4): Scatter plot diagram shows the linear relationship between Cobb's angle of L2 and Age group for male.

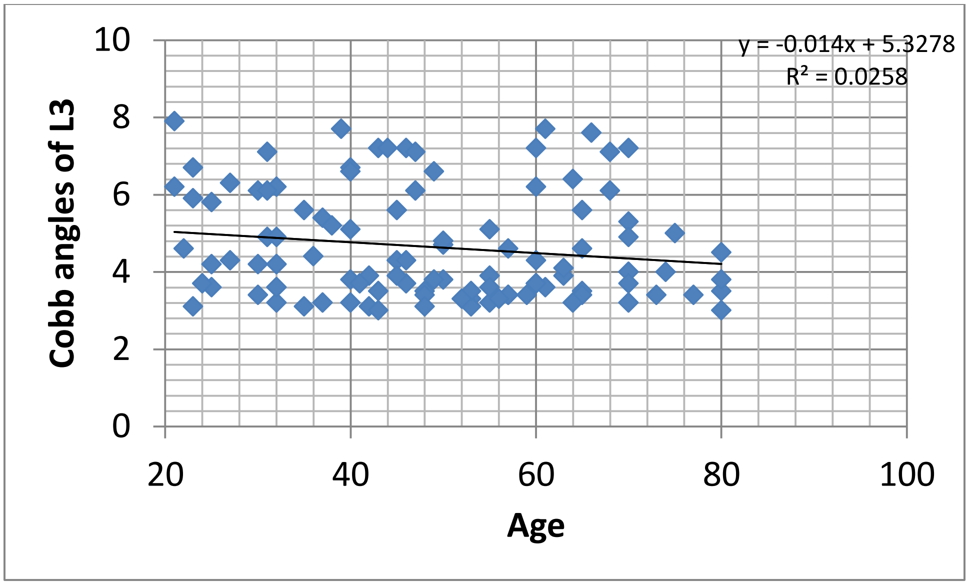

Figure (4-5): Scatter plot diagram shows the linear relationship between Cobb's angle of L3 and Age group for male.

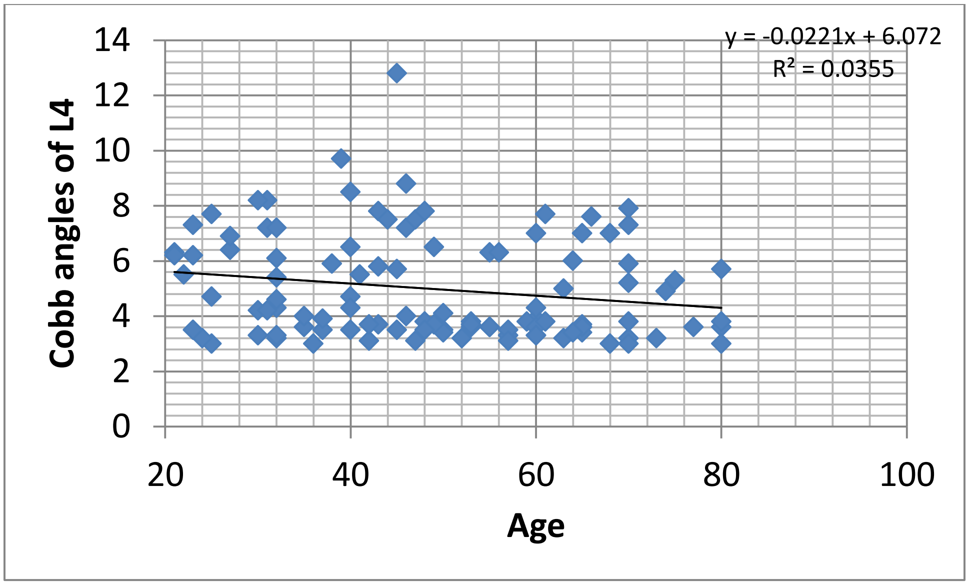

Figure (4-6): Scatter plot diagram shows the linear relationship between Cobb's angle of L4 and Age group for male.

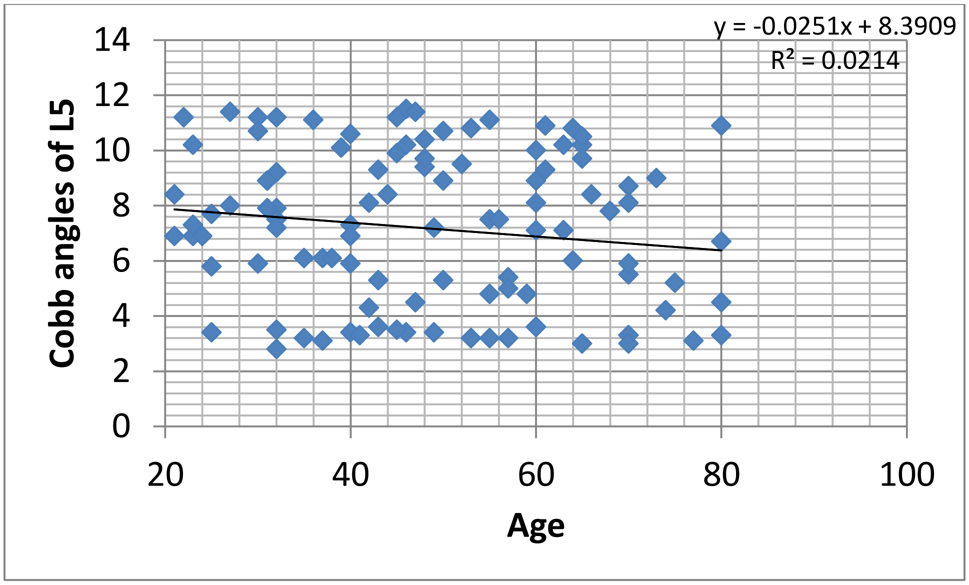

Figure (4-7): Scatter plot diagram shows the linear relationship between Cobb's angle of L5 and Age group for male.

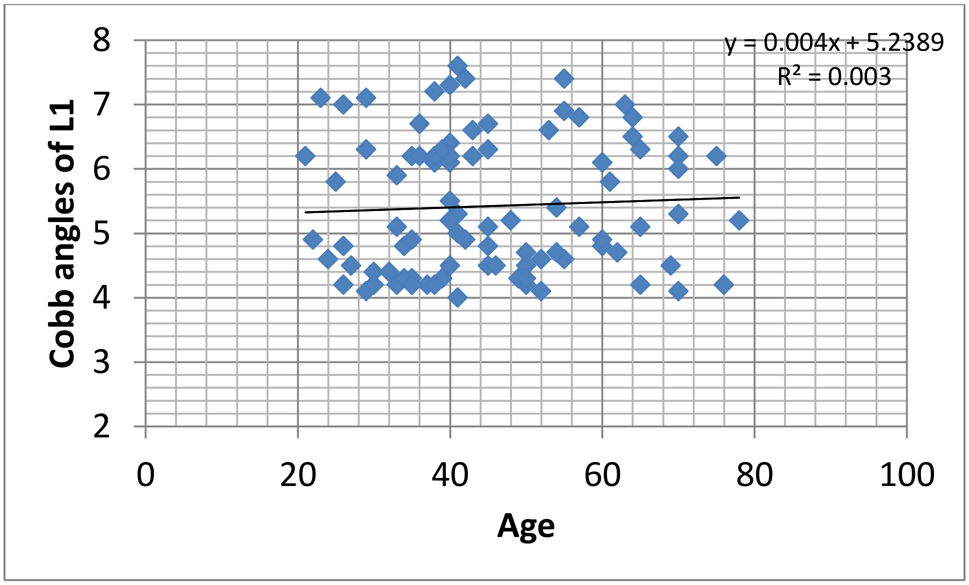

Figure (4-8): Scatter plot diagram shows the linear relationship between Cobb's angle of L1 and Age group for Female.

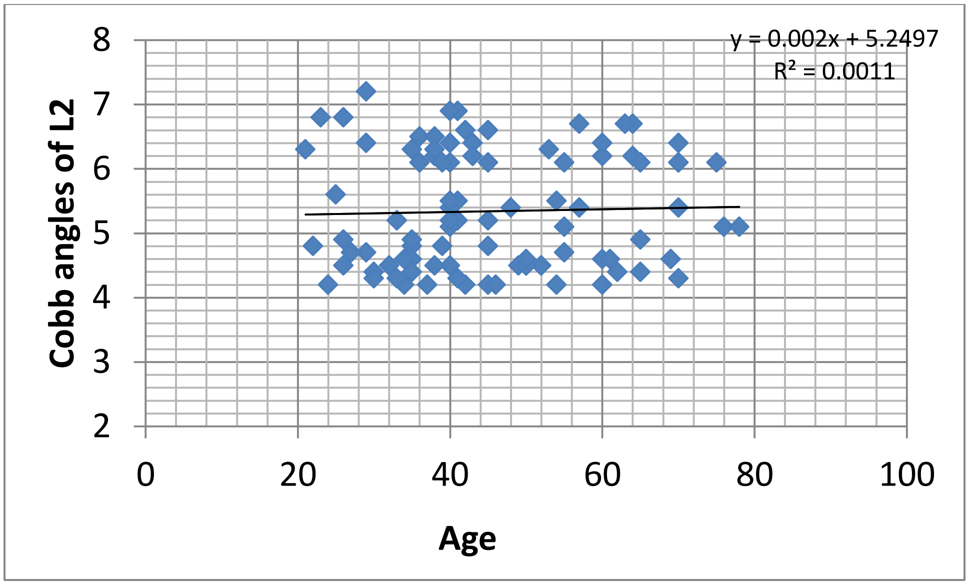

Figure (4-9): Scatter plot diagram shows the linear relationship between Cobb's angle of L2 and Age group for Female.

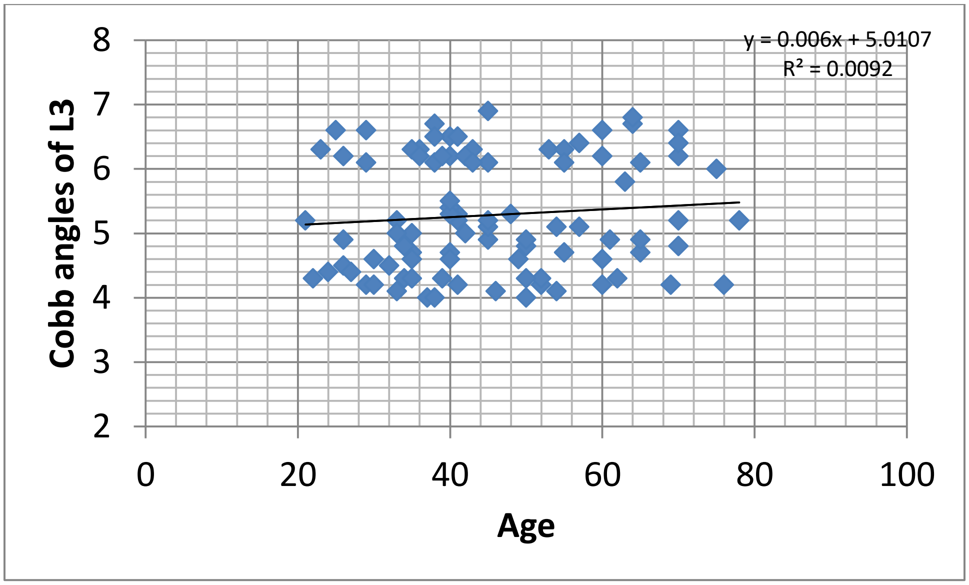

Figure (4- 10): Scatter plot diagram shows the linear relationship between Cobb's angle of L3 and Age group for Female.

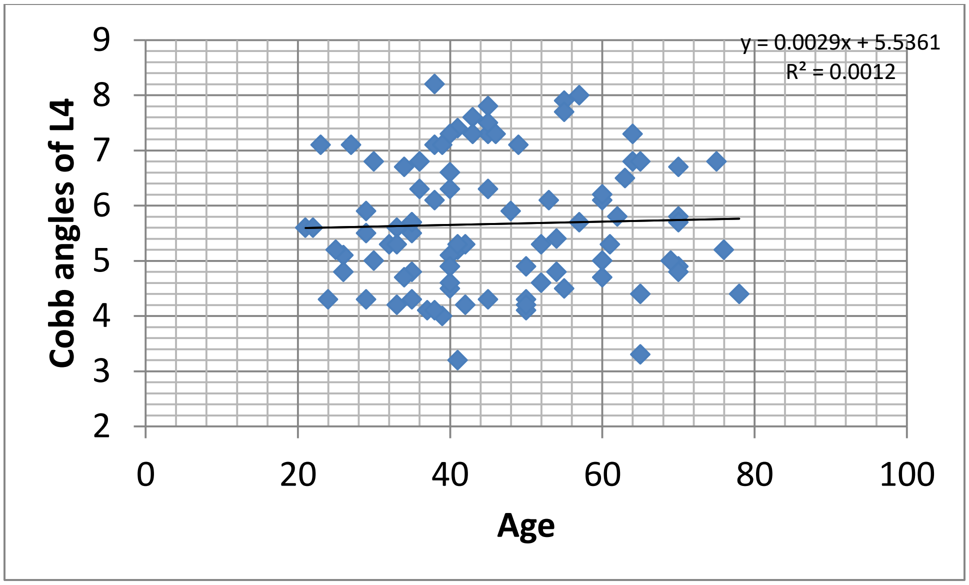

Figure (4-11): Scatter plot diagram shows the linear relationship between Cobb's angle of L4 and Age group for Female.

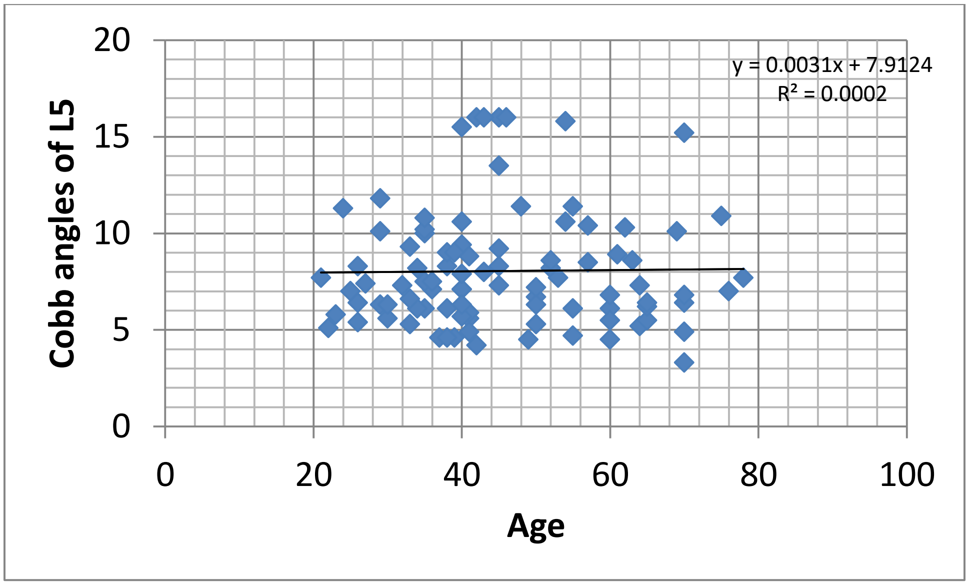

Figure (4-12): Scatter plot diagram shows the linear relationship between Cobb's angle of L5 and Age group for Female.

Table 4.4: shows results for both gender including body mass index classes, mean and standard deviation of lumbar Cobb angles

BMI classes kg/m²	**Gender**	**L1 Mean± SD**	**L2 Mean± SD**	**L3 Mean± SD**	**L4 Mean± SD**	**L5 Mean± SD**
18.5-24.9	Male	4.69±1.1	4.78±1.2	4.49±1.3	4.73±1.6	6.82±2.7
	Female	5.43±1.0	5.33±0.9	5.30±0.9	5.74±1.1	7.77±2.6
25-29.9	Male	4.87±1.6	4.82±1.4	4.85±1.5	5.34±2.2	7.63±2.7
	Female	5.34±0.9	5.29±0.8	5.21±0.8	5.53±1.1	8.30±3.3
30-39.9	Male	0±0	0±0	0±0	0±0	0±0
	Female	6.25±1.4	6.02±1.0	5.97±0.7	6.50±1.2	7.80±0.8

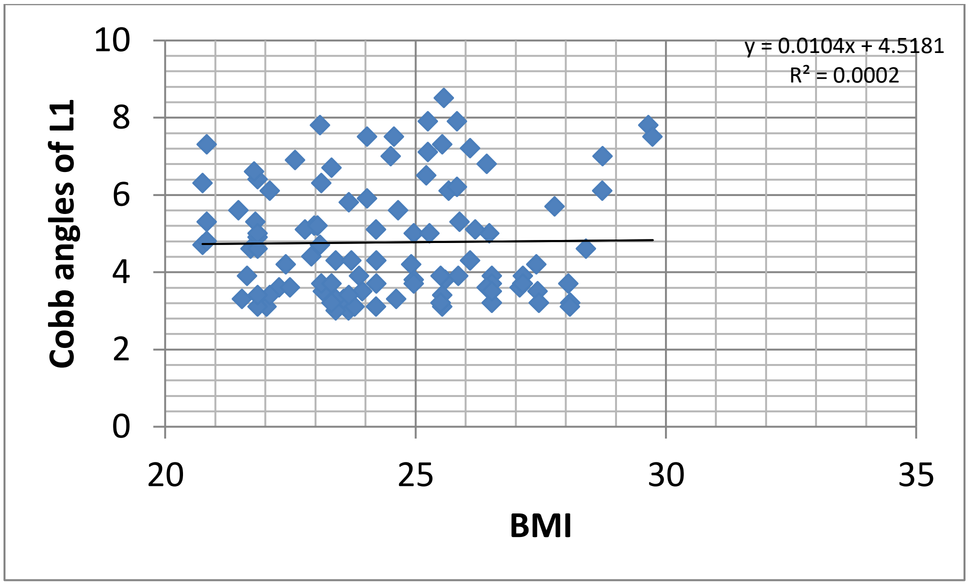

Figure (4- 13): Scatter plot diagram shows the linear relationship between Cobb's angles of L1and BMI group for male.

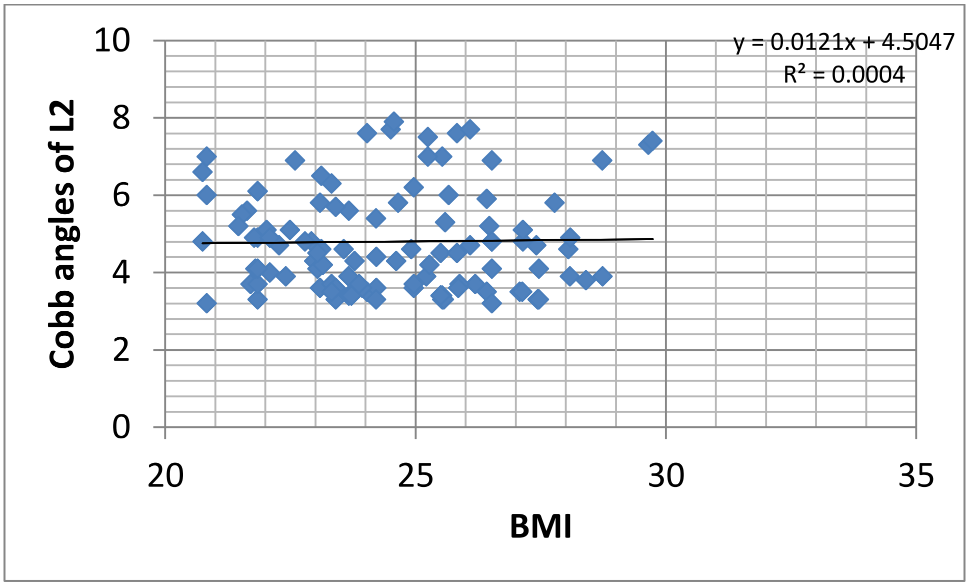

Figure (4- 14): Scatter plot diagram shows the linear relationship between Cobb's angles of L2and BMI group for male.

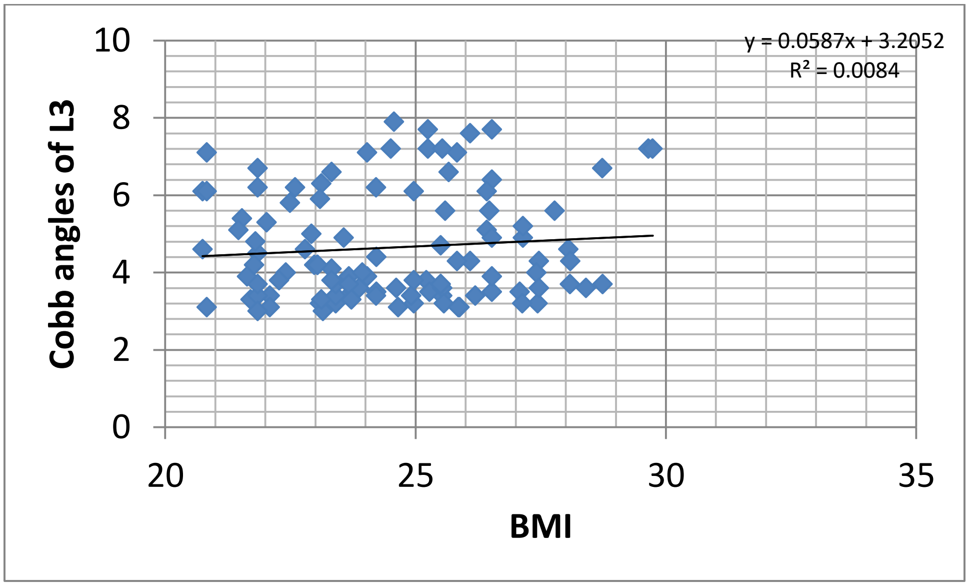

Figure (4-15): Scatter plot diagram shows the linear relationship between Cobb's angles of L3and BMI group for male.

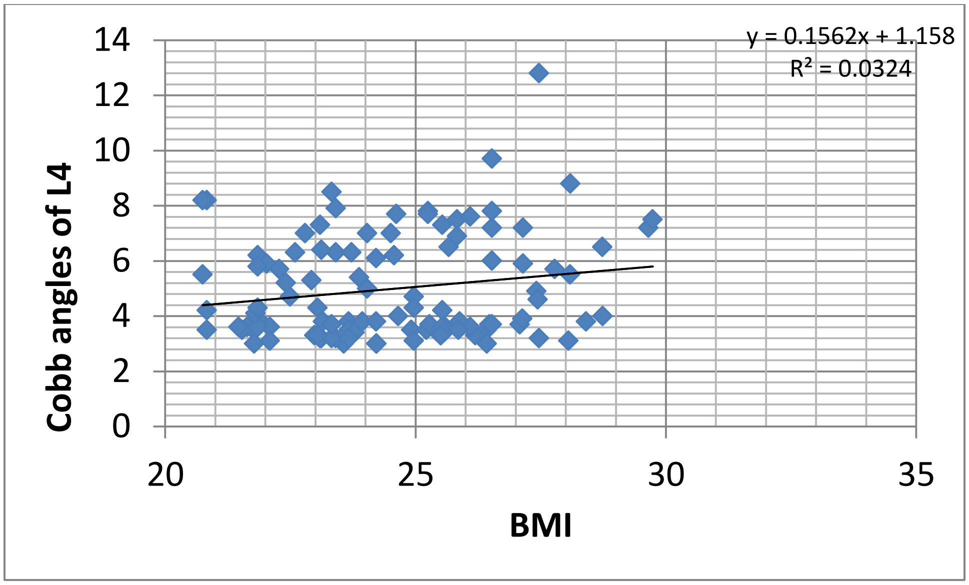

Figure (4-16): Scatter plot diagram shows the linear relationship between Cobb's angles of L4and BMI group for male.

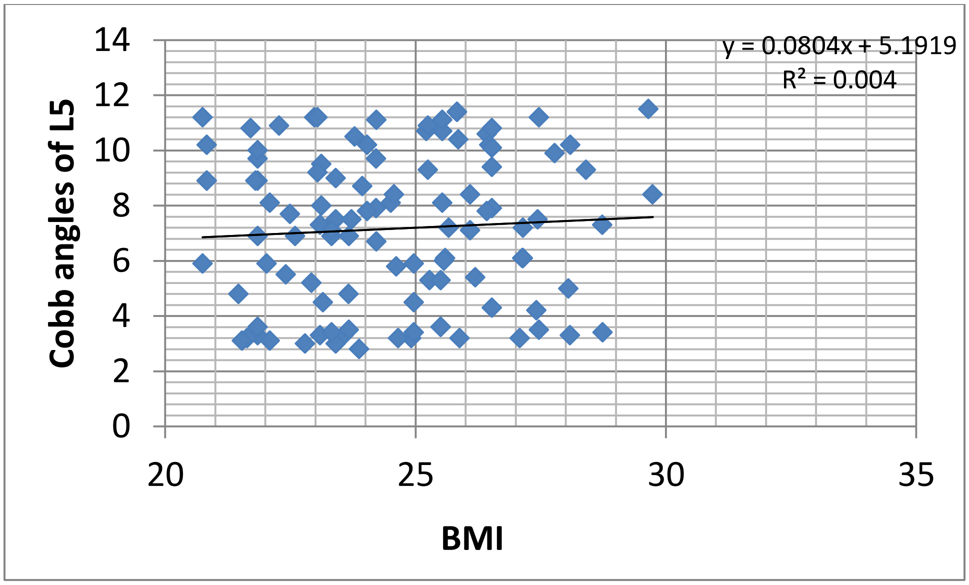

Figure (4-17): Scatter plot diagram shows the linear relationship between Cobb's angles of L5and BMI group for male.

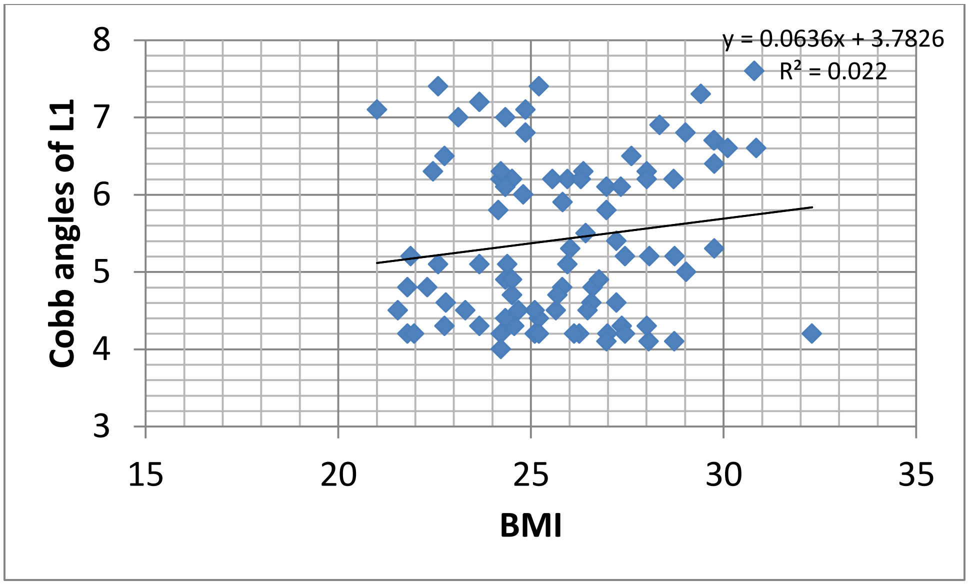

Figure (4-18): Scatter plot diagram shows the linear relationship between Cobb's angles of L1and BMI group for Female.

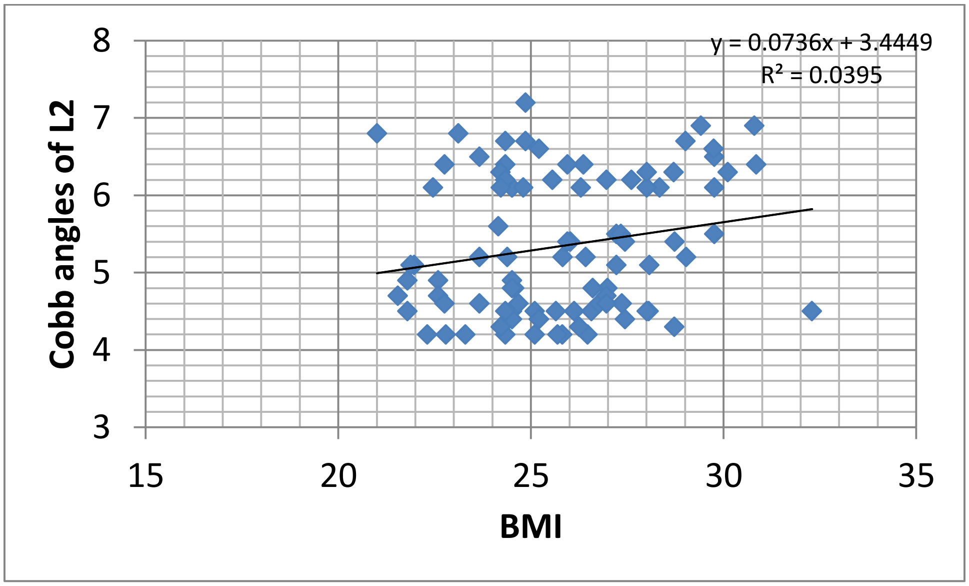

Figure (4-19): Scatter plot diagram shows the linear relationship between Cobb's angles of L2and BMI group for Female.

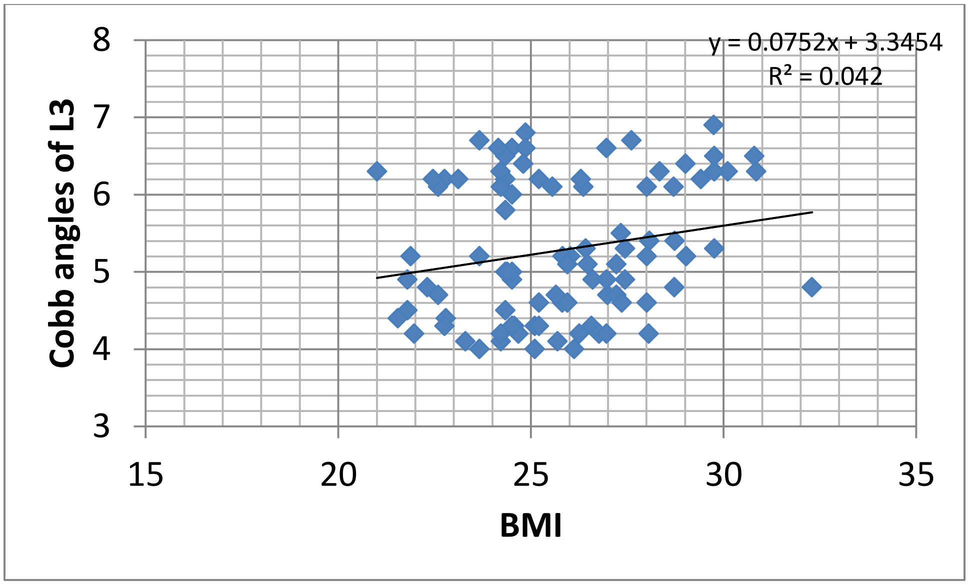

Figure (4-20): Scatter plot diagram shows the linear relationship between Cobb's angle of L3 and BMI group for Female.

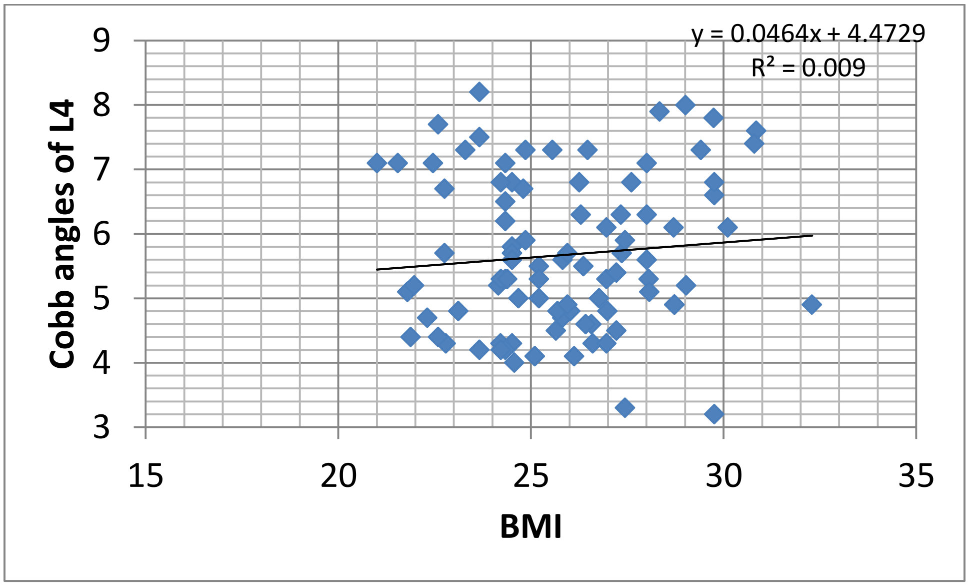

Figure (4- 21): Scatter plot diagram shows the linear relationship between Cobb's angle of L4 and BMI group for Female.

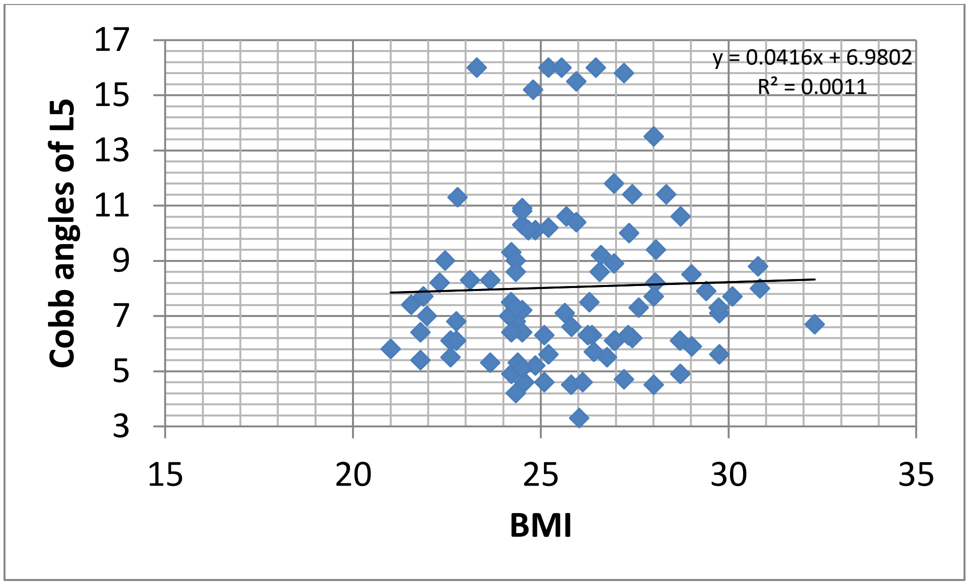

Figure (4-22): Scatter plot diagram shows the linear relationship between Cobb's angle of the L5 and BMI group for Female.

Table 4.5: Results for both gender including vertebral body height classes, mean and standard deviation of lumbar Cobb angles

Height classes mm	Gender	L1	L2	L3	L4	L5
		Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
18-20	Male	4.46±1.6	5.06±1.4	4.72±1.5	4.34±1.6	6.14±3.1
	Female	5.68±1.0	5.52±1.0	5.65±1.1	5.91±1.6	8.13±3.5
21-23	Male	4.77±1.4	4.77±1.2	4.47±1.2	4.70±1.5	7.26±2.8
	Female	5.40±1.0	5.38±0.8	5.25±0.8	5.68±1.2	8.05±2.8
24-26	Male	4.71±1.5	4.73±1.3	4.63±1.4	5.17±2.2	7.38±2.5
	Female	5.42±1.0	5.31±0.9	5.28±0.8	5.59±1.0	8.06±3.1
27-29	Male	5.15±1.4	5.05±1.3	5.25±1.3	5.45±1.5	5.67±2.8
	Female	4.90±0.7	4.56±0.05	4.50±1.0	5.53±1.0	7.35±1.7

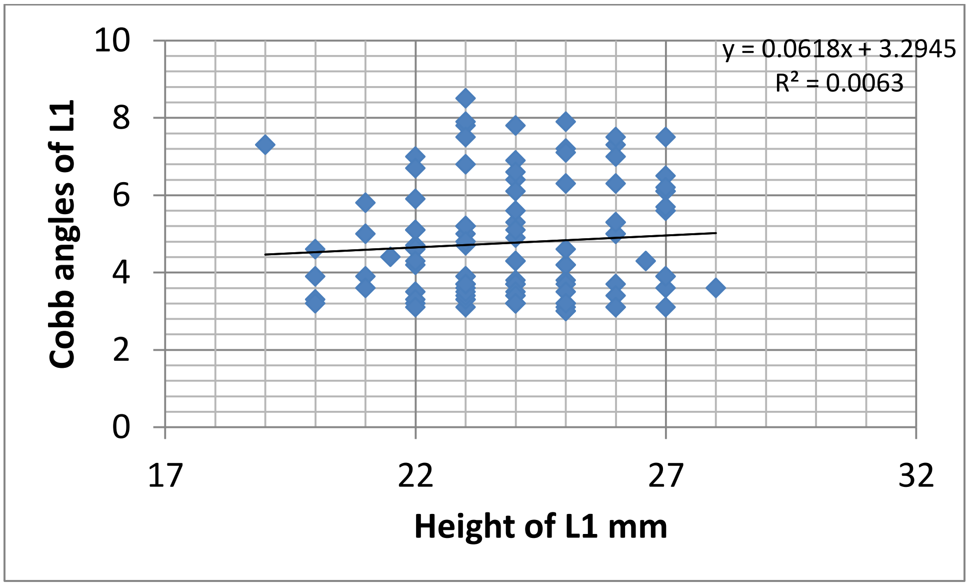

Figure (4-23): Scatter plot diagram shows the linear relationship between Cobb's angles L1and L1 height for male.

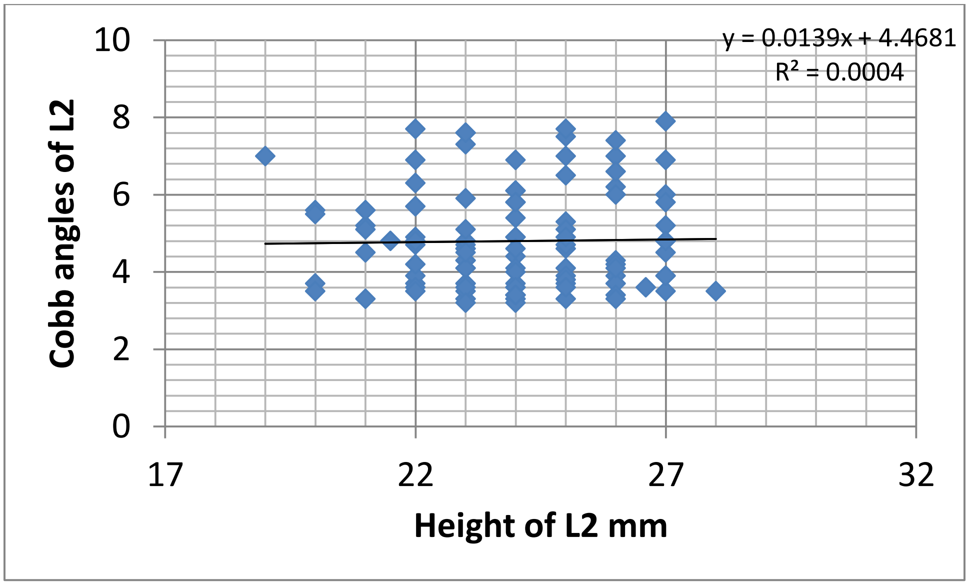

Figure (4- 24): Scatter plot diagram shows the linear relationship between Cobb's angles L2and L2 height for male.

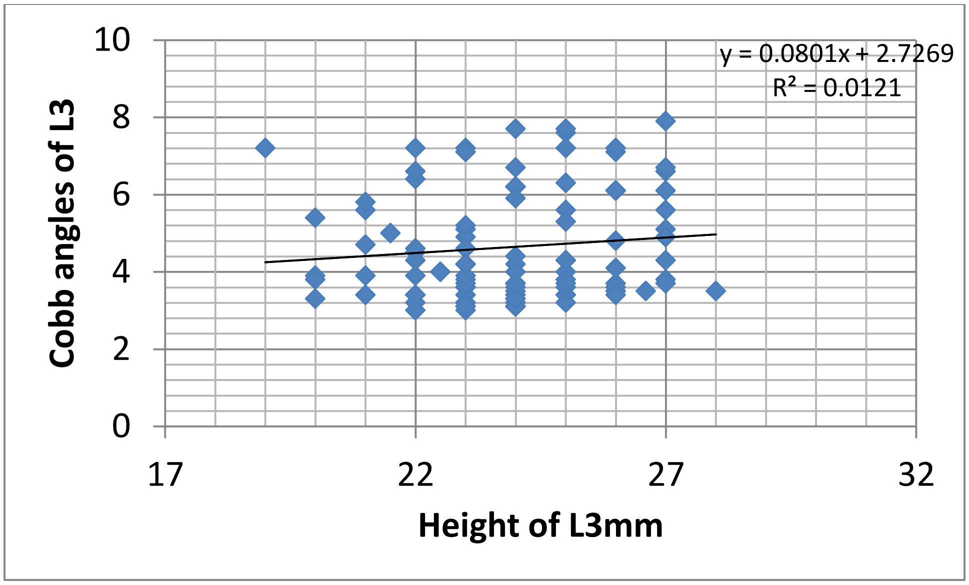

Figure (4- 25): Scatter plot diagram shows the linear relationship between Cobb's angles L3and L3 height for male.

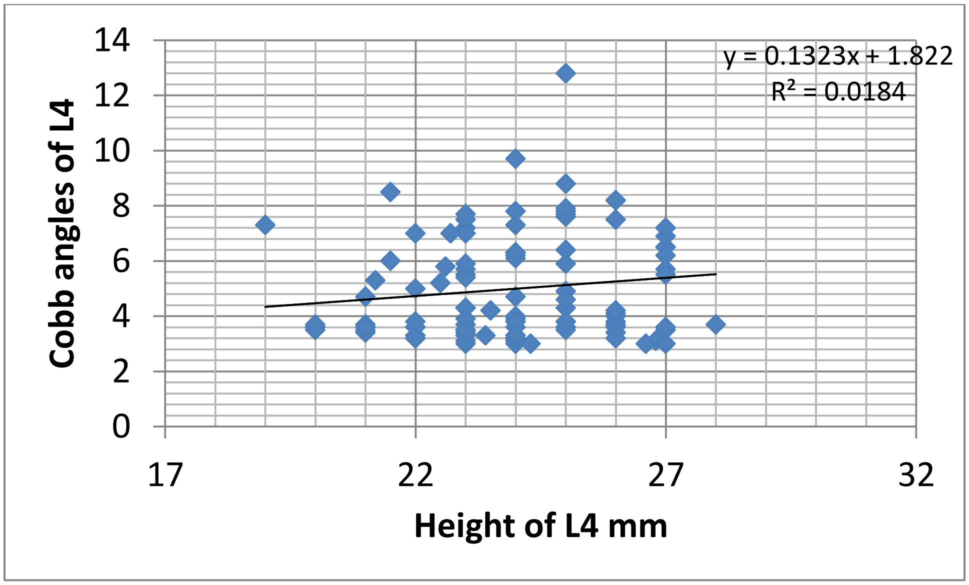

Figure (4- 26): Scatter plot diagram shows the linear relationship between Cobb's angles L4and L4 height for male.

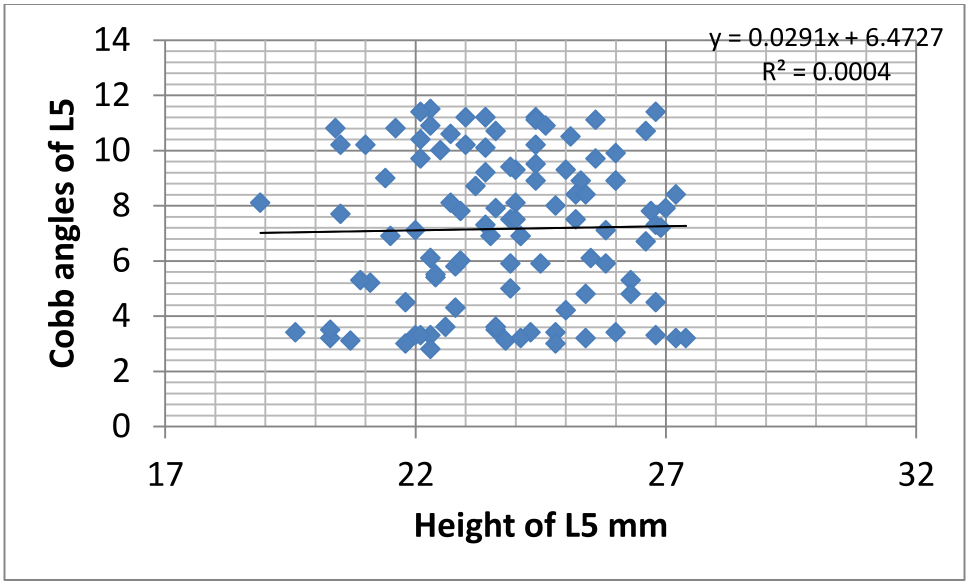

Figure (4- 27): Scatter plot diagram shows the linear relationship between Cobb's angles L5and L5 height for male.

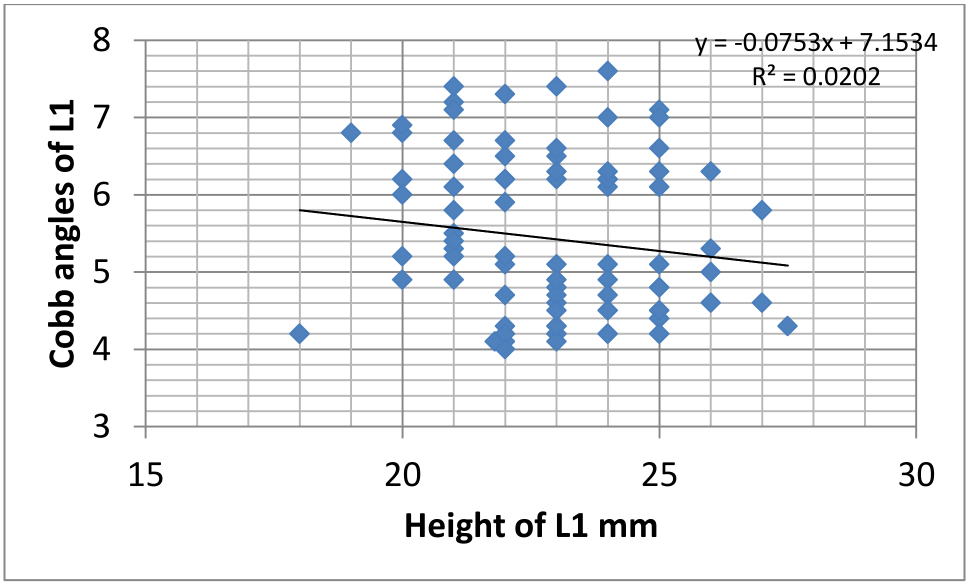

Figure (4-28): Scatter plot diagram shows the linear relationship between Cobb's angle L1 and L1height for Female.

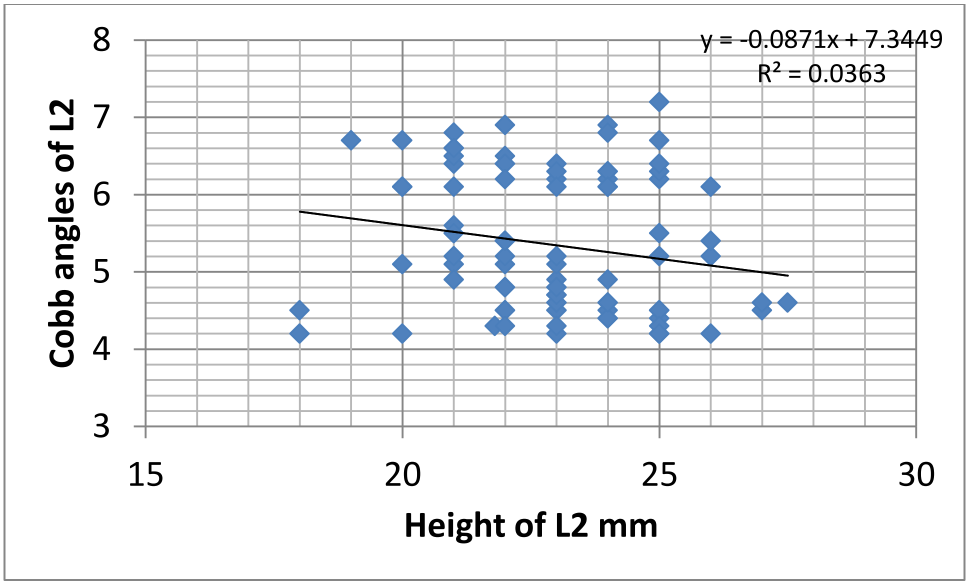

Figure (4-29): Scatter plot diagram shows the linear relationship between Cobb's angles L2and L2 height for Female.

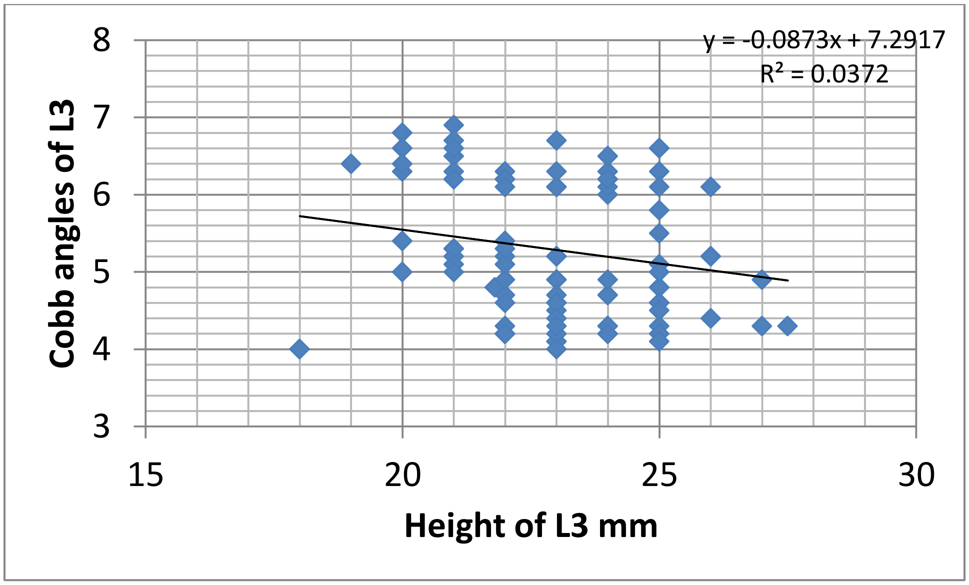

Figure (4-30): Scatter plot diagram shows the linear relationship between Cobb's angle L3 and L3 height for Female.

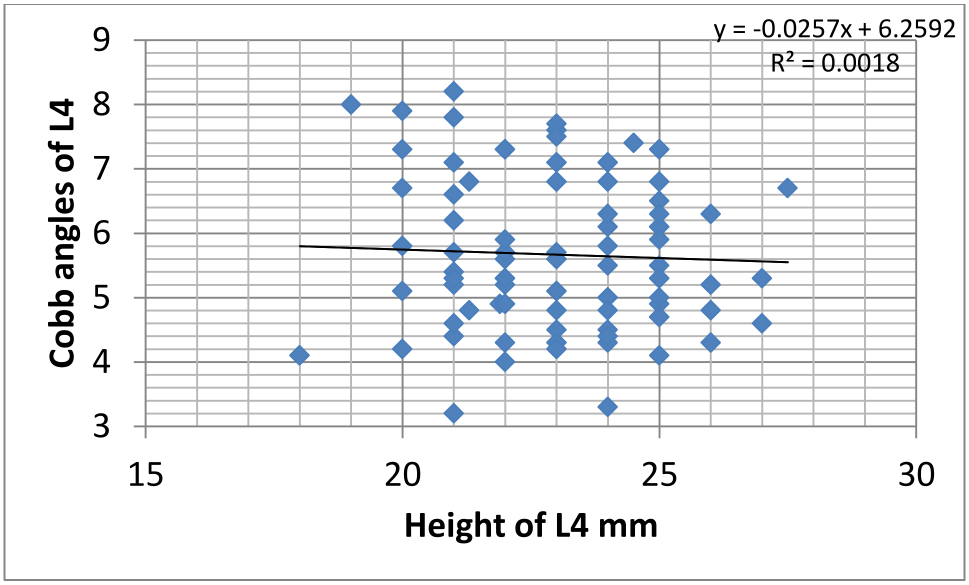

Figure (4-31): Scatter plot diagram shows the linear relationship between Cobb's angle L4 and L4 height for Female.

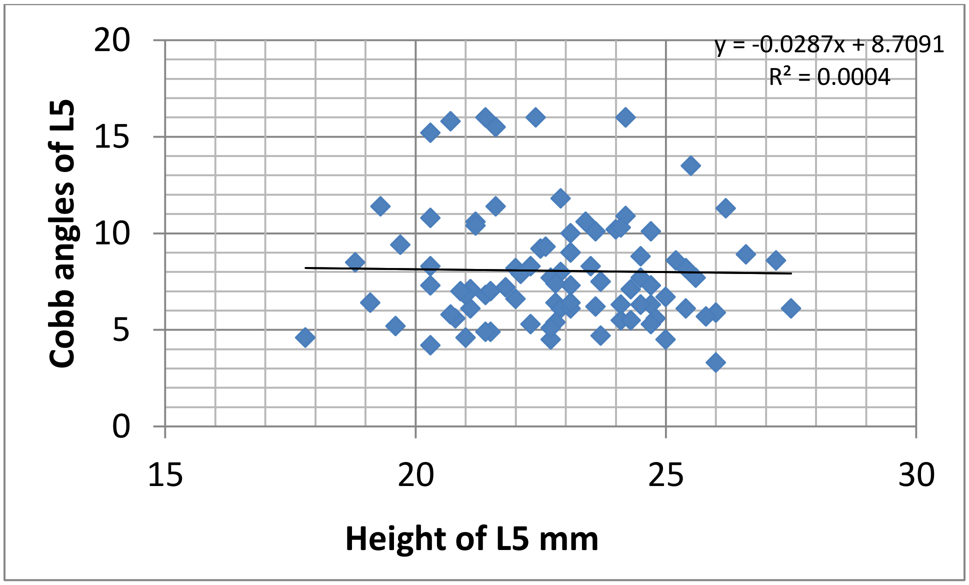

Figure (4- 32): Scatter plot diagram shows the linear relationship between Cobb's angle L5 and L5 height for Female.

Table 4.6: Results for both gender including age classes, mean and standard deviation of lumbar Cobb angle

Age classes	Gender	Lumbar cobb angle Mean± SD
21-30	Male	32.33 ± 9.7
	Female	30.56 ± 9.2
31-40	Male	29.35 ± 9.2
	Female	31.58 ± 8.4
41-50	Male	30.32 ± 7.8
	Female	39.24 ± 11.2
51-60	Male	31.85 ± 11.8
	Female	37.82 ± 8.4
61-70	Male	28.66 ± 9.9
	Female	39.02 ± 10.8
71-80	Male	30.12 ± 4.9
	Female	39.96 ± 4.0

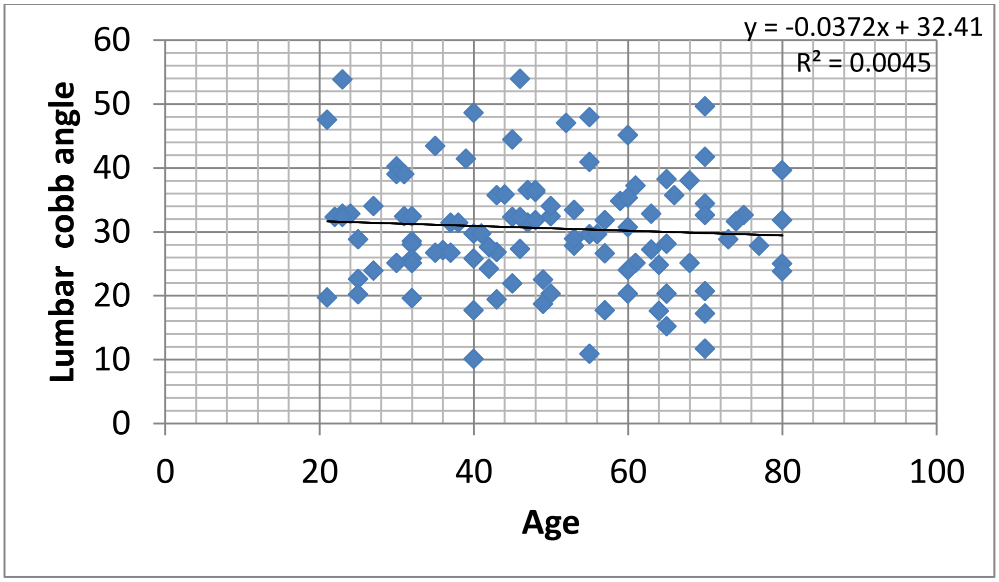

Figure (4- 33): Scatter plot diagram shows the linear relationship between Cobb's angle of Lumbar vertebrae and Age group for male.

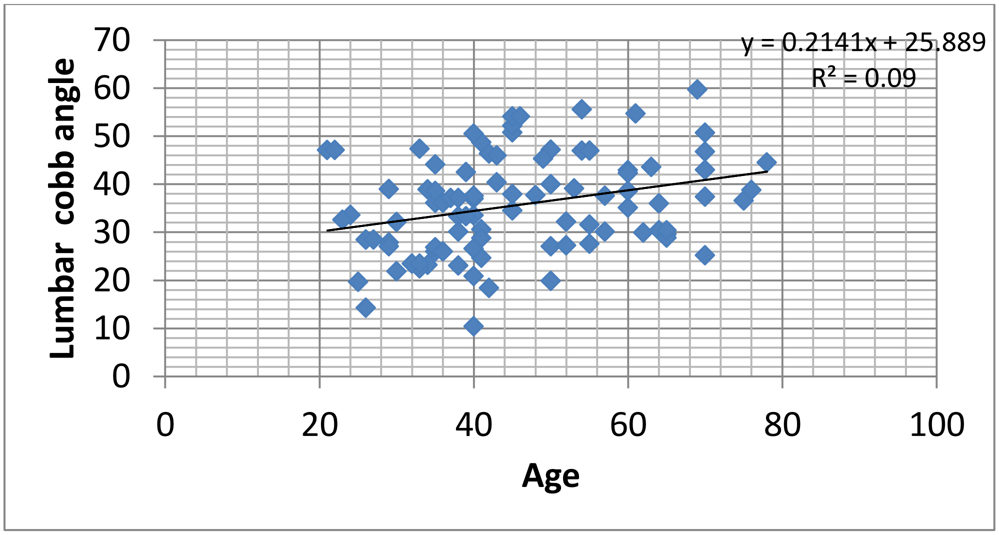

Figure (4-34): Scatter plot diagram shows the linear relationship between Cobb's angle of Lumbar vertebrae and Age group for female.

Table 4.7: shows results for both gender including body mass index classes, mean and standard deviation of lumbar Cobb angle

BMI classes	**Gender**	**Lumbar cobb angle** **Mean± SD**
18.5-24.9	Male	4.69±1.1
	Female	5.35±1.2
25-29.9	Male	4.87±1.6
	Female	5.38±1.3
30-39.9	Male	0±0
	Female	6.8±1.8

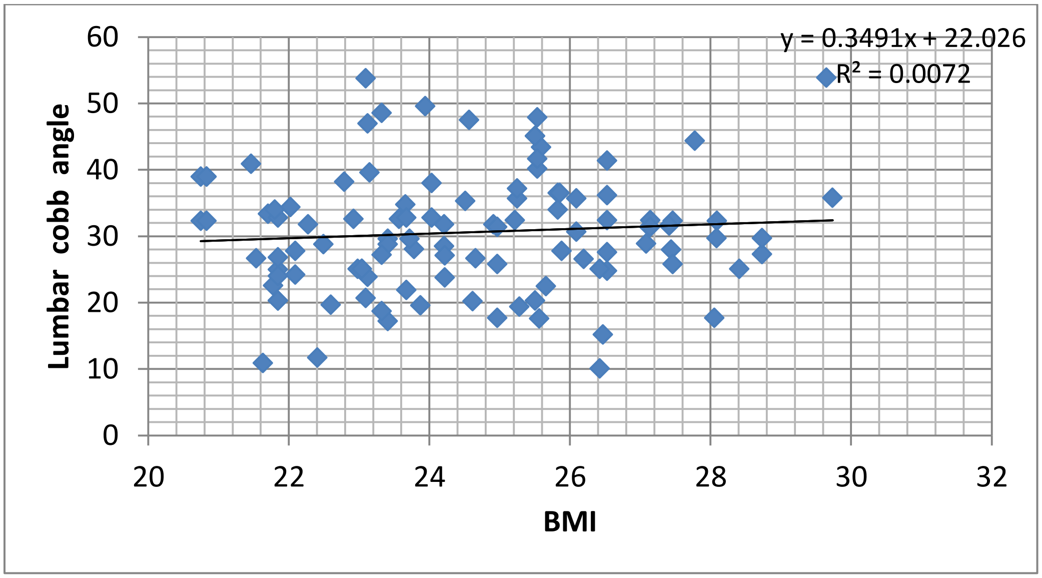

Figure (4-35): Scatter plot diagram shows the linear relationship between Cobb's angle of Lumbar vertebrae and BMI group for male.

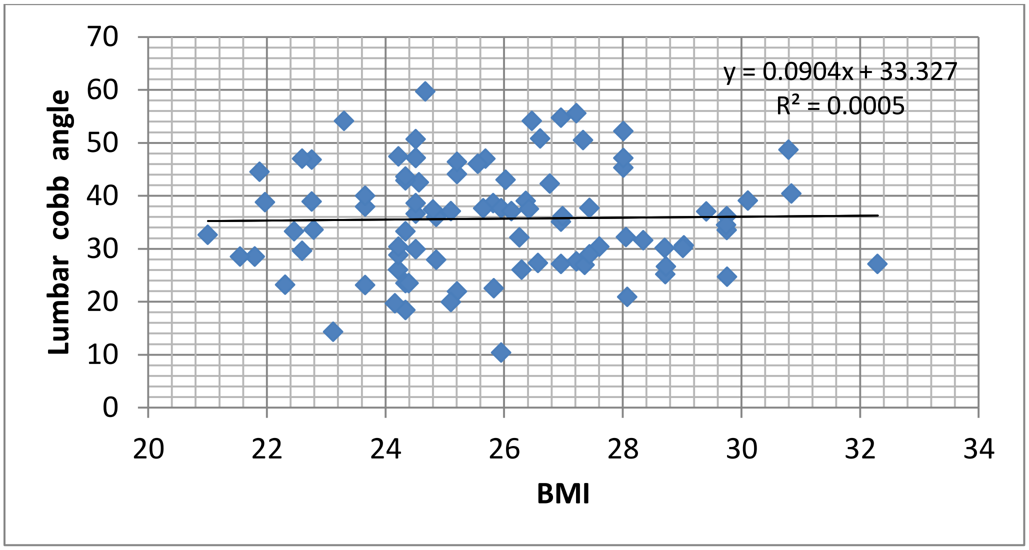

Figure (4- 36): Scatter plot diagram shows the linear relationship between Cobb's angle of Lumbar vertebrae and BMI group for female

Table 4.8: shows results for both gender including mean and standard deviation of lumbar Cobb angles, vertebral height, body weight classes

	Gender	**N**	**Mean± SD**	**Seg (2tail)**
L1 Cobb angle	Male	107	4.77±1.4	0.01*
	Female	93	5.42±1.0	
L2 Cobb angle	Male	107	4.80±1.3	0.01*
	Female	93	5.34±0.8	
L3 Cobb angle	Male	107	4.64±1.4	0.000*
	Female	93	5.28±0.8	
L4 Cobb angle	Male	107	4.99±1.8	0.03*
	Female	93	5.66±1.1	
L5 Cobb angle	Male	107	7.16±2.7	0.03*
	Female	93	8.05±3.0	
L1 height	Male	107	23.95±1.9	0.01*
	Female	93	22.99±1.9	
L2 height	Male	107	23.94±1.9	0.01*
	Female	93	22.99±1.9	
L3 height	Male	107	23.94±1.9	0.01*
	Female	93	22.99±1.9	
L4 height	Male	107	23.95±1.9	0.01*
	Female	93	22.98±1.9	
L5 height	Male	107	23.81±2.0	0.01*
	Female	93	22.85±2.0	
BMI	Male	107	24.53±2.1	.000*
	Female	93	25.79±2.4	
Lumbar vertebrae cobb angle	Male	107	30.59±8.9	.000*
	Female	93	35.65±10.1	

Table 4.9: Results for both gender including age classes, mean and standard deviation of cervical Cobb angles

Age classes	Gender	C3 Mean± SD	C4 Mean± SD	C5 Mean± SD
21-30	Male	7.85±1.6	6.81±1.6	6.51±0.9
	Female	5.23±0.3	4.3±1.1	4.83±1.7
31-40	Male	5.53±1.7	5.12±1.3	5.11±1.4
	Female	5.06±0.7	4.9±0.9	4.3±1.1
41-50	Male	4.63±1.1	4.46±1.0	4.57±1.3
	Female	4.37±0.7	4.58±0.9	3.83±1.1
51-60	Male	5.19±2.3	5.00±1.6	4.80±1.6
	Female	3.12±0.5	3.08±0.5	3.26±0.6

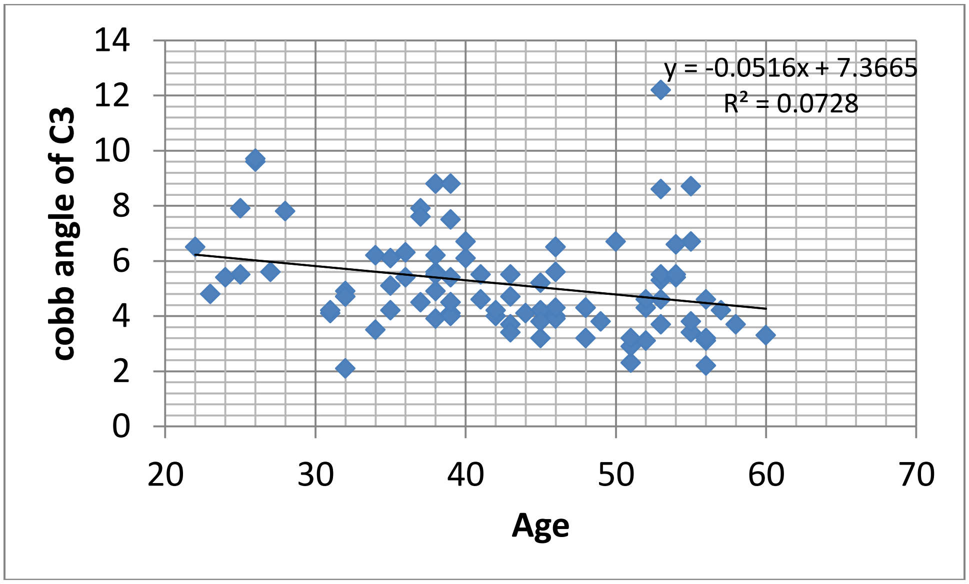

Figure (4- 37): Scatter plot diagram shows the linear relationship between Cobb's angle C3 and age group.

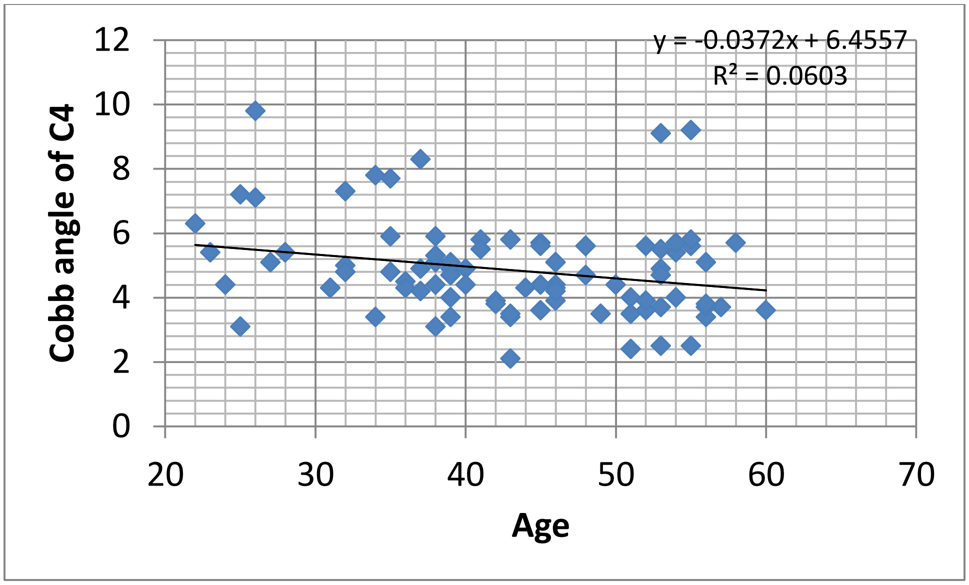

Figure (4- 38): Scatter plot diagram shows the linear relationship between Cobb's angle C4 and age group.

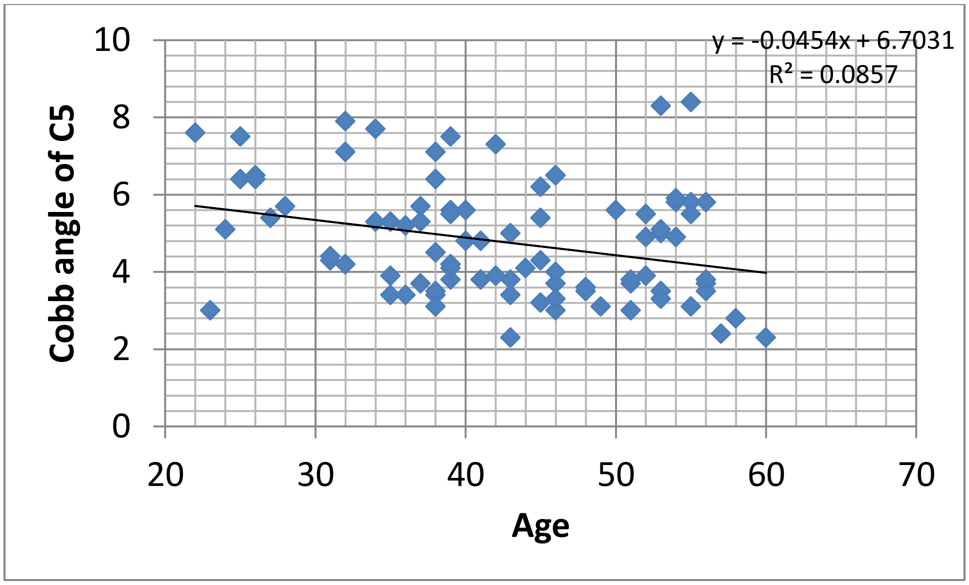

Figure (4-39): Scatter plot diagram shows the linear relationship between Cobb's angle C5 and age group.

Table 4.10: Results including body weight classes, mean and standard deviation of cervical Cobb angles

Weight classes(Kg)	***Weight***	***C3***	***C4***	***C5***
	Mean ±SD	*Mean± SD*	*Mean ±SD*	*Mean ±SD*
51-60	56.1±3.1	3.1±0.4	3.21±0.6	3.33±0.5
61-70	66.4±3.2	5.53±1.6	4.90±1.8	5.08±1.8
71-80	76.13±2.8	5.26±1.9	5.07±1.2	4.85±1.3
81-90	83.84±2.4	5.15±1.5	4.85±1.3	4.66±1.3

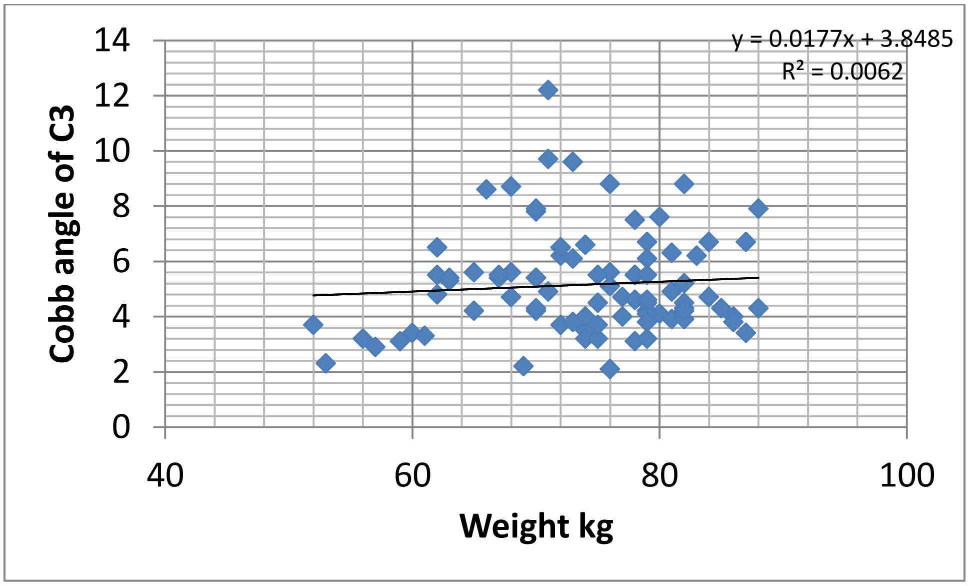

Figure (4- 40): Scatter plot diagram shows the linear relationship between Cobb's angle C3 and body weight group.

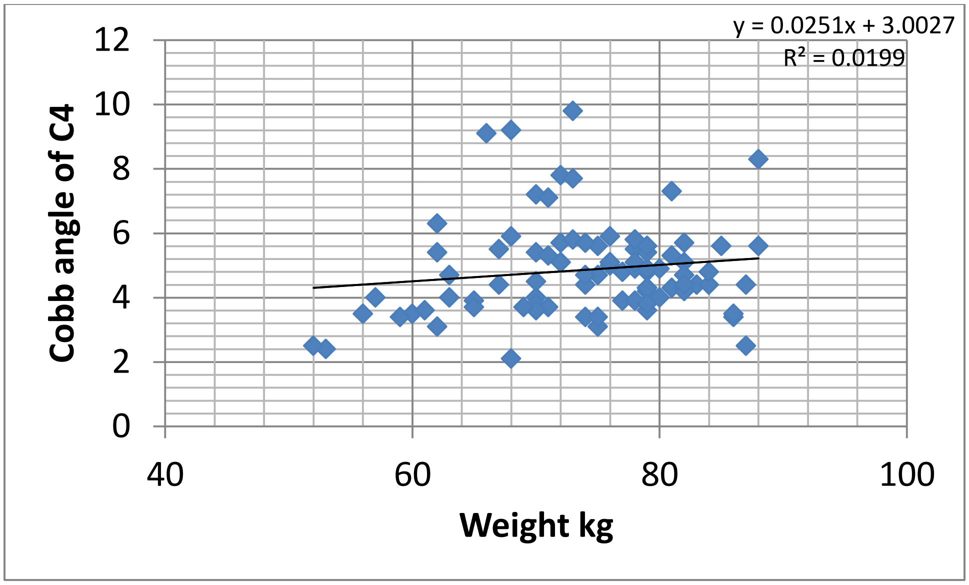

Figure (4-41): Scatter plot diagram shows the linear relationship between Cobb's angle C4 and body weight group.

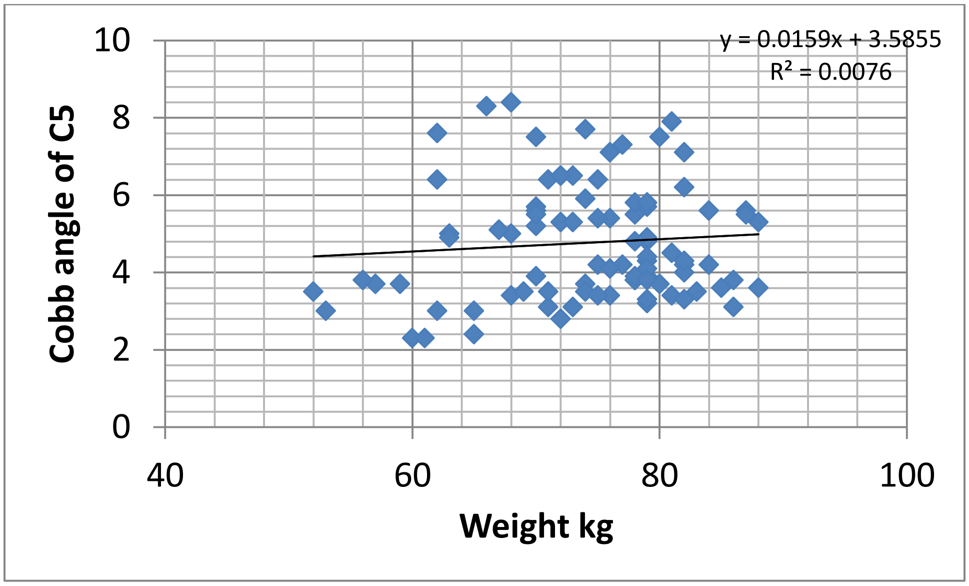

Figure (4- 42): Scatter plot diagram shows the linear relationship between Cobb's angle C5 and body weight group

Table 4.11: Results including cervical height classes and mean, standard deviation of cervical Cobb angles

Height	***Height***	***C3***	***C4***	***C5***
***Classes*(Mm)**	*Mean± SD*	*Mean± SD*	*Mean± SD*	*Mean± SD*
5-6.9	6.245±0.4	2.6 ±0.4	3.2±1.1	2.65±0.4
7-8.9	8.69±0.3	4.52±3.1	4.72±1.7	3.98±1.2
9-10.9	10.18±0.5	4.95±1.4	4.87±1.4	4.97±1.4
11-12.9	11.82±0.5	5.50±1.6	4.97±0.9	5.04±1.4

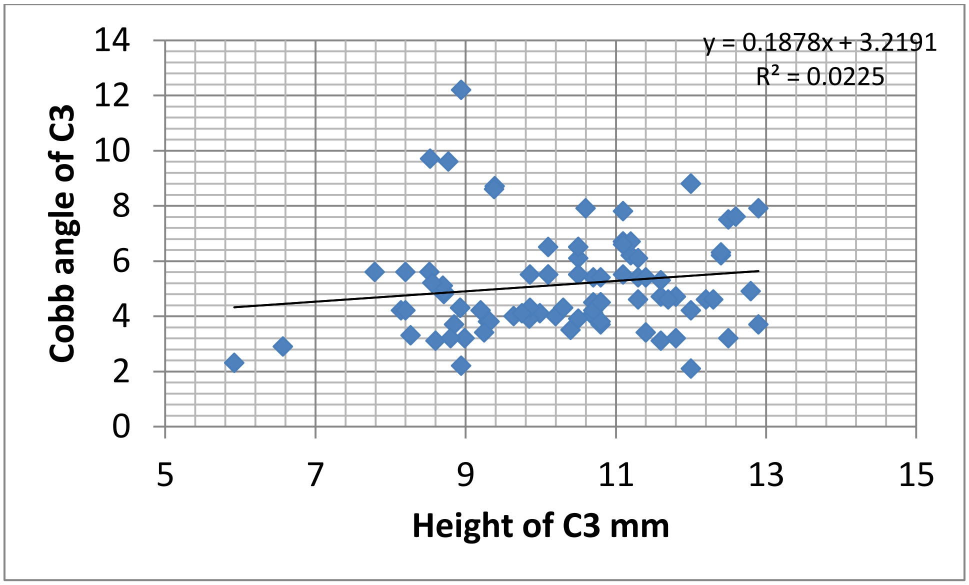

Figure (4-43): Scatter plot diagram shows the linear relationship between Cobb's angle C3 and C3 height

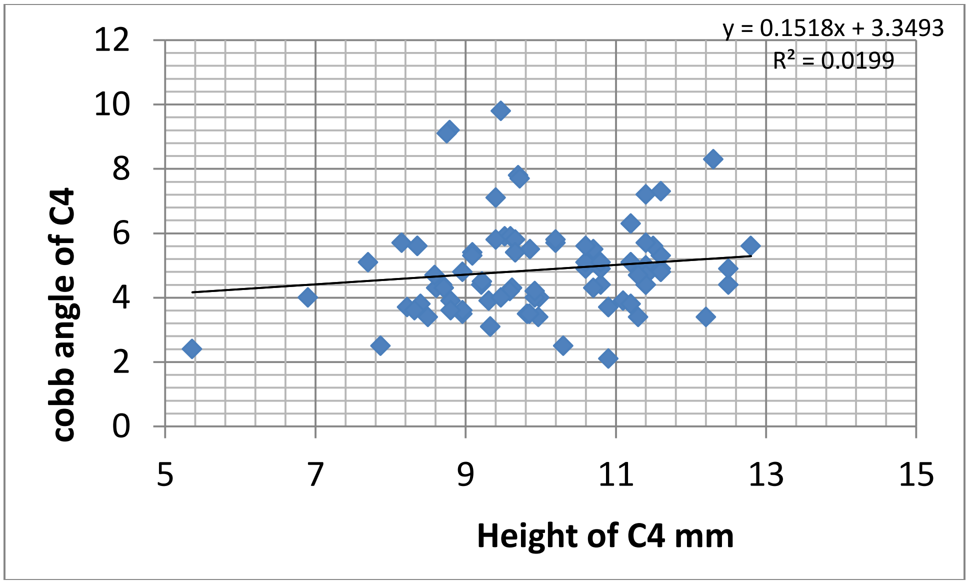

Figure (4-44): Scatter plot diagram shows the linear relationship between Cobb's angle C4 and C4 height

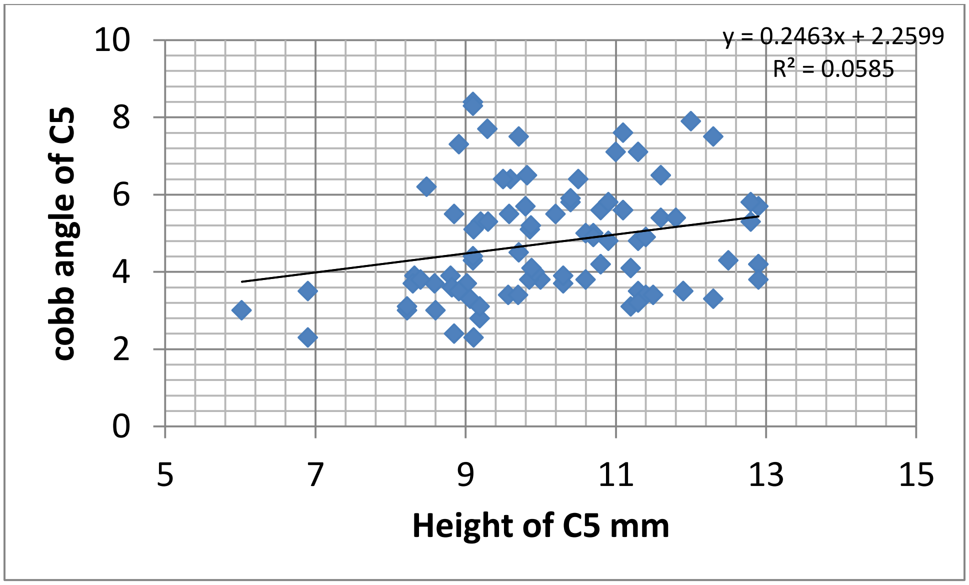

Figure (4- 45): Scatter plot diagram shows the linear relationship between Cobb's angle C5 and C5 height

Table 4.12: Results for both gender including mean and standard deviation of cervical Cobb angles, height, body weight classes

	Gender	N	Mean	STDV	Sig (2tail)
Weight	Male	66	75.83	6.5	0.001
	Female	24	69.63	10.2	
Cobb angle of c3	Male	66	5.42	1.9	0.025
	Female	24	4.45	0.9	
Cobb angle of c4	Male	66	5.08	1.5	0.019
	Female	24	4.27	1.0	
Cobb angle of c5	Male	66	5.01	1.4	0.008
	Female	24	4.09	1.2	
Height of c3	Male	66	10.79	1.2	0.000
	Female	24	9.13	1.2	
Height of c4	Male	66	10.41	1.2	0.000
	Female	24	8.86	0.9	
Height of c5	Male	66	10.63	1.2	0.000
	Female	24	8.97	1.0	

Chapter Five

Discussion, conclusion and recommendations

Chapter Five

Discussion, conclusion and recommendations

5-1 Discussion:

The purpose of this study was to standardize the normal values as reference for Cobb angle of lumbar vertebral in normal Sudanese subjects using Computerized Tomography (CT).

The sample (A) 200 lateral scouts CT scan of lumbar spine were obtained from (107males, 93 females).their ages were ranged from (21-80) years old, the sample (B) 90 lateral scouts CT scan of cervical spine were obtained from (66 males, 24 females).their ages were ranged from (22 - 60) years old.

The Cobb angles were measured from L1 to L5for both gender and correlated to their ages. The ages for both gender were classified to different groups, the measurements were presented in (table 4.3, 4.6) as mean values for lumbar vertebral Cobb angles.

The mean Cobb angle of lumbar vertebral in male was (30.59^0) and in female was (35.65^0).There was differences in Cobb angle of lumbar spine between males and females, this agrees with the findings of previous studies (Oyakhire M.O et.al 2013). The mean Cobb angles of lumbar vertebrae in males were found to be (4.77^0), (4.80^0), (4.64^0), (4.99^0), (7.16^0), and in females (5.42^0), (5.34^0), (5.28^0) (5.66^0), (8.05^0) for L1, L2, L3, L4 and L5 respectively, this agrees with the findings of previous studies (Hong, jy et.al2010). The Cobb angle related to their ages was found to be decreased by increasing age; the justification for these (Ayad.CE et.al 2013), in Skaf, GS et.al(2011) the results is that imbalance of trunk muscle due to weakness of abdominal muscles can decrease in lumbar Cobb angle. In (Bailey JF et.al 2016), (Hay.O et.al2015), (Murrie VL et.al 2003) a study for the female lumbar spine is morphologically suited to increased lumbar Cobb angle and in Onyemaechi, NO, (2017) the lumbar lordosisn increase due to increase in weight. The presented figure (4-33): correlate between the age and the Lumbar vertebral Cobb angle. There were linear relationships, as the age increased the angle was decreased except for female figure (4-34): it increases. By applying the following equation the female Cobb angle can be estimated:

Female Cobb angle = 0.2141Xage + 25.88 Equation: 1

This relationship is for all female within this sample.

BMI for both gender were classified to different groups, the measurements were presented in (table 4.4, 4.7) as mean values for lumbar vertebral Cobb angles. The mean BMI in males was (24.53 kg/m^2), and in females was (25.79 kg/m^2). The mean Cobb angle of lumbar vertebral in male was (30.59^0) and in female was (35.65^0). There is significant differences in Cobb angle of lumbar spine between the both genders at p=0.000.

The presented figures (4-35, 4-36) correlate between BMI and the Lumbar vertebral Cobb angle and where was a linear relationship between Cobb angle of the lumbar vertebral and BMI. By applying the following equations the Cobb angle can be estimated:

Male Cobb angle= 0.3491xBMI + 22.026 Equation: 2

Female Cobb angle= 0.904xBMI + 33.327 Equation: 3

The linear relationship between Cobb angle of the lumbar vertebral and BMI due to increased mechanical loading of the lumbar spine (Onyemaechi, NO.et.al 2016), the anterior shifting of the center of mass, resulting in increased flexion of the lumbar vertebral (Kumagai, G,2014) and which increased the Cobb angle of the lumbar vertebral. This agrees with the findings of previous studies.

The vertebral body height for both gender were classified to different groups, the measurements were presented in (table 4.8) as mean values for lumbar vertebral

Cobb angles. The mean vertebral body height in males were found to be (23.95mm), (23.94mm), (23.94mm), (23.95mm), (23.81mm) and in females (22.99mm), (22.99mm), (22.99mm), (22.98mm), (22.85mm)for L1, L2, L3, L4 and L5 respectively, the end plates angles increase were as the body vertebral body height increase, where was a linear relationship between Cobb angle of the lumbar vertebral and height. There were significant differences in Cobb angle of lumbar spine between the both genders at p=0.000. In Hermann, A.P, (1993) age and sex play important roles in lumbar lordosis change during growth, the vertebral height decreased with age, As a result of increased age, the imbalance of trunk muscle due to weakness of abdominal muscles can decrease in lumbar Cobb angle (Hermann, A.P, 1993),(Damasceno LH et.al2006).

In sample (B) The Cobb angles were measured from C3 to C5for both gender and correlated to their ages, body weight, and vertebral body height. The ages body weight, and vertebral body height for both gender were classified to different groups, the measurements were presented in (table4.9) as mean values for cervical vertebral Cobb angles.

The mean Cobb angles of cervical vertebral in males were found to be (5.42^{0}), (5.08^{0}), (5.01^{0}), and in females (4.45^{0}), (4.27^{0}), (4.09^{0}) for C3, C4, and C5 respectively, this agrees with the findings of previous studies (Been E et.al 2017). There were significant differences in Cobb angle of cervical spine between both genders at p=0.000. Differences in the cervical lordosis angles might be related to gender differences in skull morphology, larynx, or thorax shape and size (Linder-Aronsonet.al 1979), (Scheer JK et.al 2013). The Cobb angle related to their ages was found to be decreased by increasing age; the biochemical changes resulting from the increase of age-dependent changes because a decrease in disc height, cause changes in the disc geometry, and affect cervical curvature (Aşkin et.al2017), in (Midde et.al, 2017) the normal lordosis value of the cervical spine of

Indian population has been evaluated, and there was no correlation of Cobb's angle on any studied variables. In (Grob et al, 2007) determined that the cervical curvature angle increased with age in females rather than males. In Kumagai et al, 2014) reported that the cervical lordosis angle increased with age in females exclusively. In our study, there was significant correlation between age and Cobb angle measurements. Justification for these results is that imbalance of trunk muscle due to weakness of neck muscles can decrease in cervical Cobb angle.

The presented figures (4-37, 4-38and 4-39): correlate between the age and the cervical vertebral Cobb angle. There were linear relationships, as the age increased the angle was decreased. By applying the following equation the Cobb angle can be estimated:

C3 Cobb angle = $-0.0516 X age + 7.3665$ Equation: 4

C4 Cobb angle = $-0.0372 X age + 6.4557$ Equation: 5

C5 Cobb angle = $-0.0454 X age + 6.7031$ Equation: 6

This relationship is for both genders within this sample.

Weight for both gender were classified to different groups, the measurements were presented in (table 4.10) as mean values for cervical vertebral Cobb angles. The mean weight in males were found to be (75.83 kg) and in females(69.63 kg), the end plates angles increase were as the subject body weight increase, where was a linear relationship between Cobb angle of the cervical vertebral and weight. There were significant differences in Cobb angle of cervical spine between both genders at $p=0.000$.the head and it weight were displaced forward of the spinal column and the muscles in back of the spinal column were contracted to maintain the balance, due to muscles contraction the cervical cobb angle in increased (Cailliet and Eccles,1996). The presented figures (4-40, 4-41, and 4-42): correlate between weight and the cervical vertebral Cobb angle and where was a linear relationship between Cobb angle of the cervical vertebral and weight. By applying the following equations the Cobb angle can be estimated:

C3 Cobb angle = 0.0177Xweight + 3.8485 Equation: 7

C4 Cobb angle = 0.0251Xweight+ 3.0027 Equation: 8

C5 Cobb angle = 0.0159Xweight + 3.5855 Equation: 9

This relationship is for both genders within this sample.

The vertebral body height for both gender were classified to different groups, the measurements were presented in (table 4.11) as mean values for cervical vertebral Cobb angles. The mean vertebral body height in males were found to be (10.79 mm), (10.41 mm), and (10.63 mm) and in females (9.13 mm), (8.86 mm), and (8.97 mm) for C3, C4, and C5 respectively, this agrees with the findings of previous studies (Busche-McGregor M et.al 1981). the end plates angles increase were as the body vertebral body height increase, where was a linear relationship between Cobb angle of the cervical vertebral and height. There were significant differences in Cobb angle of cervical spine between both genders at p=0.000. Age and sex play important roles in cervical lordosis change during growth (Hellsing et.al1987) , the vertebral height decreased with age (Kim et.al,2013), As a result of increased age, the imbalance of trunk muscle due to weakness of neck muscles can decrease in cervical Cobb angle.

The presented figures (4-43, 4-44, and 4-45): correlate between the vertebral height and the cervical vertebral Cobb angle and where was a linear relationship between Cobb angle of the cervical vertebral and the vertebral height. By applying the following equations the Cobb angle can be estimated:

C3 Cobb angle = 0.1878Xheight + 3.2191 Equation: 10

C4 Cobb angle = 0.1518Xheight + 3.3493 Equation: 11

C5 Cobb angle = 0.2463Xheight + 2.2599 Equation: 12

This relationship is for both genders within this sample.

5-2 Conclusion:

The purpose of this study was to standardize the normal values as reference for Cobb angle of lumbar vertebral in normal Sudanese subjects using Computerized Tomography (CT).

The mean Cobb angle of lumbar vertebral in male was (30.59^0) and in female was (35.65^0). By applying the following equation the female Cobb angle can be estimated:

Female Cobb angle = 0.2141Xage + 25.88 Equation: 1

This relationship is for all female within this sample.

There were differences in Cobb angle of lumbar spine between males and females. The mean Cobb angles of lumbar vertebrae in males were found to be (4.77^0), (4.80^0), (4.64^0), (4.99^0), (7.16^0), and in females (5.42^0), (5.34^0), (5.28^0) (5.66^0), (8.05^0) for L1, L2, L3, L4 and L5 respectively. There is significant differences in Cobb angle of lumbar spine between both genders at p=0.000.

The mean BMI in males was ($24.53\ kg/m^2$) and in females was ($25.79\ kg/m^2$).By applying the following equations the Cobb angle can be estimated:

Male Cobb angle= 0.3491xBMI + 22.026 Equation: 2

Female Cobb angle= 0.904xBMI + 33.327 Equation: 3

The mean vertebral body height in males were found to be (23.95mm), (23.94mm), (23.94 mm), (23.95mm), and (23.81 mm) and in females (22.99mm), (22.99mm), (22.99 mm), (22.98mm), and (22.85mm) for L1, L2, L3, L4 and L5 respectively.

The mean Cobb angle of cervical vertebral in males were found to be (5.42^0), (5.08^0), (5.01^0), and in females (4.45^0), (4.27^0), (4.09^0) for C3, C4, and C5 respectively. By applying the following equation the Cobb angle can be estimated:

C3 Cobb angle = -0.0516Xage+ 7.3665 Equation: 4

C4 Cobb angle = -0.0372Xage+ 6.4557 Equation: 5

C5 Cobb angle = -0.0454Xage+ 6.7031 Equation: 6

There were significant differences in Cobb angle of cervical spine between both genders at p=0.000.

The mean weight in males were found to be (75.83 kg) and in females (69.63 kg). By applying the following equations the Cobb angle can be estimated:

C3 Cobb angle = 0.0177Xweight + 3.8485 Equation: 7

C4 Cobb angle = 0.0251Xweight+ 3.0027 Equation: 8

C5 Cobb angle = 0.0159Xweight + 3.5855 Equation: 9

The mean vertebral body height in males were found to be (10.79 mm), (10.41 mm), and (10.63 mm) and in females (9.13 mm), (8.86 mm), and (8.97 mm) for C3, C4, and C5 respectively. By applying the following equations the Cobb angle can be estimated:

C3 Cobb angle = 0.1878Xheight + 3.2191 Equation: 10

C4 Cobb angle = 0.1518Xheight + 3.3493 Equation: 11

C5 Cobb angle = 0.2463Xheight + 2.2599 Equation: 12

The mean Cobb angle end plates of the cervical and lumbar vertebrae differ significantly from males and females' Sudanese subjects.

5-3 Recommendations:

Further studies should measure the Cobb angle and dimensions of the cervical and lumbar vertebrae in sagittal plane.

Used of other variables such as patient height and relation to Cobb angle of the lumbar vertebrae.

Patient work used as a variable in measuring and it relation to Cobb angle of the lumbar vertebral.

The Cobb angle measurements should be used in diagnosis of the spinal curvature in computed tomography.

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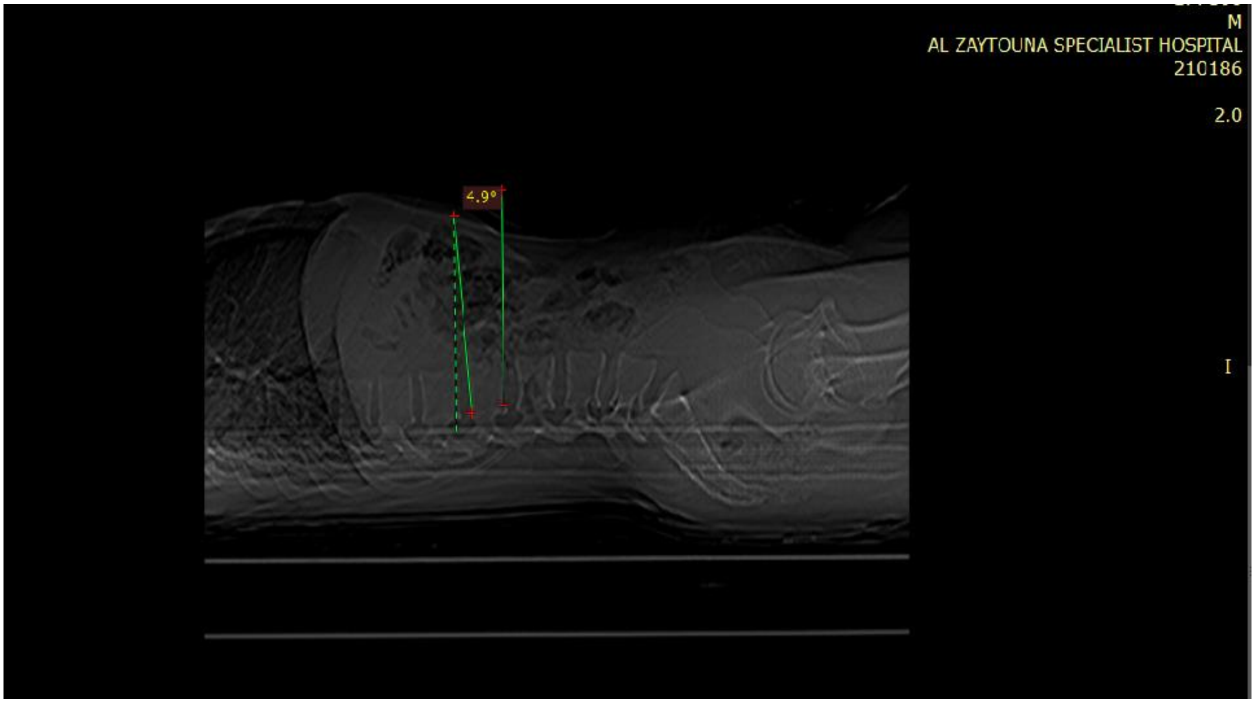
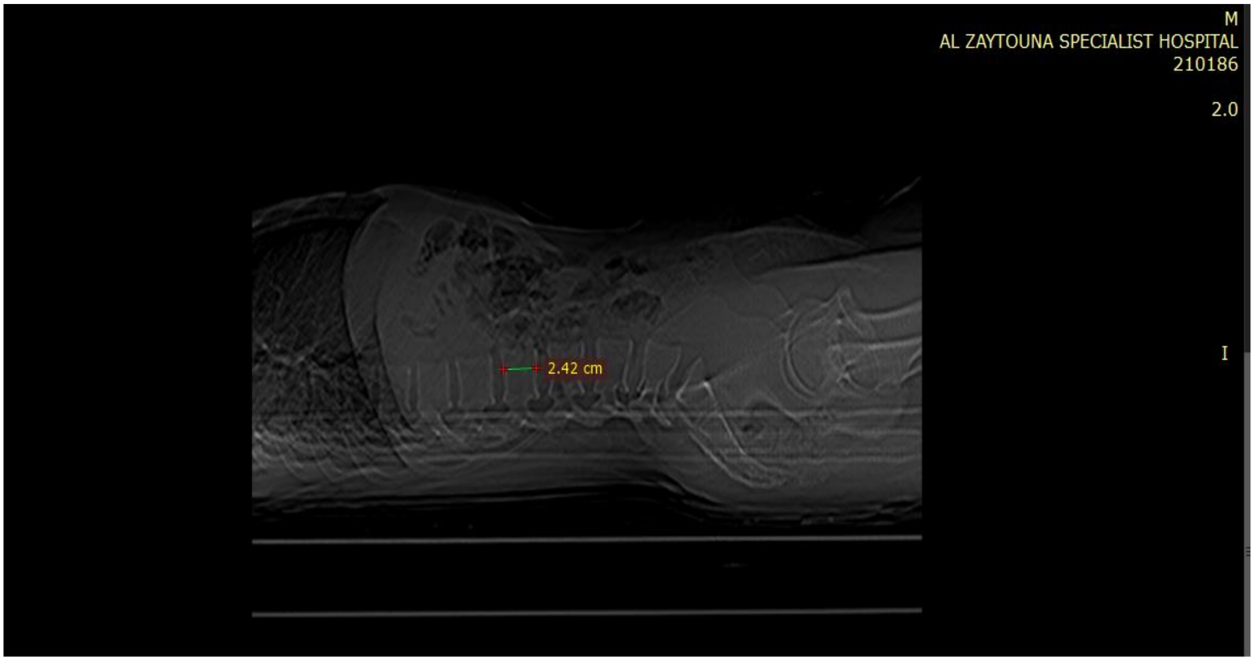
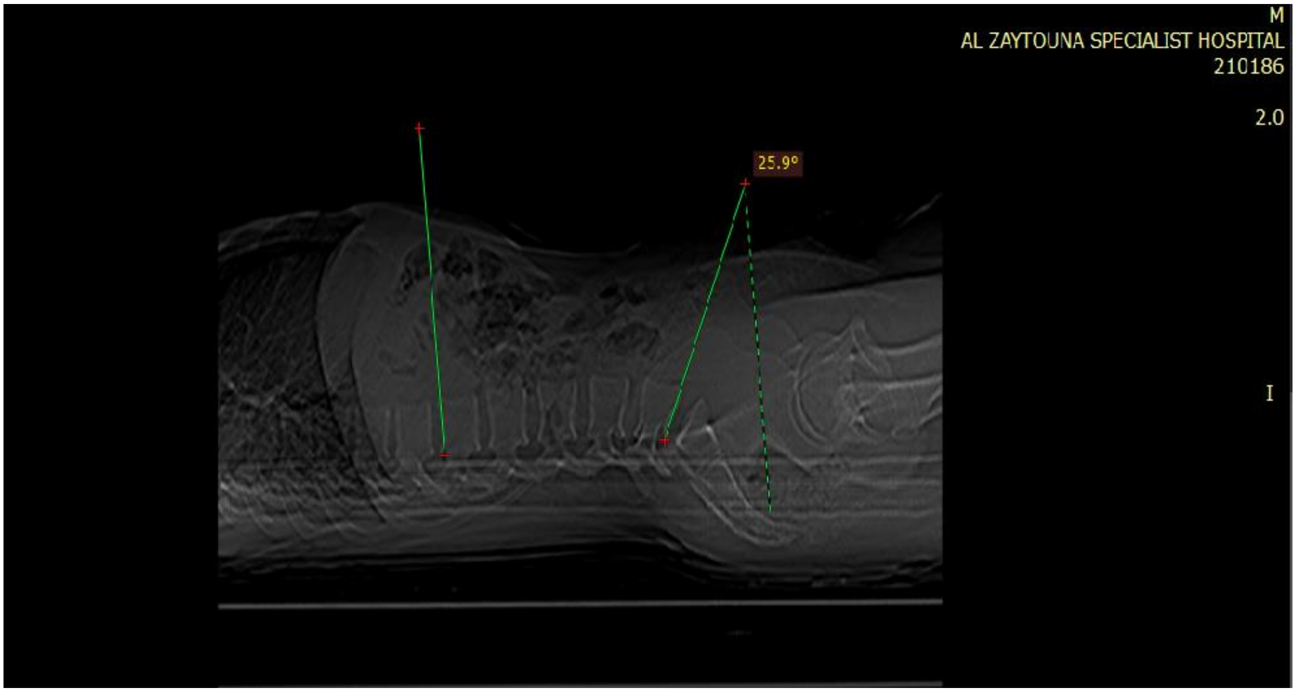
Appendix



Appendix 1: Scout view show measure of Cobb angle in lumbar spine

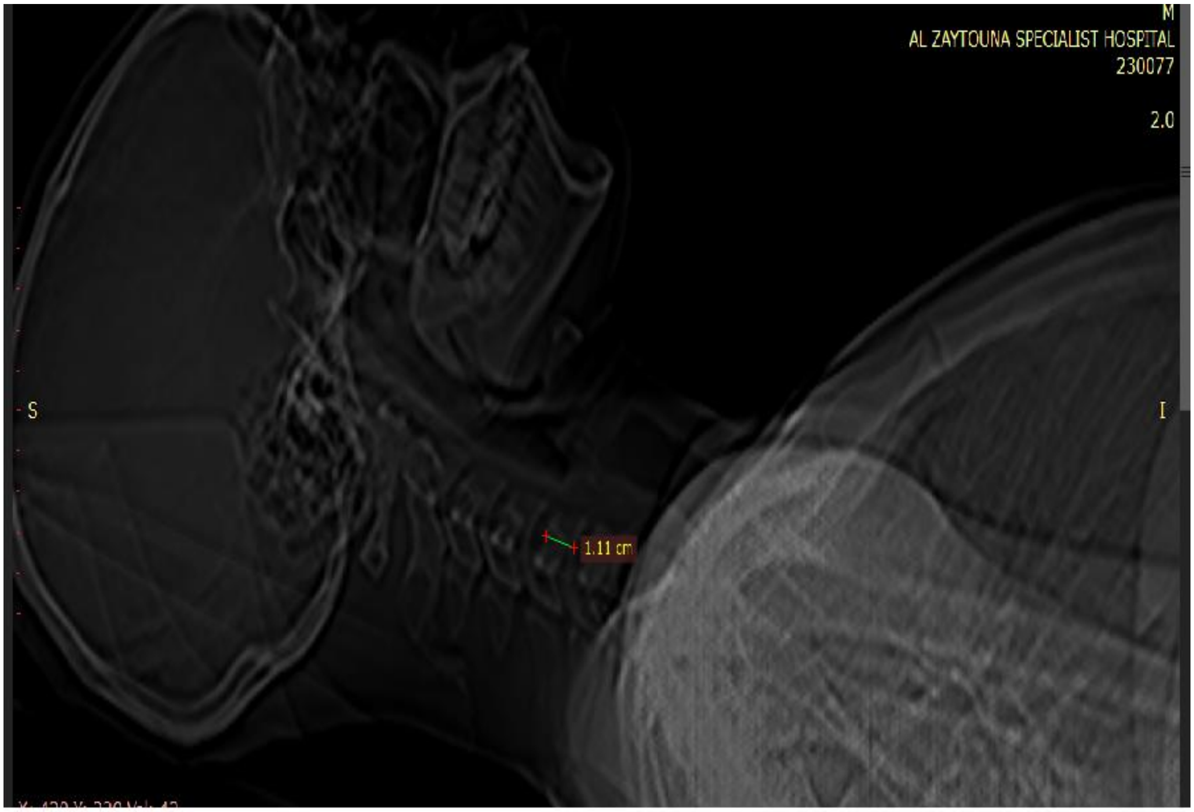


Appendix 2: Scout view show measure of vertebral body height in lumbar spine



Appendix 3: Scout view show measure of Cobb angle from L1 to L5.

Appendix 4: Scout view show measure of Cobb angle in cervical spine



Appendix 5: Scout view show measure of vertebral body height in cervical spine

Data collection sheet

For lumbar vertebrae

Gender	Age	weight(kg)	length(cm)	BMI	Cobb angle					Height(mm)					Cobb angle of lumbar
					L1	L2	L3	L4	L5	L1	L2	L3	L4	L5	

Data collection sheet

For cervical vertebrae

Gender	Age	weight(kg)	Cobb angle			Height(mm)		
			C3	C4	C5	C3	C4	C5