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Perspective

Lumbar lordosis

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Abstract Lumbar lordosis is a key postural component that has interested both clinicians and researchers for many years. Despite its wide use in assessing postural abnormalities, there remain many unanswered questions regarding lumbar lordosis measurements. Therefore, in this article we reviewed different factors associated with the lordosis angle based on existing literature and determined normal values of lordosis. We reviewed more than 120 articles that measure and describe the different factors associated with the lumbar lordosis angle. Because of a variety of factors influencing the evaluation of lumbar lordosis such as how to position the patient and the number of vertebrae included in the calculation, we recommend establishing a uniform method of evaluating the lordosis angle. Based on our review, it seems that the optimal position for radiologic measurement of lordosis is standing with arms supported while shoulders are flexed at a 30° angle. There is evidence that many factors, such as age, gender, body mass index, ethnicity, and sport, may affect the lordosis angle, making it difficult to determine uniform normal values. Normal lordosis should be determined based on the specific characteristics of each individual; we therefore presented normal lordosis values for different groups/populations. There is also evidence that the lumbar lordosis angle is positively and significantly associated with spondylolysis and isthmic spondylolisthesis. However, no association has been found with other spinal degenerative features. Inconclusive evidence exists for association between lordosis and low back pain. Additional studies are needed to evaluate these associations. The optimal lordotic range remains unknown and may be related to a variety of individual factors such as weight, activity, muscular strength, and flexibility of the spine and lower extremities.

Keywords: Spine; Posture; Lordosis; Spinal pathology; Spinal measurements

Introduction

Research studies have shown an increasing recognition of the functional and clinical importance of lumbar lordosis [1–5]. It is a key feature in maintaining sagittal balance. Sagittal balance or ''neutral upright sagittal spinal alignment'' is a postural goal of surgical, ergonomic, and physiotherapeutic intervention. However, a wide variety of thoracic and lumbar spinal curves may correspond with the accepted criterion of sagittal balance (50 mm of C7–S1 sagittal deviation in asymptomatic adults while standing) [6,7], making it difficult for surgeons, researchers, therapists, and patients to know if they are examining or achieving the same postural goal [8].

In this topical review, we determined, based on existing literature, normal and abnormal parameters of lumbar lordosis and examine the different factors associated with the lordosis angle. To accomplish this, we searched PubMed, PEDro, EMBASE, and Google scholar databases (inception–2012) for the key words ''spine'', ''spinal'', ''lordosis'', ''lumbar'', ''posture'', ''pathology'', ''measurements'', and combinations of key words. All relevant articles in English were reviewed. Pertinent secondary references were also retrieved. We are aware that this traditional approach to reviews has much more potential for bias than systematic reviews or meta-analyses; however, we have endeavored to be inclusive and open minded. We also consulted experts in spinal surgery and radiology to produce this review on lumbar lordosis.

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Anatomy of lumbar lordosis

Lumbar lordosis is the inward (ventral) curvature of the lumbar spine formed by the wedging of lumbar vertebral bodies and the intervertebral disks [9,10] (Fig. 1). Dorsal wedging of the vertebral bodies and disks (anterior part longer than posterior) increases the lordosis angle, whereas more ventral wedging of these structures (anterior part shorter than posterior) reduces the lordosis angle (Fig. 1). Lumbar lordosis is similarly influenced by the shape of the vertebral bodies and the shape of the intervertebral discs, because each account for nearly 50% of the variability seen in lordotic angles of adults [11,12]. Each of the five lumbar segments (vertebral body and the adjacent disc) contribute to the lordosis. The last lumbar segment (L5) contributes almost 40% to overall lordosis. The first segment (L1) contributes only 5% [13]. The lordosis angle also correlates with the orientation of the inferior articular processes—greater lordosis correlates with more dorsally (horizontally) inclined inferior articular (facet) processes in relation to the vertebral bodies [14] (Fig. 1).

A close correlation exists between the lordosis angle (the common measure of lumbar lordosis) and other postural variables. Many researchers have found a high correlation between the lumbar lordosis angle and pelvic and thoracic orientation in space. Greater lordosis angles correlate with a more horizontally inclined sacrum (increased sacral slope, more vertical sacral endplate), increased pelvic incidence, and increased pelvic tilt [15,16]. Most researchers found that greater lordosis usually correlates with higher thoracic kyphosis, but cases of increased lordosis with reduced thoracic kyphosis have also been reported [15–17]. Small lordosis angles usually correlate with a more vertical sacrum, small pelvic tilt, pelvic incidence, and reduced thoracic kyphosis; however, cases of reduced lumbar lordosis with increased thoracic kyphosis have also been detailed [15–17].

Ontogenetic development of the lumbar lordosis

Although many authors believe that the spine of the human fetus shows only one kyphotic curvature from cranial to caudal [18,19], studies have shown that the fetal spine has lordotic curvature at the lumbosacral junction [20,21]. Choufani et al. [20] in a magnetic resonance imaging (MRI) study of 45 fetuses aged 23 to 40 weeks gestation demonstrated that all fetuses had lordotic lumbar curvature with a mean radius of 18.7 mm. This lordosis was uncorrelated with gestational age, which means that it was not related to growth and, according to the authors, might have been genetically determined.

Few researchers have examined the lordosis angle in early childhood, with Reichmann and Lewin [21], being a notable exception. They found that lordosis angles increased during the first 3 years of life, claiming that at the age of 3, the child's spine reaches an adult-like lordosis angle. Other researchers, however, found that the lordosis angle continues to increase during later childhood and puberty [22,23] even until the age of 20 [6] (Table 1). For example, Cil et al. [22] demonstrated an increase of the lordosis angle from 44.3° at 3 to 6 years to 54.6° at 13 to 15 years.

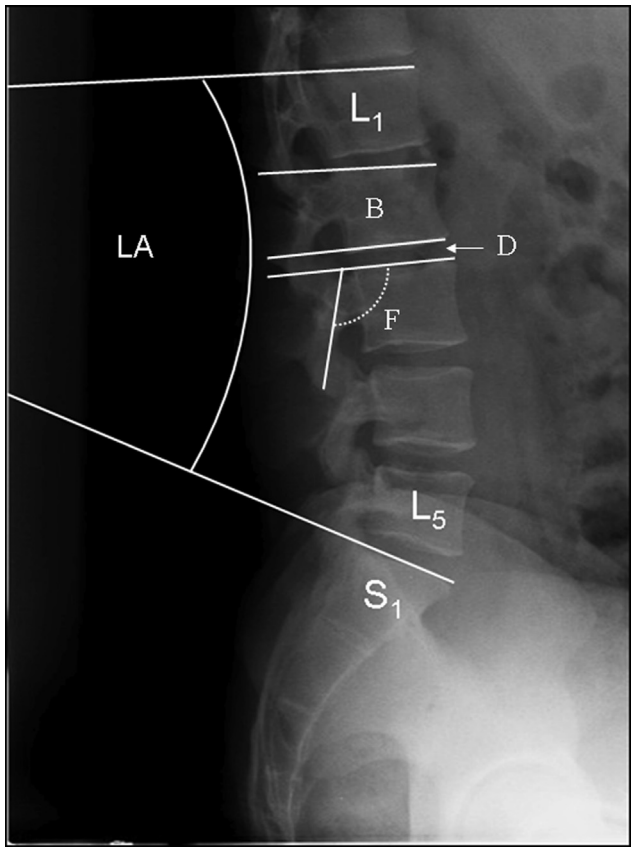

Fig. 1. Measurements of lumbar lordosis Cobb's angle (LA), vertebral body (B) and intervertebral disc (D) wedging, and facet joint angle (F).

It can be concluded that lumbar lordosis begins to develop in fetuses. The major increase of the lordosis angle occurs during the first 3 years of life and continues increasing at least until puberty. There are many gaps in the current knowledge regarding the ontogenetic development of lumbar lordosis. Additional studies are essential to fill in this gap and to identify the factors that determine lordosis development. Ascertaining the normal values of lordosis in children is essential for early detection and treatment of postural abnormalities.

Evaluation of lumbar lordosis

Number of evaluated vertebrae

One of the fundamental questions regarding lordosis evaluation is the number of vertebrae or segments (vertebra and adjacent intervertebral disk) measured. The most common evaluation of lumbar lordosis uses the angle formed by all five lumbar segments (L1–L5). When employing Cobb's