ELSEVIER

Gait & Posture 5 (1997) 101–107

GAIT & POSTURE

Measurement of lumbar lordosis as a component of clinical gait analysis

Michael W. Whittle*[a,b], David Levine[c]

[a]Cline Chair of Rehabilitation Technology, The University of Tennessee at Chattanooga, 615 McCallie Avenue, Chattanooga, Tennessee 37403, USA

[b]H. Carey Hanlin Gait Analysis Laboratory, Siskin Hospital for Physical Rehabilitation, 1 Siskin Plaza, Chattanooga, Tennessee 37403, USA

[c]The University of Tennessee at Chattanooga, 615 McCallie Avenue, Chattanooga, Tennessee 37403, USA

Received 17 January 1995; revised 31 May 1995; accepted 3 January 1996

Abstract

A new method is described for the measurement, during clinical gait analysis, of the angle of lumbar lordosis, defined as the difference in the sagittal plane angle between the two ends of the lumbar curve. The use of additional markers mounted directly on the skin of the back was found to be unsatisfactory. The use of skin-mounted rigs, at the two ends of the lumbar curve, was sufficiently accurate and convenient for routine adoption in a clinical gait analysis setting. Reliability studies showed good test-retest agreement for both static and dynamic measurements of lumbar lordosis.

Keywords: Gait; Posture; Lordosis

1. Introduction

Lumbar lordosis is defined as the anterior convexity of the lumbar spine, in the sagittal plane [1] (Fig. 1). The degree of lumbar lordosis is variable between individuals, and is the result of many factors. The fifth lumbar vertebra (L5) is wedge-shaped, the anterior aspect of the vertebral body being approximately 3 mm thicker than the posterior aspect [2]. The vertebrae above L5 are less wedge-shaped, but due to the shape of L5 and the first sacral (S1) vertebrae, each vertebra above this level lies slightly posterior to the vertebra above it. The intervertebral discs in the lumbar area are also wedge-shaped, especially between L4 and L5, and between L5 and S1, the intervertebral disc at the L5–S1 interspace being 6-7 mm thicker anteriorly than posteriorly [3]. These factors all contribute to producing the normal lumbar lordosis.

Changes in the lumbar lordosis frequently occur in pathological gait, usually in association with alterations in pelvic tilt, and commonly as a compensation for a limited range of flexion/extension at the hip joint [4,5]. The parameters typically measured in clinical gait analysis [6] include the movements of the pelvis, but do not include changes in the lumbar lordosis.

Various methods for measuring the lumbar lordosis have been used in an attempt to quantify the curve. Goniometry, radiography, skin markers over the spinous processes, and use of flexible rulers have all been used [7–14].

Spinal motion has also been measured during gait by Thurston and others, in both normal individuals [15–17] and in patients with osteoarthritis of the hip [18]. These studies used stroboscopic illumination and television cameras, interfaced to a computer, to measure the three-dimensional (3-D) positions of retroreflective markers attached to the subject [19]. The movements of the pelvis and the lower thoracic spine were measured in a room-based coordinate system, but the technique did not specifically measure the lumbar lordosis. The aim of the present study was to devise a way to include the measurement of lumbar lordosis in clinical gait analysis, both statically and dynamically, using the protocol for the Vicon gait analysis system.

Thurston et al. [15] used lightweight rigs, fixed to the spine in the lumbar and sacral regions, to record move-

* Corresponding author, at the University of Tennessee address.

0966-6362/97/$17.00
PII S0966-6362(96)01079-X

The reliability studies indicated that the method of measurement was sufficiently reproducible for routine use. Repeat static measurements on the same subject over the course of about 30 min, and dynamic measurements during four successive walks, showed only small variations, which could well have been due to real changes in lordosis, rather than to measurement errors. In the absence of a 'gold standard' against which to compare the measurements obtained here, it was not possible to establish validity. Consideration was given to the use of radiography to establish the relationship between the skin-mounted rigs and the underlying skeleton at different degrees of lumbar spine flexion. However, this was considered ethically unacceptable, since it would require making two or three mediolateral X-rays of the subjects, which would result in significant dosage to sensitive internal organs, including the ovaries.

The present paper is concerned primarily with the principles of lumbar lordosis measurement and with marker placement. Further enhancements are planned for the methods of data analysis, which will be reported in a subsequent paper. One limitation of the technique at present is that the lumbar lordosis was measured in the plane of progression, rather than in an anatomically based reference system. For the normal subjects used in the present study, the calculated errors this introduced in the measurement of lumbar lordosis were $< 1°$. However, it is proposed to revise the analytical procedure, to use the attitude of the pelvis to define the subject's sagittal plane, and also to examine lumbar spinal motion in the coronal and transverse planes, as well as in the sagittal plane.

5. Conclusions

A system to measure lumbar lordosis statically and during clinical gait analysis was devised, using rigs with lightweight wands that were fixed to the sacrum and the upper lumbar/lower thoracic spine. These rigs were constructed of materials commonly found in gait analysis laboratories, and were found to measure lumbar lordosis both reliably and conveniently.

Acknowledgement

The authors would like to thank Karen Hood, MS, PT, for her assistance in data collection. This study was partially supported by a grant from the Foundation for Physical Therapy, Inc.

References

[1] Bogduk N, Twomey L T. *Clinical Anatomy of the Lumbar Spine (2nd edn.)*. New York: Churchill Livingstone, 1991: 45–47.
[2] Gilad I, Nissan M. Sagittal evaluation of elemental geometrical dimensions of human vertebrae. *J Anat* 1985; 143: 115–120.
[3] Schmorl G, Junghanns H. *The Human Spine in Health and Disease (2nd edn.)*. New York: Grune & Stratton, 1971: 18.
[4] Polster J, Spiker U, Hoefert H R, Krenz J U. Biomechanics in lumbar lordosis. In: Nelson R C and Morehouse C A, eds. *Biomechanics IV*. Baltimore: University Press, 1974.
[5] Whittle M W. *Gait Analysis: An Introduction*. Oxford: Butterworth-Heinemann, 1991.
[6] Kadaba M P, Ramakrishnan H K, Wooten M E, Gainey J, Gorton G, Cochran G V B. Repeatability of kinematic, kinetic, and electromyographic data in normal adult gait. *J Orthop Res* 1989; 7: 849–860.
[7] Troup J D G, Hood C A, Chapman A E. Measurements of the sagittal mobility of the lumbar spine and hips. *Ann Phys Med* 1963; 9: 308–321.
[8] *Joint Motion: Methods of Measuring and Recording*. Chicago: American Academy of Orthopaedic Surgeons, 1965: 48–49.
[9] Moll J M H, Wright V. Normal range of spinal mobility. *Ann Rheum Dis* 1971; 30: 381–386.
[10] Hansson T, Bigos, S, Beecher P, Wortley M. The lumbar lordosis in acute and chronic low-back pain. *Spine* 1985; 10: 154–155.
[11] Burdett R G, Brown K E, Fall M P. Reliability and validity of four instruments for measuring lumbar spine and pelvic positions. *Phys Ther* 1986; 66: 677–684.
[12] Hart D L, Rose S J. Reliability of a non-invasive method for measuring the lumbar curve. *J Orthop Sports Phys Ther* 1986; 8: 180–184.
[13] Pearcy M. Measurement of back and spinal mobility. *Clin Biomech* 1986; 1: 44–51.
[14] Lovell F W, Rothenstein J M, Personius W J. Reliability of clinical measurements of lumbar lordosis taken with a flexible rule. *Phys Ther* 1989; 69: 96–105.
[15] Thurston A J, Whittle M W, Stokes I A F. Spinal and pelvic movement during walking — a new method of study. *Eng Med* 1981; 10: 219–222.
[16] Thurston A J. Reliability studies of a television/computer system for measuring spinal and pelvic movement. *J Biomed Eng* 1982; 4: 129–132.
[17] Thurston A J, Harris J D. Normal kinematics of the lumbar spine and pelvis. *Spine* 1983; 8: 199–205.
[18] Thurston A J. Spinal and pelvic kinematics in osteoarthritis of the hip joint. *Spine* 1985; 10: 467–417.
[19] Whittle M W. Calibration and performance of a three-dimensional television system for kinematic analysis. *J Biomech* 1982; 15: 185–196.
[20] Oxford Metrics. *Vicon Clinical Manager Users Guide*. Oxford: Oxford Metrics Ltd., 1992.
[21] Shrout P E, Fleiss J L. Intraclass correlation: uses in assessing rater reliability. *Psychol Bull* 1979; 86: 420–428.