Reduction of Crosstalk in the Measurement of Lumbar Spinal Motion

Michael W. Whittle
Cline Chair of Rehabilitation Technology, The University of Tennessee at Chattanooga

Introduction

A recurring difficulty in measuring movement in three dimensions is that motion in one plane (e.g. frontal) is likely to introduce errors into measurements made in a plane at right angles (e.g. sagittal), a phenomenon known as "crosstalk". Cheng & Pearcy (1999) described an algorithm which was designed to overcome this problem, primarily for use with the hip, knee and ankle joints. The current paper describes its application to measurements of lumbar spinal motion, using a method described by Whittle et al. (1999).

Statement of Clinical Significance

Low back pain is a common condition, which causes considerable suffering and economic loss. The accurate measurement of movements of the lumbar spine will help to identify its causes, and contribute to the assessment of different methods of treatment.

Methodology

The measurement of lumbar spinal motion using two skin-mounted "rigs", one fixed to the skin over the sacrum, and one over the thoraco-lumbar junction, has been described elsewhere (Whittle et al., 1999, 2000). The three-dimensional position of reflective markers on the rigs was determined using a Vicon system (Vicon Motion Systems, Oxford). A coordinate system based in the pelvis was used to determine the orientation of the upper rig. A number of different techniques have been used to convert this orientation into the three-dimensional motions of lumbar spinal flexion/extension (kyphosis/lordosis), lateral bend and axial rotation. The initial analysis was based on projection of marker coordinates onto anatomical planes (Whittle et al., 1998). This was subsequently refined into a method based on Euler rotations (Whittle, 2002). The present analysis used another method, that of Cheng & Pearcy (1999), in an attempt to reduce or eliminate crosstalk. In Fig. 1, lateral bend is conventionally determined as the angle "a", between the Z axis and the projection onto the frontal plane of the vector V. In Cheng & Pearcy's method, the angle "b" is used, which is the angle between the vector itself and its projection onto the sagittal plane, thus eliminating crosstalk due to rotations around the Y axis (flexion/extension). Similar methods were used for the other two planes of motion.

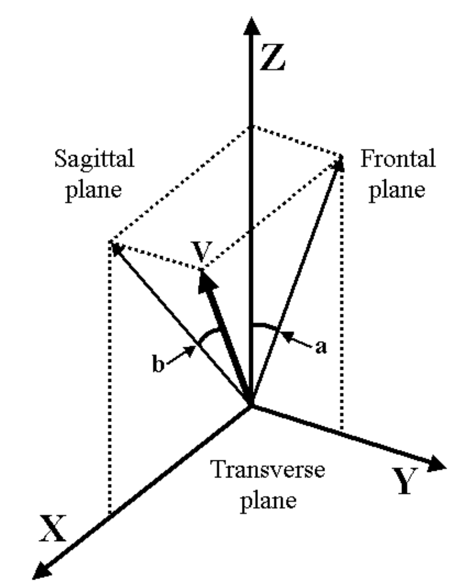

Fig 1: The method of Cheng & Pearcy, 1999 (see text).

20 healthy adult females (age range 20-31) walked on a treadmill at 1.8m/s. A more detailed description of this study (which included standing and running, and uphill and downhill gradients) has been reported elsewhere (Whittle et al., 2000). The three planes of motion of the lumbar spine were calculated by two different methods: Euler rotation (Whittle, 2002),

and by the method of Cheng & Pearcy (1999). The differences between the two results were calculated, and related to the magnitude of the angular movements in the other two planes.

Results

Lateral bend: measurements by Euler rotation produced identical results to that by the method of Cheng & Pearcy (1999).

Axial rotation: showed a mean difference of zero between the two methods of measurement (range -0.10º to +0.25º).

Flexion/extension (kyphosis/lordosis): the mean difference was -0.20º (range -1.76º to +0.13º). However, flexion/extension showed considerable variability between subjects. In many, there was a significant correlation between the lateral bend or axial rotation and the difference in flexion/extension estimated by the two methods. Fig. 2 shows data from a typical subject, in whom 10º of lateral bend caused a change in lordosis of approximately 1º. Most such curves had an approximately parabolic shape.

Discussion

In the absence of a "gold standard", it is impossible to say that one method of measuring three-dimensional lumbar spinal motion is "better" than another. However, the presence of crosstalk is a known problem, and it is reasonable to favor a solution which seeks to eliminate it. The magnitude of the differences that this makes, in comparison with a method based on Euler angles, is extremely small: zero for axial rotation, and less than 0.25º for lateral bend, neither of which is likely to be of any clinical significance. Larger differences between the methods (to a maximum of 1.76º) were observed for flexion/extension. The discrepancies were larger at higher angles of axial rotation and lateral bend, and this, together with the approximately parabolic shape of the typical curve (Fig. 2) suggested that the discrepancies were probably due to crosstalk, and that they might become considerable at even larger angles of rotation and bend. The present data were obtained from walking normal subjects, and it is to be anticipated that these effects would become more important when greater angles of lateral bend and axial rotation are present, such as in individuals with abnormal spinal motion, or during activities which involve greater degrees of spinal movement. The algorithm of Cheng & Pearcy (1999) thus appears to be an improvement on the Euler rotation method.

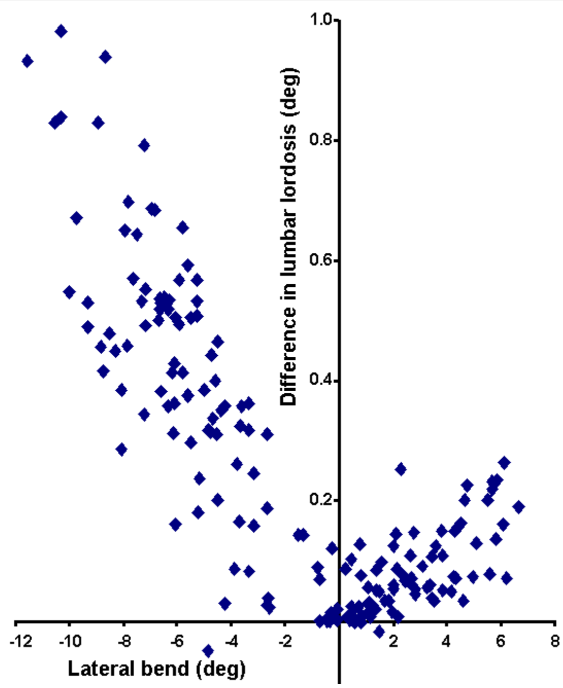

Fig 2: Lateral bend *versus* the difference in lordosis (see text)

References

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