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Three-dimensional relationships between the movements of the pelvis and lumbar spine during normal gait

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Abstract

The three-dimensional motions of the pelvis and lumbar spine in walking were measured, in 20 normal adult males, using "Vicon" optoelectronic system, with reflective targets attached to lightweight rigs over the thoracolumbar junction and upper sacrum. Pelvic motion (using a room-based coordinate system) corresponded to published data. In the sagittal plane, the change in lumber lordosis across the gait cycle was consistent within subjects, but varied considerably between subjects. The phase relationships between pelvic tilt and lumbar lordosis also varied considerably between subjects. In the frontal plane, there was a much more consistent pattern of motion, spinal lateral bend generally following the pattern of pelvic obliquity, although there was some additional lateral bend, just prior to initial contact, superimposed on the generally linear relationship. The transverse plane showed similar waveforms between axial rotation of the pelvis and axial rotation of the lumbar spine, except that motion of the pelvis was of greater magnitude, and occurred later in the gait cycle than the motion of the lumbar spine. Since arm swing could be expected to increase axial rotation of the spine as a whole, this suggests that the thoracic spine undergoes greater motion than the lumbar spine, in this plane. Comparisons between the present study and two other published

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pelvis was twisted in relation to the line of progression, with the right side forward. The lumbar spine had a corresponding twist to the right. The roughly circular outline of the angle–angle plot in Fig. 9 indicates a phase lag of approximately 90° between the two waveforms, the axial rotation of the lumbar spine changing earlier in the gait cycle than the pelvic rotation, although both achieved their maximal and minimal values just after initial contact on each side. Crosbie et al. (1997) also noted a phase lag between axial rotation of the thoracic spine and of the pelvis, and speculated that it might represent a mechanism for conserving angular momentum. Inman et al. (1981) also showed that the phase difference in axial rotation, between the pelvis and the shoulder, was less than 180°, which is consistent with the present results, if it is assumed that the lumbar spine reflects, at least in part, motion of the shoulders as well as of the pelvis.

In the shape of the curve of axial rotation, the present study agreed better with the data of Rowe and White (1996) than with that by Crosbie et al. (1997). However, the latter authors did note that this plane of motion was their least accurate measurement.

5. Summary

(1) The measurement of the three-dimensional motion of the lumbar spine, by rigs on the pelvis and at the thoracolumbar junction, is practical and convenient, with a high degree of inter-subject reliability.

(2) Changes in lumbar lordosis during the gait cycle are very variable from one subject to another, and it is impossible to make generalizations about the pattern of motion.

(3) The pattern of lateral bend of the lumbar spine corresponds closely to that of pelvic motion in the frontal plane, except for a small additional lateral bend of the lumbar spine, just prior to initial contact.

(4) Axial rotation of the pelvis and the lumbar spine produce similar waveforms, except that motion of the pelvis is a little greater, and occurs later in the gait cycle than the corresponding motion in the pelvis.

(5) Allowing for differences in technique, especially with regard to coordinate system definitions, the results from the present study are in reasonable agreement with those from two other recent studies.

(6) Lumbar lordosis has its own pattern of movement: it is not simply a reflection of pelvic motion. It most closely follows pelvic motion in the frontal plane.

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