A FOLLOWER LOAD STABILIZES THE LUMBAR SPINE WITH MINIMAL CHANGES IN SAGITTAL PLANE MOBILITY

INTRODUCTION: Patwardhan, et al. [1] have shown that the lumbar spine can support physiologic compressive loads in a static posture if the load was applied along the follower load path, i.e., along a path approximating the tangent to the spinal curve, the segmental bending moments and shear forces on the mid-transverse plane of the discs are minimized. The purpose of this study was to investigate the effect of a compressive follower preload on the neutral zone, range of motion (ROM), and flexibility of the lumbar spine in flexion and extension.

METHODS: The six specimens tested had no radiographic signs of significant degeneration or bridging osteophytes. The compressive follower preload range was 0-1200 N, which was the maximum load level the apparatus could apply. The flexion and extension moment ranges were 0-8 Nm and 0-6 Nm, respectively. A follower preload was applied bilaterally with cables and weights. The cables, attached to L1, passed through guides on L2-L5 and were connected underneath to a loading hanger. The ROM for zero preload was determined first. The load cycle began with zero moment. The applied moment was changed by computer-control of water volume in bags attached to the loading arms at L1.

Next, the follower load path was optimized for neutral posture by adjusting the cable guides. The neutral path produced minimum changes in lumbar lordosis when the follower load (0-1200 N) was applied to the specimen in neutral posture. Once adjusted, the cable path was not altered. The ROM test was repeated for the same range of follower preload.

Total ROM and neutral zone were determined from the load-displacement curve (Fig 1). The flexibility coefficients a1 and a2 were defined as the slopes of the load-displacement curve at low and high flexion moments, respectively. Similarly, a3 and a4 are the flexibility coefficients at low and high extension moments, respectively.

RESULTS: Fig. 1a shows the response when the follower preload was applied along a path optimized for neutral posture. The response in Fig. 1b is for the follower preload applied along a path optimized for a forward flexed posture. Both show a gradual change from a nonlinear to a linear curve with increasing follower preload magnitude. The effect of changing the follower load path is clearly seen on the flexion response. The decrease in ROM is consistent with the more linear load-displacement curve at low and high flexion moments, respectively.

We believe the follower load path represents the overall effect of muscles that stabilize the spine and allow it to support compressive loads of physiologic magnitude not only in a static posture, but throughout the ROM in a dynamic task as seen in this study. Our results suggest that spinal stability under physiologic magnitudes of compressive loads can be achieved with minimal changes in spinal mobility in the sagittal plane. These results may help explain how muscles stabilize the lumbar spine in lifting tasks that involve trunk bending.

Our study is limited in that the effects of degeneration and loading rate were not investigated. Also, as the specimen was moved through its ROM, it is likely that the follower load path did not pass precisely through the instantaneous centers of rotation, creating an “imperfect” follower load path. While limited testing implies that the results are not significantly influenced by this effect, it is the subject of ongoing investigation.


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