INTRODUCTION

Sagittal trunk motion is accomplished through a coordination of pelvic rotation and lumbar spine flexion/extension. As trunk range of motion in healthy subjects is not fundamentally different to persons with low-back pain (LBP), other means of discriminating the two populations must be used. Research suggests that lumbar-pelvic (LP) coordination could be a potential diagnostic metric for LBP. Though LP coordination has been studied at length, there is little consensus regarding the gross contributions of the lumbar spine and pelvis to total trunk motion; literature values for lumbar to pelvic (L/P) ratios range from 0.4 to 1.97. Such a spread of literature values would pose difficulties for the comparison of healthy and LBP populations. Previous studies have not controlled lifting parameters such as weight or trunk extension velocity as possible influences of LP coordination. A study of the effect of lifting parameters upon LP coordination was performed to provide a complete description of lifting behavior and to assess possible sources of error in previous quantifications of LP coordination.

PROCEDURES

18 subjects (13 M, 5 F) with no prior history of LBP volunteered to participate in the study. Subjects performed lifting exertions at 15, 30 and 60 deg./s trunk extension velocity with 0 and 10 kg loads carried in the hands. To control trunk extension velocity, subjects were required to follow a target region in a real time display that was pre-programmed to travel at the desired trial velocity. Spinal motions were recorded from six degree of freedom electromagnetic sensors placed over the spinous processes of the S1 and T10 vertebrae. The shape and magnitude of the LP coordination was quantified using principal component analysis (PCA). For direct comparison to literature values, L/P ratios were calculated over three 30° windows as reported in previous studies. A repeated measures ANOVA was performed on all findings, and significance was noted for all effects with $\alpha < 0.05$.

RESULTS AND DISCUSSION

PCA results show that the weighting coefficient of the most powerful eigenvector was significantly affected by task weight. This eigenvector describes the basic lifting behavior of all subjects, so significance with weight describes a gross effect upon the lumbar and pelvic contributions to total trunk motion.

![Fig. 1: Weight effect on LP Coordination](image)
The weighting coefficient of the third most powerful eigenvector was significantly affected by the trunk extension velocity. This eigenvector describes a time dependent shift in the L/P ratio, so significance with velocity describes a timing effect on the LP coordination.

Fig. 2: Velocity effect on LP Coordination

Calculated L/P ratios agree to some extent with literature values, but previous studies did not control the aforementioned lifting parameters. The average L/P ratio was approximately 2.25, describing the lumbar spine as responsible for roughly 70% of the total motion.

Marras reported that lifting parameters influenced lumbar spine behavior. As the lumbar and pelvic angles recorded in this study describe the shape of the lumbar spine, the lifting parameter effects on LP coordination found in this study are consistent with his findings. Minitski found that weight affected lumbar timing and not lordotic magnitude, suggesting L/P ratio was not affected as was found in this study. However, Davis found that lumbar timing was affected by weight with the bent-knee lifting method, but not with the straight-leg lifting method. Given that Minitski’s study did not limit knee flexion, Davis’ finding could well explain how Minitski’s study contradicts the findings of this study.

SUMMARY

LP coordination is statistically different under differing lifting parameters. Task weight affects the magnitude of the gross LP contributions to trunk extension, while trunk extension velocity affects the timing of the lumbar and pelvic contributions to trunk extension. As previous research did not take these lifting parameters into account, these findings could explain the wide range of L/P ratios previously reported. Given this, if LP coordination is to be used to compare healthy and LBP populations, lifting parameters such as weight and trunk extension velocity must be carefully controlled. Now that the LP coordination has been quantified for healthy subject population, future work can be done to compare this data set with persons with LBP. A similarly performed PCA could yield a physiologic eigenvector describing LBP behavior as statistically different from that of healthy subjects. Another future direction of LP coordination research is to employ it as measure of spinal stability.

REFERENCES


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