The Effects of Gender, Speed, and Target Height on the Coupling of Spine and Hip Motions During Full Body Reaching Tasks. Johnna E. Cottrell, Haley M. Shupe, Kasey A. Kinnions and James S. Thomas. School of Physical Therapy, Ohio University, Athens OH, USA

Introduction

Every day we perform reaching tasks that can be compiled by combining an infinite number of movement patterns. When there are greater degrees of freedom (DOF) available than are required to complete a task, the problem of kinematic redundancy is introduced (Hasan, 1999). Our central nervous system (CNS) attempts to control for this abundance of options by imposing rules to simplify complex joint motions (Hasan, 1999). One possible control strategy addressed theoretically in the literature is the scaling of torque produced by upper extremity segments while completing a multi-joint reaching task. Multi-joint tasks have more torque that must be factored into the planning of the movement, and the CNS coordinates shoulder and elbow motions so that control is simplified and redundant DOF are reduced. Coupling of spine and hip motions thought to occur in a similar manner and kinematic patterns have been described during forward and backward reaching tasks. Although movement patterns of the spine and hip have been identified, no evidence exists proving that the CNS simplifies the redundant DOF available during unimanual tasks in the spine and hip literature.

The purpose of this study was to investigate the effects of specific variables in the S/H ratio during forward reaching tasks. In this study we hypothesized that gender and target height will have an effect on the S/H ratio, however the S/H ratio will be inconstant relative to the speed of movement.

Methods

Sixteen healthy individuals, 8 men (M= 25.25 ± 3.99) and 8 women (M= 23.63 ± 3.54), were recruited to participate. Experimenters used trunk length, hip height, and arm length to determine the target locations for each subject. As a result, the hip target could be reached by flexing the hips 40, 60 and 80 degrees with the shoulder flexed at 90 degrees, the elbow extended and movement about the axes and ankles. The middle and low target heights could be reached in a similar manner by flexing the hips 60 and 90 degrees respectively. The MotionMaster (MM™) was used to record motion of the lumbar spine and hip during full-body reaching tasks in the para-sagittal plane. Sensors were attached to the seventh cervical vertebra (C7), sacrum, and mid-high of the right hip by Velcro® straps. Lumbar spine motion was defined as the difference between the orientations recorded for each instance in time at C7 and sacral sensors. Hip motion was defined as the sum of the orientations recorded at the mid-thigh and sacral sensors (Figure 1A).

Participants performed reaching tasks to three targets in the para-sagittal plane at comfortable and fast speeds. For each speed, subjects performed three trials at each target height and were given no instructions regarding the limb segment geometry to begin with a movement trial. The final joint angles were determined by averaging the targets in half the time of their comfortable and fast-paced trials.

There was a main effect of movement speed on the spine/hip ratio (F(1,14)=8.36, p<.05). As the speed of movement increased, the spine/hip ratio decreased (Fig. 1). Across all targets the mean spine hip ratio was 1.51 for comfortable speeds and 1.29 for fast-paced speeds. Changes in hip orientation plotted against changes in segment orientation (Figure 2). As the hip target was lowered, the spine target was decreased. The spine/hip ratio was defined as the change in hip orientation divided by the change in joint angle of the hip. The spine/hip ratios were analyzed with a mixed ANOVA, which would be significant if there was a trend for the spine/hip ratio to decrease as the target height was lowered (F1,14)=3.4, p=.077). There were no main effects of gender on the spine/hip ratio.

Results

The effects of gender, speed, and target height on the coupling of spine and hip motions during full-body reaching tasks. Figure 3 illustrates that the spine/hip ratio is simplified and redundant DOF are reduced. Coupling of spine and hip motions thought to occur in a similar manner and kinematic patterns have been described during forward and backward reaching tasks. Although movement patterns of the spine and hip have been identified, no evidence exists proving that the CNS simplifies the redundant DOF available during unimanual tasks in the spine and hip literature.

Figure 1. A) Target locations were determined from the subject’s trunk length, arm length, and hip height. B) Subjects could reach Target 1, 2, and 3, in theory, by flexing their hips 40° (with the elbow extended and the shoulder flexed 90°) without any motion of the ankles, knees, or spine. C) An individual subject reaching for Target 2 at a comfortable pace.

Figure 2. Change in the spine/hip ratio is displayed for all subjects at each target height for both comfortable and fast-paced speeds. The mean contributions of individual segments that make up the S/H ratio are illustrated for all three target heights and both comfortable and fast-paced speeds. A) The changes in spine orientation for an individual reaching for target 2 at a comfortable pace. B) The mean contributions of individual segments that make up the S/H ratio are illustrated for all three target heights and both comfortable and fast-paced speeds. A) The changes in hip orientation plotted against changes in spine orientation for an individual reaching for target 2 at a comfortable and fast-paced speed. B) The mean changes in hip orientation for all subjects. Conclusions

The results clearly indicate that the coupling of spine and hip motions change as movement speed varies. It may be the case that individuals with low back pain have altered coupling of the spine and hip that is only revealed when the task parameter of movement speed is varied. Additionally, it appears from these data that there is considerable variability in the coupling of the spine and hip motions for reaches to various target heights. This study provides baseline data for investigations of movement patterns of individuals with impairments of the lumbar spine.

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