ANALYSIS OF JOINT KINEMATICS DURING QUIET STANDING FOLLOWING LOCALIZED LUMBAR EXTENSOR FATIGUE

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INTRODUCTION

In recent years, many studies have reported increases in postural sway with localized muscle fatigue. Results of these studies have shown increases in sway based on characteristics of the center of pressure (COP) and center of mass (COM) trajectories. While these measures are certainly important in assessing postural stability and control (Maki et al., 1991), they are limited in discerning postural strategies and movement patterns (Kuo et al., 1998). Therefore, in order to advance our understanding of these reported changes in postural sway following fatigue, it is necessary to employ measures which are more sensitive to subtle changes in body movements.

The purpose of this investigation was to characterize changes in postural sway and postural control during quiet standing using joint kinematics. It is not clear what changes in body movements contribute to the reported increases in COP and COM-based measures of sway. Are the effects local to the site of fatigue? Is there any evidence of changes in postural strategy which are indicative of changes in postural control? To answer these questions, changes in COP, COM, and joint kinematics were analyzed during quiet standing following localized lumbar extensor fatigue.

METHODS

Twelve physically active males with no reported history of low back pain participated in the experiment. Participants attended three experimental sessions. During each session, postural sway was recorded before and after a lumbar extensor fatiguing protocol. This protocol consisted of lumbar extensor exercises performed on a 45° roman chair with intermittent assessment of fatigue level by measuring the maximum possible torque exerted around the low back, approximately L3 (Davidson et al., 2004). Body position and COP data during quiet standing were collected for 30 seconds both before and after the lumbar fatigue protocol. During these collections, instructions were given to “stand as still and as quietly as possible” with feet together, eyes closed, and arms at their sides.

Posture in the anterior-posterior (AP) plane was described using (1) mean COM and COP position; (2) mean joint angles. Postural sway was described using (1) standard deviation (SD) of COM and COP position; (2) SD of ankle, knee, hip, and back angles; and (3) SD of ankle, knee, hip, and back angular velocities. Cross correlations of selected variables were also performed to quantify AP postural strategy in terms of the so-called ankle strategy and hip strategy: (1) ankle angle and COM position; (2) hip angle and COM position; (3) ankle angle and hip angle. A two-way repeated measures ANOVA was used to determine the significant effects of fatigue on the dependent variables.
RESULTS AND DISCUSSION

Three main findings emerged from this investigation. First, participants adopted a slightly forward lean when fatigued. Second, changes in sway involved increased variability in joint kinematics at different joints, including joints distal to the fatigued musculature. Despite these changes, ankle angle correlated well with AP COM position. Third, global measures of COM and COP did not reveal localized changes in sway such as joint kinematics.

The slight forward lean adopted by participants may represent a strategic change in posture which is beneficial to balance control. A slight forward lean necessitates an increase in muscle activity and concurrent increased ankle stiffness thus reducing reliance on sensory feedback control.

Qualitatively, the increase in kinematic variability in joints distal to the feet (Figure 1) is consistent with previous work by Gatev et al. (1999). Variability increases following low back fatigue are indicative of more erratic sway. Despite these changes, ankle angle remained highly correlated with COM position, suggesting that an ankle strategy remained the predominant strategy after fatigue.

In addition, no changes were found in COM or COP displacements with fatigue in spite of simultaneous increases in joint kinematic variability. COM and COP variables are traditionally the most commonly used means of assessing sway. However, the results of this study indicate that additional or multivariate measures of sway are necessary to understand how fatigue affects movement patterns during quiet standing.

REFERENCES


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