INTRODUCTION

Rotation between jobs is commonly used to reduce the incidence of workplace injuries [1]. Many tasks that are included in job rotation schemes have standing postures as a necessary and unavoidable component. Typically job rotation design has focused on alternating between jobs with high and low physical demands [2]. While prolonged standing may be classified as a task component with low physical demand, there may be adverse effects of moving from a sustained static posture to a more dynamic activity [1]. Epidemiology studies have shown a strong association between prolonged standing and low back pain (LBP) [3]. It is possible that including a period of prolonged standing in a job rotation cycle may have detrimental effects. The purpose of this study was to investigate the impact of a prolonged standing exposure on biomechanical profiles (trunk muscle activation, joint stiffness and kinematics) during 3 functional movements.

METHODS

Forty-three volunteers (22 male, 21 female) participated in this study. A set of 3 functional movements that incorporate base elements of common occupational tasks (squatting, forward bending from the hips, and single leg standing) were performed pre- and post- a 2-h standing exposure. Continuous electromyography was collected from 8 bilateral muscle groups (latissimus dorsi, thoracic and lumbar erector spinae, rectus abdominis, internal and external oblique, gluteus maximus and medius). An 8-segment (trunk, pelvis, bilateral thigh, shank and foot) bottom-up inverse dynamic rigid link model was created from kinematic data (Optotrak Certus, Northern Digital Inc., Waterloo, ON) using Visual3D software (C-Motion Inc, Kingston, ON) and kinetic data from in-floor force platforms positioned under each foot (Advanced Medical Technologies Inc, Newton, MA). Primary outcome measures of interest included Flexion Relaxation Ratios (FRRs) during forward bending, Center-of-Pressure (COP) excursion during single leg standing (SLS), and active vertebral joint rotation stiffness (VJRS) during SLS and squatting.

FRRs for the thoracic and lumbar erector spinae and gluteus maximus muscles were calculated as a ratio between the linear enveloped EMG signals in upright standing and fully flexed positions. Antero-posterior and medio-lateral COP (COP_{AP} and COP_{ML}) were calculated from the force platform data and maximum excursion over the 10-s SLS trial was calculated as the difference between the minimum and maximum COP values for each direction and each lower extremity. VJRS was calculated for each axis and each lumbar motion segment using an existing anatomical model in combination with distributed moment equations [4,5] for the eccentric and concentric phases of the squat and the SLS tasks.

Statistical analyses were conducted using multifactorial general linear models in SPSS version 17.0 (SPSS, Inc, Chicago, IL) with a significance criterion of $p \leq 0.05$.

RESULTS

There were significant changes from pre-post standing exposure in two of the outcome measures for the SLS task. During right SLS, there was a significant decrease ($F_{1,32} = 4.473, p < 0.05$) in active vertebral stiffness about the lateral bend axis at the L₃L₄ and L₄L₅ motion segments.
following the standing exposure (Fig. 1). Participants increased their relative trunk lateral bending angle (trunk relative to pelvis) during right SLS following standing exposure ($F_{1,38} = 8.63, p < 0.05$) (Fig. 2). There was also a significant interaction between gender and standing exposure for COP<sub>AP</sub> ($F_{1,39} = 4.201, p < 0.05$) and COP<sub>ML</sub> ($F_{1,39} = 8.506, p < 0.01$) during SLS, with males demonstrating increased and females demonstrating decreased COP excursion in both directions following standing exposure. There were no significant pre-post standing differences for FRR during forward bending or VJRS during the squat task.

**Figure 1:** There was decreased vertebral rotation stiffness about the lateral bend axis from L<sub>2</sub> – L<sub>5</sub> during right SLS following standing exposure.

**DISCUSSION**

Results from this study indicate that there are biomechanical changes that take place during functional movement performance in response to a prolonged standing exposure, including a decrease in vertebral rotation stiffness, increased COP excursion and increased trunk lateral bend during a simple balance challenge.

The decreased stiffness observed in lateral bending during SLS could be an issue if the task being rotated to following prolonged standing included the necessity for resisting a side-load in combination with a balance activity, as might be seen in occupations such as construction, where workers spend most of their day in standing conditions and are also manipulating heavy loads, often at heights or on unstable/uneven surfaces.

It is unclear whether the increased COP observed in males would translate to greater difficulty with higher-level balance challenges or imply a balance deficit, as the magnitude of COP excursion remained relatively small (on the order of a 2-4 centimeters). This small decrease in postural stability could potentially have an impact on an individual’s ability or safety in performing balance-intensive tasks following a period of standing, particularly if the task in question involved high risk (walking a narrow beam, working on unstable surfaces). Individuals who already have some balance deficit may be negatively impacted by a period of prolonged standing, and this should be a consideration when designing and implementing task rotation in the workplace.

The increase in right lateral bending of the relative trunk angle during RSLS following standing exposure may have been a compensation to decrease the moment arm for the right gluteus medius by centering the trunk mass more directly over the stance limb.

**CONCLUSIONS**

Prolonged standing exposures may have a negative impact on balance responses and the ability to resist lateral bending loads during balance challenges. These findings may not preclude prolonged standing from being a viable task component of job rotation except in certain high-risk scenarios. These factors should be considered when designing job rotation order.

**REFERENCES**