WHAT ASPECTS OF POSTURAL TRANSITIONS AFFECT BALANCE CONTROL UPON STANDING?

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INTRODUCTION

Postural transitions represent self-initiated threats to postural stability [1]. The transition from sitting to standing has received considerable attention in the biomechanical literature, partially due to the musculoskeletal and postural control challenges related to aging that are elucidated during this task [2]. Similar challenges arise during transitions from other postures, although these movements have received minimal attention in the literature. One difficulty in studying such transitions is the variability within the movements, which is generally controlled during sit-to-stand movements. It is uncertain how factors related to the transition from non-seated postures are associated with the resulting imbalance upon standing.

METHODS

Forty-five healthy men aged 18 to 66 years transitioned to standing after maintaining one of three static postures. Static postures included bent at waist, squat, and forward kneel (Figure 1). Nine replications of each condition were analyzed for a total of 27 trials.

Participants transitioned to quiet standing at a self-selected velocity when alerted by an auditory signal. Data was collected for a total of 20s, which included the time to transition (<5s). A minimum rest period of one minute was provided between trials to minimize cumulative fatigue effects.

Whole body motion data was collected at 100Hz and low-pass filtered using a fourth order Butterworth filter, 8Hz cutoff. Whole body center of mass (COM) position data were calculated as the weighted sum of 13 segments. Center of pressure (COP) position data was sampled at 1000Hz from two forceplates prior to low-pass filtering (zero lag fourth-order Butterworth, 5Hz cutoff).

Displacement and velocity of the COM during the transition were calculated for each posture, followed by the area of the base of support upon standing. COP-based balance measures for the period following the transition to standing were calculated to determine the level of balance control. They included COP range AP (antero-posterior), COP range ML (medio-lateral), peak COP velocity AP and peak COP velocity ML. Repeated measures analyses of variance using mixed models were performed to determine the effect of posture ($\alpha=0.05$).

RESULTS AND DISCUSSION

Postural transitions to standing require substantial movement of the center of mass that is dependent upon the initial position. Three postures were examined that significantly differed in horizontal and vertical displacement of the COM (Figure 2). The peak velocity of the COM during the transition was also significantly affected by the initial posture (Figure 3). The smallest values were associated with bent at waist while the largest values were obtained when transitioning from a forward kneel.
Participants applied motor control strategies when transitioning from bent at waist to prevent excessive movement in the AP direction that could lead to a loss of balance.

Balance measures were generally smaller, reflecting more stability, for bent at waist with increases occurring for the squat and then forward kneel. The trends in the data were similar to those related to the displacement and velocity of the COM. Figure 4 illustrates the effect on COP range ML although the effect was similar for all balance measures, including those related to displacement and velocity of the COP.

The area of the BOS was relatively consistent across posture. The squat resulted in significantly larger areas (0.14m²); mostly due to larger stance widths required to maintain balance during the static squat. There was no significant difference between bent at waist and forward kneel (0.13m²). Since the effect of posture was not significant, the influence of the BOS on the balance control measures was minimal.

**CONCLUSIONS**

The transition from a non-seated posture to standing has been shown to create a perturbation that may be detrimental to balance and increase vulnerability to falls. It is uncertain what aspects of the transitions are responsible for the differences in the imbalances created upon standing but an initial examination of three different non-seated postures indicated that investigations of the movement of the COM might prove more valuable than the area of the BOS established at the end of the transition.

**REFERENCES**