AN EXPERIMENTAL STUDY OF POSTURAL CONTROL DURING DOWNWARD REACH AND PICK-UP MOVEMENTS: EFFECTS OF AGE AND LIMITING THE LENGTH OF THE BASE OF SUPPORT

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INTRODUCTION

Difficulty bending down to pick up an object from the floor has been associated with increased fall risk in older adults [1]. Stooping, crouching, or kneeling difficulty is prevalent among older adults but few studies have explored the mechanisms underlying downward reaching and pick-up difficulty [2]. Rapid and accurate control of the center of pressure (COP) is expected for maintaining balance during downward reaching and pick-up movements. Particularly among older adults with stooping, crouching, or kneeling difficulty, as they are associated with decreased lower extremity torque capacity [3].

This study seeks to quantify the effects of body configuration changes in downward reaching and pick-up movements. Limiting the length of the base of support will be used to assess how decreased torque generating capacity affects the balance of healthy older women. Body configuration limitations when reaching down to targets at the reaching envelope are expected to lead to faster and more frequent compensatory COP movements in older women when compared to younger women. Decreasing the length of the base of support at the toe is expected to lead to disproportionate increases in losses of balance during the upward recovery phase of movement.

METHODS

Subjects. Healthy young (mean\pm SD, age 22\pm3, Body Mass Index [BMI] 24\pm5, N = 5) and healthy older women (age 76\pm7, BMI 25\pm6, N = 5) were recruited from the local community.

Protocol. To determine whether the effect of age on the COP control of downward reaching movements becomes more pronounced in tasks with a limited base of support, we examined movement time, COP path length, and rate of losses of balance.

Participants performed symmetric two-handed downward reaches to a target placed on the floor while standing with a full or minimal base of support on a platform fixed to a single AMTI force plate (100 Hz sampling rate). Participants were instructed to move the tips of their fingers ‘as fast as possible’ to a pseudo-randomized base of support condition. The minimal base of support was defined as the minimal distance between the toes and the posterior edge of the platform during a successful maximal toe reach (Fig. 1). The target was placed at the participants’ maximal forward reaching distance along the floor. Kinematic data of the entire body were collected using standard motion capture methods (25 Hz sampling rate). Three trials were performed of each foot support condition, but only the
first successful and unsuccessful trials were considered in this analysis.

Analysis of joint motion using optoelectronic cameras provided an assessment of the mean number of losses of balance (LOBs), defined as a stepping response, occurring during 1) the downward reach, or 2) the upward recovery (return-to-stance) movement. Linear mixed models using a restricted maximum likelihood method were used to examine the effect of age, base of support condition, and loss of balance.

RESULTS AND DISCUSSION

Older women had shorter reaching distances and larger minimal bases of support (p<.05). Older women tended to have more losses of balance upon return to stance (Table 1). When reaching down, movement time and COP path length were not significantly different between young and older women. However, older women tended to be slower when they lost their balance, while younger women tended to be faster while reaching down when they lost their balance (p = .063). COP path length was significantly decreased when performing the downward reaching task on a limited base of support (p < .005).

<table>
<thead>
<tr>
<th></th>
<th>Young Women (N=5)</th>
<th>Older Women (N=5)</th>
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<tbody>
<tr>
<td>Maximal forward reaching distance along floor (cm)*</td>
<td>76.5±5.8</td>
<td>64.6±7.4</td>
</tr>
<tr>
<td>Minimal Base of Support (cm)*</td>
<td>8.1±0.7</td>
<td>12.2±1.1</td>
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<tr>
<td>Loss of Balance during upward recovery Phase (%)</td>
<td>20%</td>
<td>40%</td>
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Table 1: Characteristics of young and older women (* p < .05).

Figure 1: Illustration of movement during successful downward reaching (a) and upward recovery (b) phases with its (c) corresponding COP trajectory.

SUMMARY/CONCLUSIONS

Preliminary findings suggest that when reaching down and picking up an object from the floor, older women, compared to young, may be more likely to lose balance when returning to a stance position. Discrepancies between the downward reaching movement time of successful and unsuccessful movements suggest different mechanisms of losses of balance, which merit further study. The capacity to control excess angular momenta may play a significant role in maintaining balance during downward reaching movements.

REFERENCES


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