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Haptic information and cognitive-visual task reduce postural sway in faller and non-faller older adults

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ABSTRACT

Understanding the effects of haptic input while performing a cognitive-visual task on postural control can broaden comprehension of the functional integration hypothesis in older adults with and without a history of falls. We aimed to investigate the effect of haptic input provided by light touch (LT) and the anchors while performing a cognitive-visual task in faller and non-faller older adults when standing upright. Twenty-two fallers and twenty-two non-fallers older adults participated in this study. They stood upright with feet together and performed six experimental conditions combining haptic cues (none, LT, and anchors) and the presence/absence of the cognitive-visual task (the adapted visual Stroop test). In the anchor condition, participants held a flexible cable in each hand, with the other end of the cable attached to a force transducer. They pulled on the cables just enough to keep them taut, applying a small amount of force. The results showed that there was no group difference in postural sway in any condition. All participants reduced postural sway with haptic input provided by LT and anchors. They also reduced their postural sway in the anterior-posterior direction while performing the cognitive-visual task. Fallers and non-fallers benefited equally from the haptic input. Both groups were able to reduce postural sway with the cognitive-visual task, which supports the hypothesis that postural sway is modulated to facilitate the execution of other non-postural tasks and a history of falls does not affect this ability.

1. Introduction

The study of mechanisms and behaviors related to falls occurrence in older adults has received attention from researchers from different fields. Regarding postural control, a substantial amount of studies have investigated the dual-task paradigm, which allows one to assess the relationship between postural control and a concomitant non-postural task (Chen, Chen, Tu, & Tsai, 2015; Chen, Chu, Pan, & Tsai, 2018; Chen & Tsai, 2015; Huxhold, Li, Schmiedek, & Lindenberger, 2006; Prado, Stoffregen, & Duarte, 2007; Vuillerme, Isableu, & Nougier, 2006); however, results are divergent, especially in older adults. Some studies (Jamet, Deviterne, Gauchard, Vançon, & Perrin, 2004; Vuillerme et al., 2006; Woollacott & Shumway-Cook, 2002) showed that performing a cognitive task led to an increase in postural sway, which is interpreted as deterioration in postural control due to the competition of attentional resources between both tasks (Huxhold et al., 2006). Other studies have shown a reduction in postural sway under cognitive-visual task conditions (Huxhold et al., 2006; Prado et al., 2007), with the suggestion that postural sway is integrated, and thereby reduced, in a functional manner to fulfill the goal of the visual task (Chen et al., 2015, 2018). This functional integration hypothesis suggests

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that the postural sway is adaptively modulated to facilitate the performance of other non-postural tasks (i.e., a supra-postural task).

To date, there has been no research examining postural control in older adults with a history of falls while performing a cognitive-visual task with added haptic input, although Chen et al. (2018) verified the effects of light fingertip touch (LT) while performing a visual search task in healthy older adults. Haptic input obtained by an object contacting the hands and fingers provides information about body position relative to the support surface based on the position and orientation of the arms and cutaneous information from the fingers (Chen & Tsai, 2015; Chen et al., 2015). Common devices used for adding haptic cues include LT of the index finger on a rigid or non-rigid surface (Arora, Musselman, Lanovaz, & Oates, 2017; Chen & Tsai, 2015; Vuillerme et al., 2006) and haptic anchors (small weights attached to strings, Mauerberg-deCastro et al., 2014). In general, studies that investigated haptic information using LT or anchors identified reductions in postural sway in young and older adults (Baccini et al., 2007; Mauerberg-deCastro et al., 2014; Vuillerme et al., 2006). Chen et al. (2015, 2018) verified the effects of LT on postural sway combined with a cognitive visual search task in young and older adults: Both LT and the visual search task reduced postural sway and the addition of LT improved the accuracy of the visual search task in both age groups. The authors suggest that the LT facilitated the visual search task by reducing postural sway, which supports the functional integration hypothesis.

It is unknown if older adults, particularly those with a recent history of falls (i.e., fallers), can integrate haptic cues while standing and performing a cognitive-visual task. Fallers are known to have balance deficits (Lord, Sherrington, Menz, & Close, 2007; Overstall, Exton-Smith, Imms, & Johnson, 1977; Rinaldi & Moraes, 2016; Santos, Abreu, & Moraes, 2018; Thapa, Gideon, Brokman, Fought, & Ray, 1996), which may prevent them from reducing postural sway to successfully perform a non-postural task. Having this knowledge would broaden understanding of the functional integration hypothesis in this population. This study aimed to assess the effect of haptic information, provided by LT and anchors, and of a cognitive-visual task on postural sway in older adults with and without a history of falls. We hypothesized that fallers would benefit more from the haptic information provided by LT and anchors than non-fallers because of the general finding that fallers exhibit larger postural sway than non-fallers. Furthermore, we hypothesized that the cognitive-visual task would reduce postural sway, providing additional support to the functional integration hypothesis and extending it to older adults classified as fallers. Based on Chen et al. (2015, 2018), we expected that the force applied on the touch surface for the LT or on the cables of the anchors would not increase because of the cognitive-visual task, reinforcing the functional integration hypothesis.

2. Methods

2.1. Participants

Forty-four older adults participated in this study and were allocated to two groups: without (non-fallers, age range: 64–83 years-old) and with (fallers, age range: 63–83 years-old) history of falls (Table 1). Fallers were identified as individuals who had experienced at least two falls in the 12-month period before data collection (Freire Júnior, Porto, Marques, Magnani, & Abreu, 2017; Melzer, Benjuya, & Kaplanski, 2004). Non-fallers reported no fall in the last twelve months. The local ethics committee approved all the procedures. Participants were screened before starting the experiment by filling out a questionnaire to check history of falls,

Table 1
Mean and standard deviation (±) of the anthropometric and clinical parameters of the fallers and non-fallers older adults.

Parameters	Fallers (n = 22)	Non-fallers (n = 22)	p-value
Falls	3.0 ± 2.4	–	–
Sex (Female/Male)	19/3	19/3	–
Age (yrs)	74.0 ± 6.0	73.9 ± 5.8	0.95
Body mass (kg)	69.5 ± 6.5	68.4 ± 7.8	0.27
Body height (cm)	157.8 ± 15.1	160.2 ± 11.3	0.79
Mini Mental State Examination (pts)	28.4 ± 1.3	29.3 ± 5.0	0.012**
Education (yrs)	7.5 ± 3.7	10.1 ± 4.9	0.048**
Mini-BESTest (pts)	18.9 ± 3.6	26.0 ± 2.3	≤0.001*
Trail-Making Test - Part A (s)	47.3 ± 18.9	46.8 ± 14.1	0.93
Trail-Making Test - Part B (s)	125.5 ± 67.3	104.7 ± 38.6	0.21
Baecke - Physical Activity Level (pts)	4.7 ± 2.3	4.7 ± 2.4	0.91
Tactile sensitivity – Dominant hand (pts)[a]	3.1 ± 0.4	2.8 ± 0.2	0.003**
Tactile sensitivity – Non-dominant hand (pts)[a]	3.0 ± 0.3	2.8 ± 0.2	0.006**
Tactile sensitivity – Dominant foot (pts)[a]	4.3 ± 0.5	4.1 ± 0.4	0.29
Tactile sensitivity – Non-dominant foot (pts)[a]	4.4 ± 0.6	4.1 ± 1.2	0.10
Right eye visual acuity (pts)	0.75 ± 0.2	0.81 ± 0.3	0.34
Left eye visual acuity (pts)	0.72 ± 0.2	0.81 ± 0.2	0.21
Stroop test - Sitting (errors)	2.2 ± 1.7	1.1 ± 1.8	0.07
Stroop test - Standing - Baseline (errors)	3.6 ± 4.0	2.3 ± 2.8	0.20
Stroop test - Standing - Anchors (errors)	2.5 ± 2.3	2.8 ± 2.7	0.94
Stroop test - Standing - Light Touch (errors)	3.0 ± 3.6	2.3 ± 2.7	0.52

[a] Exponential scale: green monofilament: 2.7 pts (0.05 gf); blue monofilament: 3.3 pts (0.2 gf).
* Indicate significant difference between groups.
** Indicate significant difference between groups, however, values are within the normal clinical range.