Gait & Posture 62 (2018) 105–110

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Not just a light fingertip touch: A facilitation of functional integration between body sway and visual search in older adults

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ARTICLE INFO

Keywords:
Body sway
Visual search
Light fingertip touch
Functional integration
Older adults

ABSTRACT

Background: Prior studies demonstrated that, compared to no fingertip touch (NT), a reduction in body sway resulting from the effects of light fingertip touch (LT) facilitates the performance of visual search, buttressing the concept of functional integration. However, previous findings may be confounded by different arm postures required between the NT and LT conditions. Furthermore, in older adults, how LT influences the interactions between body sway and visual search has not been established.

Research questions: (1) Are LT effects valid after excluding the influences of different upper limb configurations? (2) Is functional integration is feasible for older adults?

Methods: Twenty-two young (age = 21.3 ± 2.0) and 22 older adults (age = 71.8 ± 4.1) were recruited. Participants performed visual inspection and visual searches under NT and LT conditions.

Results: The older group significantly reduced AP sway ($p < 0.05$) in LT compared to NT conditions, of which the LT effects on postural adaptation were more remarkable in older than young adults ($p < 0.05$). In addition, the older group significantly improved search accuracy ($p < 0.05$) from the LT to the NT condition, and these effects were equivalent between groups.

Significance: After controlling for postural configurations, the results demonstrate that light fingertip touch reduces body sway and concurrently enhances visual search performance in older adults. These findings confirmed the effects of LT on postural adaptation as well as supported functional integration in older adults.

1. Introduction

Aging is typically associated with degradation in both sensory and motor systems [1–4]. As motor function progressively declines, older adults often report difficulties in everyday domains involving balance. Even in relatively stable standing postures (e.g., shoulder-width and wide-based stances), studies have consistently reflected a significantly greater magnitude of body sway in older adults compared to young adults [2,5]. Additionally, studies on visual search and aging typically require participants to identify particular pre-defined targets (e.g., a letter or numeral) within cluttered visual scenes in which older adults already demonstrate degraded visual search performance (e.g., lower accuracy and/or slower speed) [6–8]. The present study is specifically concerned with the interaction between adjusting body sway in an upright stance and performance during visual searches in older adults.

Of note, an earlier study has investigated postural responses in young and older adults whilst they inspected a blank board or searched for near/far target letters within a block of text [8]. The results showed the execution of a visual search task resulted in reduced sway relative to execution of an inspection task in both groups. More interestingly, during execution of visual searches, older adults exhibited greater amounts of body sway, as well as lower levels of visual search performance compared to young adults. The concept of functional integration states that posture can be adjusted to benefit the completion of other non-postural activities [9]. Based on functional integration, postural control is not independent of visual searches; however, adaptation of body sway is functionally linked to visual search performance. Accordingly, it was suggested that, compared to young adults, older adults may be less able to functionally modulate and stabilize body sway during visual searches.

The concept of functional integration has been challenged recently by scholars who consider that the functional integration perspective is only valid if a reduction in body sway can indeed facilitate better performance during visual searches [10]. To examine functional integration, young adults were instructed to hold the index digit of their dominant hand lightly (< 1 N) against a stable reference and to control light touch contact precisely at the same spot of the touch plate, while concurrently searching for target letters in a block of text during quiet

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https://doi.org/10.1016/j.gaitpost.2018.03.018
Received 25 September 2017; Received in revised form 5 February 2018; Accepted 6 March 2018

upright standing. This canonical "light touch" experimental design was utilized because previous studies have repeatedly reported that light touch with the index fingertip is effective in reducing displacement of the center-of-pressure (COP) in children, young adults, and older adults [11–16]. As a result, light fingertip touch not only reduced body sway, but also concurrently enhanced visual search accuracy in young adults [10]. This aligns with the characteristics of functional integration, suggesting the modulation of body sway can facilitate visual search performance.

However, it is worth mentioning that different configurations of the upper extremities affect control of body sway and responses of body kinematics [17,18]. Accordingly, earlier findings regarding the effects of adapting sway resulting from a light fingertip touch [10] may be somewhat influenced by various arm configurations used for both no touch and light touch conditions. To address this limitation, our experimental protocol was derived and modified from Kouzaki and Masani's study, where arm positions were kept identical between experimental conditions [19]. Additionally, in older adults, the effects of light fingertip touch on the interaction of body sway and visual search have not been established. Therefore, the purpose of this study is to test the feasibility of functional integration for older adults by exploring whether improved visual search performance is possible through precise control of light fingertip contact (compared to the no touch condition). Firstly, we hypothesized that, even after ruling out potential influences of different limb configurations between no touch and light touch conditions, using a light fingertip touch would still significantly reduce older adults' body sway. Secondly, following previous studies showing the effect of light touch on improving visual search performance in children and young adults [10,12], we hypothesized that older groups would perform better in visual searching under light fingertip touch conditions than without a fingertip touch.

2. Methods

The experimental protocol was approved in advance by the Antai Memorial Hospital Institutional Review Board. Informed consent was obtained from each participant prior to data collection. Research was conducted at National Kaohsiung Normal University.

2.1. Participants

Forty-four adults participated in the study. Inclusion criteria were (1) independence in daily living activities, (2) scoring greater than 53 on the Berg functional balance scale [20], (3) scoring greater than 27 on the Mini-mental status examination [21], and (4) having normal or corrected-to-normal vision. Exclusion criteria included any medical history of neurological diseases, musculoskeletal disorders, or complaints about dizziness and vertigo, which may influence postural control. Participants who took medication that may have impacted postural stability were also excluded. Convenience sampling was used to enroll participants living in nursing homes or dormitories near the National Pingtung University of Science and Technology (NPUST) campus and who agreed to join this study without compensation. Young participants were undergraduate/graduate students from NPUST. Older participants were recruited from five nursing homes nearby. The young group was composed of 22 adults (10 female and 12 male) aged 19–25 years; the older group was composed of 22 adults (12 female and 10 male) aged 66–78 years. Handedness was determined via self-reporting of which hand the participant used for the majority of daily activities. All participants were right-side dominant. Table 1 reports basic test data for both groups. No significant differences between groups were found, except for age.

Table 1
Basic data for the young and older groups.

	Young group (n = 22, 10 female, 10 male)	Older group (n = 22, 12 female, 10 male)	*t*	*p*
Age (year)	21.3 ± 2.0	71.8 ± 4.1	−52.14	0.00
Body height (cm)	168.5 ± 7.7	166.4 ± 8.4	0.88	0.38
Body weight (kg)	65.4 ± 9.7	69.7 ± 10.6	−1.41	0.17
MMSE	29.9 ± 0.5	29.3 ± 0.9	1.55	0.13
BFBS	56.0 ± 0.0	55.8 ± 0.5	1.70	0.10

BFBS: Berg functional balance scale, MMSE: Mini-mental status examination.

2.2. Apparatus

2.2.1. Force platform

A force platform (model 9260AA6; Kistler Instrumente GmbH, Ostfildern, Germany) was employed to acquire COP kinematics in both the body's anterior-posterior (AP) and medial-lateral (ML) axes. Participants were asked to stand barefoot quietly and comfortably on the platform with feet planted shoulder-width apart for each trial. The position of each participant's feet was marked to ensure consistency across trials. Data on COP kinematics was sampled at 100 Hz.

2.2.2. Touch plate

A load cell (LSB 200, Futek Advanced Sensor Technology, Inc., Irvine, CA) was attached to the center of a 5 × 5 cm stationary plate, which was mounted on a tripod. The height and position of the tripod was adjusted such that the configuration of the upper limb (i.e., angle of elbow and wrist joint) remained the same across participants. Data on the kinetics of light fingertip touch in the vertical direction were obtained at a sampling rate of 100 Hz using LabVIEW 2012 (National Instruments Inc., Austin, Texas).

2.3. Protocol

Experimental procedures were explained to participants, after which participants were exposed to a total of twelve trials within the four conditions: visual inspection and no touch (VI + NT), visual inspection and light touch (VI + LT), visual search and no touch (VS + NT), and visual search and light touch (VS + LT). There were three trials in each condition and trials were blocked in terms of experimental conditions. The order of blocked trials was randomized according to a Latin square design.

For the VI trials, participants were instructed to maintain their gaze within the perimeter of a 29.7 × 21 cm white poster board, which was affixed 0.4 m away at eye level on a wall for each participant. The poster board dimension was 24.0° (horizontal) × 16.7° (vertical) in visual angles. For the VS trials, participants searched for a given Arabic numeral and counted how many designated target numerals were presented in a block of digits. There were 13 lines of Arabic numerals printed in 18 point Times New Roman bold font on the same size poster board, and the vertical visual angle for each Arabic numeral was 0.6°. Further, the lines of numerals were numbered sequentially on the left hand paper margin (see Supplementary material). Participants were instructed to visually search from top to bottom and from left to right. If participants finished their visual search early, they had to start over from the top and sum the number of target numerals counted. Once the trial was over, participants needed to orally indicate how many target numerals were counted and physically point at the very last numeral they visually focused upon. Six target numerals (0, 2, 5, 6, 7, and 9) were used randomly for the three VS + NT and the three VS + LT trials. The visual conditions used here were modified from a previous study [10] because some of the older participants were not familiar with English letters. All participants reported that they could clearly see the