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Research article

# Dementia alters standing postural adaptation during a visual search task in older adult men

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## HIGHLIGHTS

- We examine the effects of dementia on postural adaptation during visual search.
- Dementia influences overall standing postural sway.
- Postural adaptation correlates with task performance only in those non-demented.
- Dementia alters the ability to adapt one's posture to a visual search task.
- The perception-action synergy may serve as a novel assessment for dementia.

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## ABSTRACT

This study investigated the effects of dementia on standing postural adaptation during performance of a visual search task. We recruited 16 older adults with dementia and 15 without dementia. Postural sway was assessed by recording medial–lateral (ML) and anterior–posterior (AP) center-of-pressure when standing with and without a visual search task; i.e., counting target letter frequency within a block of displayed randomized letters. ML sway variability was significantly higher in those with dementia during visual search as compared to those without dementia and compared to both groups during the control condition. AP sway variability was significantly greater in those with dementia as compared to those without dementia, irrespective of task condition. In the ML direction, the absolute and percent change in sway variability between the control condition and visual search (i.e., postural adaptation) was greater in those with dementia as compared to those without. In contrast, postural adaptation to visual search was similar between groups in the AP direction. As compared to those without dementia, those with dementia identified fewer letters on the visual task. In the non-dementia group only, greater increases in postural adaptation in both the ML and AP direction, correlated with lower performance on the visual task. The observed relationship between postural adaptation during the visual search task and visual search task performance—in the non-dementia group only—suggests a critical link between perception and action. Dementia reduces the capacity to perform a visual-based task while standing and thus, appears to disrupt this perception-action synergy.



## 1. Introduction

In older adults, dementia is associated with decreased mobility and increased risk of falls [1,2]. The successful completion of many activities of daily living requires individuals to stand while, concurrently interacting with their environment. For example, we must often stand while reading, talking and/or reaching for an object. A healthy postural control system adapts or adjusts to such dual tasking in order to optimize performance [3,4]. Intriguingly, however, optimal postural adaptation may be dependent upon the demands of the secondary task. For example, performance of tasks that require visual search may benefit from reduced postural sway, whereas, other tasks (e.g., mental arithmetic) may not [5,6]. Among

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healthy adults, the kinematics of standing body sway changes with age [3,4,7–9]. Dementia may further disrupt balance and potentially increase the risk of falling [2,10], especially, during situations in which individuals must simultaneously maintain their posture and perform additional cognitive tasks.

Existing research has focused on postural adaptation during performance of non-visual mental tasks [2,3,7,8,10]. Most studies report that performing this type of task increases postural sway in both healthy [8] and demented older adults [2,10]. On the other hand, both younger and older healthy adults reduce their postural sway when performing a standing visual search task as compared to looking at a blank board [9]. Visual search while, standing is essential to many activities of daily life. It places restrictive constraints on the postural system such that a reduction in postural sway may stabilize the visual system and facilitate visual search performance [5,9]. The effect of dementia on the capacity to perform visual tasks while standing, however, is unknown. We hypothesized that in older adults, those with dementia would exhibit an impaired ability to reduce their postural motion during performance of a visual search task, relative to those without dementia. We further predicted that in general, postural adaptation during performance of a visual search task would correlate with visual search task performance.

## 2. Materials and methods

### 2.1. Subjects

Men and women aged 60–90 years were recruited from the VA Medical Center in Minneapolis, MN. Potential subjects were previously screened by a clinical team, consisting of a neurologist, gero-psychiatrist, internist, and neuropsychologist, for dementia within a 4 month period prior to study initiation. Included in the screening was the mini-mental state exam (MMSE), which is both valid and reliable for initial dementia screening [11]. The research protocol was approved by the VA Medical Center and Institutional Review Board. Subjects or their guardians provided written informed consent prior to study involvement.

Inclusion criteria for the dementia group included, a consensus diagnosis of Alzheimer's disease and a MMSE score of 12–23 [11,12]. Inclusion criteria for the non-dementia group included, a MMSE score of 27–30 and a consensus by the clinical team as not having dementia [12]. Exclusion criteria included any other neurological or musculoskeletal disorder, physician-diagnosis of peripheral neuropathy, or significant visual impairment as defined by an inability to see presented letters within the visual search task (see Section 2.3).

### 2.2. Apparatus

Standing postural sway was assessed with a standard Wii balance board (Nintendo, Inc.). The Wii board is a valid and reliable instrument to record postural motion [13,14]. The board utilizes four piezoelectric strain gauges to record center-of-pressure (COP) fluctuations in both the medial–lateral (ML) and anterior–posterior (AP) directions [13]. The board was connected to a laptop via bluetooth capabilities. Data was recorded at 30 Hz and stored on the laptop for later analysis.

### 2.3. Protocol

Target boards were placed 2.5 m in front of the Wii board at eye level. Subjects completed two 60-s trials in each of two conditions; control and visual search. The four trials were completed in random order.

In the control condition, subjects were instructed to maintain their gaze within the perimeter of a blank white target board (33.75 by 42.50 cm) [5,9]. In the visual search condition, subjects were instructed to count the frequency of a designated letter (i.e., M and T, one for each trial) in a panel of 156 randomized alphabet letters (serif typeface: Times New Roman; size: 32pt; standardized spacing) displayed on a white board of the same dimensions. The dispersion of the target letters was similar for each subject. Subjects were told to start back and "check their count" if they completed the text block before the end of the trial. At the end of each trial, the subject reported the total number of counted target letters. Of note, visual acuity was assessed prior to initiating the protocol by asking the subjects if the letters on the display were visually clear. Before each trial, subjects were instructed to remove their shoes and stand comfortably on the Wii board with hands at their sides. No further posture-related instructions were given. The experimenter noted any instances of non-posture-related bodily movements (e.g., turning one's body or head to look at the experimenter or repositioning/folding one's arms). In order to minimize mental and physical fatigue, the first successfully completed trial (i.e., instructions were followed and non-posture related bodily movements were not observed) for each condition was used for analyses.

### 2.4. Data analyses

Following Prado et al. [9], visual search task accuracy was calculated by dividing the number of reported target letters by the number of target letters within the amount of total reported letters scanned.

Postural sway variability was operationally defined as the standard deviation (SD) of COP position and was analyzed separately for the ML and AP directions. Normality of the data was tested and as a result, the exclusion of measures that were ±2SD outside the mean was implemented. Postural adaptation during performance of a visual search was quantified by calculating the absolute and percent change in both ML and AP sway variability between conditions. The percent change was calculated using the following formula:

$$\frac{\text{visual search sway variability} - \text{control sway variability}}{\text{control sway variability}} \times 100$$

This calculation provided, a combined measure of the ability to adapt postural sway during performance of a visual search task and also normalizes the data for subjects who may have relatively, low or high postural sway variability in the control condition. In addition, this calculation allowed us to correlate postural activity with visual search task performance (see Section 2.5).

### 2.5. Statistical analyses

Analyses were performed using JMP software (SAS Institute, Cary, NC). Descriptive statistics were used to summarize all variables. Outcomes have been expressed as mean ± SD or categorical (yes/no). Student's *t*-tests or Fisher's exact tests were used to compare group characteristics and visual performance.

The effects of dementia on postural adaptation during performance of a visual search were examined using one-way ANCOVAs. Dependent variables were postural adaptations, in terms of the absolute or percent change in ML and AP sway variability between task conditions (i.e., control and visual search). The model effect was group. Models were adjusted for age, BMI and education. Significance level was set to $p = 0.05$ for each outcome. Of note, for the ML axis, four subjects (2 dementia, 2 non-dementia) demonstrated sway variability measures that were greater than two SDs outside of the group mean within at least one condition and were therefore excluded from ML sway analysis. For the AP axis, one subject from