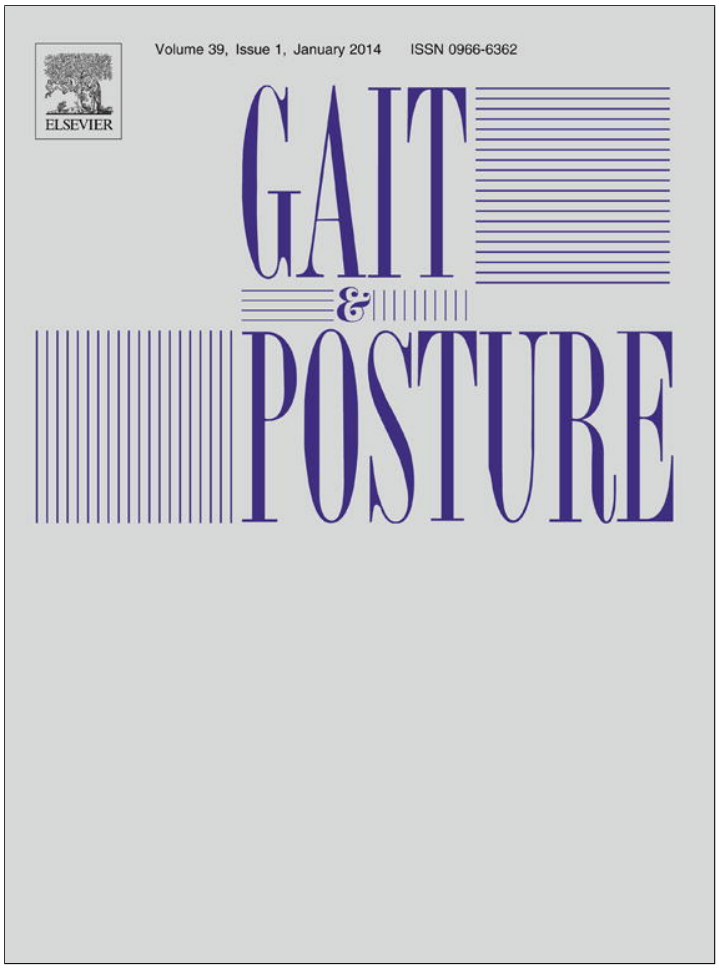

Gait & Posture 39 (2014) 628–630

Contents lists available at SciVerse ScienceDirect

Gait & Posture

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

Short communication

Postural control and cognitive decline in older adults: Position versus velocity implicit motor strategy

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ARTICLE INFO

Article history:
Received 9 March 2013
Received in revised form 2 May 2013
Accepted 1 July 2013

Keywords:
Posture
Cognitive decline
Velocity control hypothesis

ABSTRACT

The present study explored the impact of cognitive decline on postural control strategies in older adults with and without cognitive decline from mild cognitive impairment (MCI) to mild-to-moderate Alzheimer disease (MMAD). We hypothesized that the cognitive decline affected the postural control leading to higher bounding limits of COP velocity dynamics. Based on a cross-sectional design, 175 *non-faller* older adults were recruited in Angers University Hospital, France, including 50 cognitively healthy individuals [CHI] (mean age 76.42 ± 4.84 years; 30% women), 64 age- and body mass index-matched participants with MCI (mean age 77.51 ± 6.32 years; 39% women), and 61 age- and body mass index-matched participants with MMAD (mean age 78.44 ± 3.97 years; 62% women). For all data collection of postural sway, the participants were asked to maintain quiet stance on force platform. The postural test consisted of two trials of quiet stance, with eyes open and with eyes closed. The COP parameters were mean and standard deviation (SD) of position, velocity and average absolute maximal velocity (AAMV) in antero-posterior and medio-lateral directions. Overall, the analysis concerning all COP parameters revealed a significant main effect of cognitive status on velocity-based variables, with post hoc comparisons evidencing that SD velocity and AAMV increased with cognitive impairment. The current findings suggest an active control (or corrective process) of COP velocity dynamics for CHI, whereas MCI and MMAD are affected by COP movements.

1. Introduction

Based on Collins and De Luca's assumption [1] supporting the idea of a position-based control of posture, Delignières et al. [2] have recently shown the key role of center-of-pressure (COP) velocity-based variables for quiet standing stability in young and older cognitively healthy individuals [CHI]. Precisely, they have found that postural sway is not fixed until a threshold in velocity is reached. Velocity series appear bounded between an upper and a lower limits, underlining the possibility of an implicit motor strategy supported by velocity-based control instead of a position-based control of posture. These findings highlighted new variables of interest, in particular those that bound the dynamics of velocity in COP time series such as the average absolute maximal velocity (AAMV) when assessing postural balance in CHI. It has been previously reported difference in implicit motor strategy of balance control between CHI and those with cognitive decline [3]. Few studies have directly investigated the cognitive status' impact on postural control in older people compared to age-related effect [3–11]. Moreover, balance was usually assessed with parametric measurements such as single leg stance or tandem walking [3,5,7–9], which prevents inferring conclusions on the implicit motor strategy of balance control. Recently, Suttanon et al. [9] showed that static balance assessed by the sway velocity was more altered with higher limits of velocity range in mild-to-moderate Alzheimer disease (MMAD) compared to cognitively healthy controls [9]. The present analysis explored the impact of cognitive decline on postural control strategies in older adults with and without cognitive decline from mild cognitive impairment (MCI) to MMAD. To our knowledge, no study has yet investigated the assumption of a velocity-based processs. Our hypothesis was that the cognitive decline affected the postural control leading to higher bounding limits of COP velocity dynamics.

2. Methods

2.1. Participants

A total of 175 *non-faller* older adults were recruited in Angers University Hospital, France, including 50 CHI (mean age

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http://dx.doi.org/10.1016/j.gaitpost.2013.07.001

76.42 ± 4.84 years; 30% women), who were compared with 64 age- and BMI-matched participants with MCI (mean age 77.51 ± 6.32 years; 39% women), and 61 age- and BMI-matched participants with MMAD (mean age 78.44 ± 3.97 years; 62% women). All participants were recruited from the Gait and Alzheimer Interactions Tracking (GAIT) cohort, which is an observational cross-sectional study designed to examine gait and balance in older community-dwellers reporting subjective memory complaint. The sampling and data collection procedures have been described elsewhere in detail [4]. For the present analysis, exclusion criteria were severe Alzheimer's disease (i.e., Mini-Mental State Examination score (MMSE) ≤ 10), acute medical illness in the three past months, neurological and psychiatric diseases with the exception of cognitive impairment, and inability to stand on one leg for at least five seconds. The experimental design of the study was approved by the Local Ethical Committee of Angers (Reference No. 2009-A00533-54).

2.2. Neuropsychological assessment

Neuropsychological assessment was performed during a face-to-face examination carried out by a neuropsychologist. The following standardized tests were used to probe several aspects of cognitive function: MMSE, Frontal Assessment Battery (FAB), ADAS-cog, TMT parts A and B, French version of the Free and Cued Selective Reminding Test and Instrumental Activities of Daily Living scale (IADL). The diagnoses of MCI and MMAD were based on the above-mentioned neuropsychological tests, physical examination findings, blood tests and Magnetic Resonance Imaging (MRI) of the brain. Participants with all categories of MCI were included in this study. The diagnosis of MMAD followed the DSM-IV and NINCDS/ADRDA criteria. Mild stage of MMAD was defined for a MMSE score ≥ 20, and moderate stage for a MMSE score between 10 and 19. Participants who were neither MCI nor MMAD and who had normal neuropsychological and functional performance were considered as CHI ([4] for details).

2.3. Postural assessment

The standing postural sway was measured using a force platform (101 cm × 101 cm; BioRescue, Dune®, France). The participant was instructed to maintain barefoot standing position, and to look straight ahead, with arms kept by the side of the body, and focused on a visual reference mark placed in front of them at a 100 cm distance. The postural test consisted of two trials of quiet stance: stance with eyes open (EO) and with eyes closed (EC). For a trial of 51.2 s duration (sampling frequency of 5 Hz), the system was linked to PosturalRescue® 2.0 software, providing COP series on the antero-posterior (AP) and medio-lateral (ML) axes.

2.4. Statistics

For the baseline characteristics (age and BMI), a one-way analysis of variance (ANOVA) with 3 (Group) between-subjects factor was performed. Similar to [10], the COP parameters were mean and standard deviation (SD) of position and velocity in AP and ML directions. We also computed the AAMV [2]. For testing the effects of cognitive status on the postural control, a one-way ANOVA was carried out for each aforesaid dependent variable.

Table 1
Comparisons between MCI, MMAD and age- and BMI-matched CHI group (one-way analysis of variance results). Statistically significant results ($p < 0.05$) are indicated in bold.

Outcomes (significant values)	CHI, mean [95% CI]	MCI group, mean [95% CI]	MMAD group, mean [95% CI]	*F*	*p*
Baseline characteristics					
Age (years)	76.42 [75.04–77.79]	77.51 [75.93–79.09]	78.4 [77.39–79.42]	2.031	0.134
Body mass index (kg/m^2)	26.05 [25.18–26.91]	26.28 [25.43–27.13]	26.62 [25.39–27.85]	0.311	0.733
COP position-based variables					
Eyes open					
Mean position_AP (mm)	−18.15 [−23.43; −12.86]	−15.68 [−20.46; −10.91]	−18.86 [−24.18; −13.55]	0.451	0.637
SD position_AP (mm)	5.23 [4.8; 5.66]	5.62 [5.22; 6.02]	6.06 [5.36; 6.76]	2.286	0.105
Mean position_ML (mm)	−0.006 [−3.46; 3.47]	−1.24 [−3.7; 1.21]	−0.07 [−3.12; 3.27]	0.254	0.776
SD position_ML (mm)	3.3 [2.9; 3.69]	3.19 [2.85; 3.53]	3.76 [3.34; 4.19]	2.553	0.081
Eyes closed					
Mean position_AP (mm)	−12.36 [−17.67; −7.05]	−12.15 [−16.99; −7.3]	−15.19 [−20.65; −9.73]	0.438	0.646
SD position_AP (mm)	5.53 [4.94; 6.11]	5.5 [5.04; 5.96]	6.42 [5.76; 7.08]	**3.431**	**0.035**[b]
Mean position_ML (mm)	−0.406 [−4.28; 3.46]	−1.64 [−4.79; 1.49]	0.78 [−2.9; 4.46]	0.503	0.605
SD position_ML (mm)	3.04 [2.69; 3.38]	3.02 [2.62; 3.43]	3.93 [3.4; 4.46]	**5.576**	**0.005**[b,c]
COP velocity-based variables					
Eyes open					
Mean velocity (mm/s)	10.33 [9.21; 11.46]	12.34 [11; 13.68]	14.64 [12.97; 16.31]	**8.576**	**0.000**[a,b,c]
SD velocity (mm/s)	6.8 [6.04; 7.57]	8.06 [7.14; 8.99]	6.8 [8.5; 8.99]	**8.025**	**0.000**[a,b,c]
Mean velocity_AP (mm/s)	8.11 [7.22; 9.01]	9.63 [8.57; 10.69]	11.52 [10.22; 12.82]	**8.782**	**0.000**[b,c]
Mean velocity_ML (mm/s)	4.8 [4.19; 5.41]	5.81 [5.1; 6.52]	6.75 [5.89; 7.61]	**6.376**	**0.002**[a,b]
AAMV_AP (mm/s)	15.65 [13.62–17.68]	19.29 [16.49–22.09]	23.07 [20.47–25.67]	**7.861**	**0.001**[a,b,c]
AAMV_ML (mm/s)	9.64 [8.1–11.19]	11.58 [9.94–13.22]	12.86 [11.38–14.34]	**3.966**	**0.021**[b]
Eyes closed					
Mean velocity (mm/s)	12.34 [10.8; 13.87]	14.78 [12.69; 16.87]	18.05 [15.69; 20.41]	**7.217**	**0.001**[a,b,c]
SD velocity (mm/s)	8.52 [7.42; 9.62]	9.89 [8.38; 11.4]	11.88 [10.26; 13.51]	**5.05**	**0.007**[b,c]
Mean velocity_AP (mm/s)	10.08 [8.77; 11.39]	11.85 [10.21; 13.5]	14.66 [12.79; 16.52]	**7.392**	**0.001**[b,c]
Mean velocity_ML (mm/s)	5.23 [4.58; 5.89]	6.53 [5.42; 7.64]	7.81 [6.61; 9.02]	**5.555**	**0.005**[b]
AAMV_AP (mm/s)	19.83 [17.05–22.62]	24.62 [20.42–28.81]	29.44 [25.71–33.17]	**6.223**	**0.002**[a,b,c]
AAMV_ML (mm/s)	10.96 [9.17–12.76]	13.13 [10.68–15.57]	15.13 [13–17.25]	**3.382**	**0.036**[b]

COP: center of pressure; AP: anteroposterior; ML: mediolateral; SD: standard deviation; AAMV: average absolute maximal velocity; CHI: cognitive healthy individual; MCI: mild cognitive decline; MMAD: mild and moderate dementia.
[a] Significant difference between CHI and MCI groups.
[b] Significant difference between CHI and MMAD groups.
[c] Significant difference between MCI and MMAD groups.

3. Results

All statistical results are summarized in Table 1. Firstly, there were no significant differences between the groups for age and BMI. Secondly, the analysis concerning all COP parameters revealed a main effect of the cognitive status on velocity-based variables, with post hoc comparisons evidencing that SD velocity and AAMV increased with cognitive impairment. Besides the analyses for many COP position variables showed that postural sway is not significantly different according to cognitive decline.

4. Discussion

The present study confirms new velocity-based variables of interest when assessing postural balance, for both fundamental and clinical purposes [2]. In support of our hypothesis, the thresholds' values that bound the dynamics of COP movement speed (as estimated by computing the AAMV) significantly depend on the progression of cognitive impairment. Contrary to position variables, SD velocity and AAMV are actually higher for MCI and MMAD, as compared to CHI, especially in the AP direction (Table 1).

Even if these results corroborate changes in poor postural stability in patients with MCI or MMAD [9,11], it is the first time to the best of our knowledge that different postural control strategies are clearly demonstrated in CHI and in age-matched MCI–MMAD participants. Precisely, we suggest an active control (or corrective process) of COP velocity dynamics for CHI [2], whereas MCI and MMAD are affected by COP movements, especially in anteroposterior direction. Actually, our current support is in line with the aging effects and declines in executive function in standing postural control or in physical performance [12]. For example, recent studies showed that changes in usual walking speed were associated with alterations of execution functions (such as information updating and monitoring) [13], specifically in older adults with MCI [14]. This hypothesis of a possible velocity-based process degradation as a function of cognitive impairment is supported by recent studies investigating how balance control evolves when confronted with specific dual-task training strategies in elderly individuals with balance impairment [15]. Moreover, age-related neural changes experienced by individuals with MCI or MMAD in specific inhibitory function may result in alterations in the sensory integration process – essential for maintaining balance in older adults [12] – because of the degradation of velocity information. The assumption of a velocity-based process for postural control may be a key to identify a new interesting biomarker of early cognitive dysfunction [4], especially to potentially diagnose individuals with increased fall risk.

Author contributions

Deschamps has full access to all of the data in the study, takes responsibility for the data, the analyses and interpretation and has the right to publish any and all data, separate and apart from the attitudes of the sponsor.

All authors meet all of the following criteria: (1) contributing to the conception and design, or analyzing and interpreting data; (2) drafting the article or revising it critically for important intellectual content; and (3) approving the final version to be published.

Acknowledgements

The research was supported by grants from the Region of Pays de la Loire, France, for the project "RP3AP" and by the French Ministry of Health (Projet Hospitalier de Recherche Clinique National No. 2009-A00533-54). The sponsors had no role in the design and conduct of the study, in the collection, management, analysis, and interpretation of the data, or in the preparation, review, or approval of the manuscript.

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