Maturitas 116 (2018) 130–136

Contents lists available at ScienceDirect

Maturitas

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

Postural control and posture-unrelated attention control in advanced age—An exploratory study

Yael Netz*, Aviva Zeev, Ayelet Dunsky

The Academic College at Wingate, Wingate Institute, Netanya 4290200, Israel

ARTICLE INFO

Keywords:
Postural control
Gender differences
Static balance
Dynamic balance
Attention control
Inhibition

ABSTRACT

Objectives: The link between postural control and cognition is under-studied, especially in healthy older adults. In the present study, we examined the link between postural control and posture-unrelated attention control.
Study design and outcome measures: Healthy individuals (n = 112) – men aged 77.2 ± 5.5, and two groups of women, aged 78.6 ± 3.5 and 68.9 ± 3.7 – participated in this cross-sectional study. Postural control was assessed by static balance (SB) posturography in eight standing positions, and by two measures of dynamic balance (DB): the Timed Up-and-Go (TUG) test, and the Functional Reach Test (FRT). Attention control (inhibition) was assessed by the Continuous Performance Test (CPT) measuring Go/NoGo tasks with and without visual and audio distractors.
Results: Men tended to perform better on DB and women on SB. In the men, significant correlations were observed between Go/NoGo tasks and DB (r range: 0.373 to 0.653 for TUG, and -0.342 to -0.530 for FRT). In the younger women, Go/NoGo tasks were correlated with SB (r range: 0.323 to 0.572), and no correlations were observed in the older women. Go/NoGo tasks without distractions followed by tasks with audio distractors explained postural control measures.
Conclusions: Posture-unrelated attention inhibition was associated with SB in the women and with DB in the men. Tasks with no distractions explained the variability in postural control in both genders. It is recommended to examine the effect of balance exercises on postural control and posture-unrelated attention control in both genders, and the contribution of the relationship between postural control and posture-unrelated attention control to falls in old age.

1. Introduction

The cerebral cortex contributes to postural control, and the loss of gray and white matter with aging is associated with decreased performance in postural tasks [1]. For example, a recent study has shown global and regional associations of both gray and white matter with walking, one-legged stand and chair stands in healthy older adults [2]. Furthermore, these posture/mobility measures were also associated with selective cognitive measures – specifically processing speed. The deterioration in postural control, as assessed by static and dynamic balance tests, is associated with falls, which are a major public health problem in old age [3]. However, the link between various aspects of cognition, and postural control is under-studied, especially in older adults who have not yet experienced cognitive deterioration or falls. In the present study we examined the link between static and dynamic balance and attention inhibition.

Measuring the link between cognition and postural control requires a multifaceted analysis, as postural control is comprised of more than one system [4]. The ability to stand and to move depends on a complex integration of sensory information from the somatosensory, vestibular, and visual systems, which work together with the nervous-muscular system to control body alignment with respect to the environment [5], in standing (static balance) and while moving (dynamic balance). Interestingly, the evidence on gender differences in postural control in old age is inconsistent. For example, some studies report greater stability in men than in women on static balance (e.g. [6]), while others argue that women are more stable than men [7,8].

The relationship of postural control with cognition adds to this complexity, as many cognitive resources are involved in postural control, especially in old age [9]. For example, a recent study observed an association between one-legged stand and processing speed but not with memory or executive functions [2], while another study did show an association between dynamic postural control and executive functions [10].

* Corresponding author.
E-mail address: neyael@wincol.ac.il (Y. Netz).

https://doi.org/10.1016/j.maturitas.2018.08.003
Received 18 March 2018; Received in revised form 18 July 2018; Accepted 4 August 2018

One of the systems involved in a person's ability to stand, to walk, and to safely and efficiently interact with the environment is motor inhibition – the ability to inhibit actions – which is a central process in human motor control [11]. In advanced age there is a reorganization of cortical and spinal control of posture, including reduced cortical inhibition [1]. Inhibition is regulated through various cortical and subcortical networks and plays a critical role in the control of many cognitive and motor functions [12].

For cognitive control, inhibition can be conceptualized as a process that blocks the spread of activation, keeping attention focused sharply on the task at hand [13], and it plays a core role in the executive function construct [14]. At the behavioral level, inhibitory control refers to the ability to manage attention within the environment while ignoring irrelevant stimuli or while suppressing a prepotent response [15].

Both cognitive and motor inhibitory functions are mediated by overlapping brain networks comprising the prefrontal cortices and basal ganglia [16], which are compromised by aging processes to a greater extent than other regions of the brain [17]. On the other hand, the capacity to employ inhibition is preserved in high-performing older individuals [11]. However, current literature still lacks a clear view on specific inhibitory pathways or networks directly involved in postural control. Cortical inhibition is modulated during postural muscles contractions, defined as contractions with the aim of maintaining a certain posture [18]. Papegaaij et al. [19] have shown that intracortical inhibition is related to postural challenge. According to Redfern et al. [20], perceptual inhibition may be a component of the sensory integration process important for maintaining balance in older adults. Finally, recent evidence [21] showed that age-related decrease in postural control is associated with structural changes in the volumes of the middle frontal gyrus and basal; two brain substructures strongly implicated in response inhibition across various sensorimotor tasks (e.g. [22]).

Notably, there is very little evidence on gender as a moderating variable in the relationship between postural control and cognition in healthy older adults. Sullivan et al. [8] reported a correlation between general cognitive status and static postural stability in women but not in men. Blankevoort et al. [23] reported a correlation between balance and cognition in men but not in women.

The aims of this exploratory study were to investigate the link between posture-unrelated attention inhibition and postural control in older adults, to examine whether gender is a moderator of this link, and to assess what specific attention inhibition tasks contribute to the variability of postural control tasks. To accomplish this, we used various static and dynamic balance tasks, as well as attention inhibition (go/no-go) tasks. All of the attention inhibition tasks included suppressing a prepotent response, and some of them required, in addition, ignoring irrelevant auditory and/or visual stimuli.

2. Methods

2.1. Participants

Community-dwelling older adults (N = 123; age 65+) were recruited from local councils and sports clubs within the area of our laboratories, as well as by ads on Facebook. Inclusion criteria were being physically active at least once a week for at least three months prior to the study, and being able to perform a maximal exercise test. Exclusion criteria were a score of < 24 on the Mini-Mental State Examination (MMSE) [24] and health concerns raised by the study's physician who supervised the exercise test. Eleven persons were excluded by the physician, mainly due to cardiovascular risk factors, leaving 112 participants for the study. Informed consent was obtained from all participants on a consent form approved by the Institutional Review Board of the Hillel Yaffe Medical Center (Hadera, Israel), and the study was conducted in accordance with the Declaration of Helsinki.

Table 1
Demographic and clinical descriptive of the participants (mean ± SDs)[a].

	Men A	Young Women B	Old Women C
N	33	41	38
Age (years)	77.2 (± 5.5) $^{>B}$	68.9 (± 3.7)	78.6 (± 3.5) $^{>B}$
Weight (kg)	77.3 (± 9.9) $^{>B,\ >C}$	70.0 (± 11.2)	67.1 (± 10.3)
Height (m)	1.7 (± 0.1) $^{>B,\ >C}$	1.6 (± 0.1)	1.6 (± 0.1)
BMI (kg/m^2)	26.3 (± 3.5)	27.9 (± 4.1)	27.2 (± 4.0)
MMSE	28.6 (± 1.9)	29.0 (± 1.4)	29.4 (± 1.3)
GDS	1.6 (± 1.9)	2.7 (± 2.6)	1.8 (± 1.9)
Education (years)	14.0 (± 3.3)	13.0 (± 4.2)	12.9 (± 2.3)
IADL	1.1 (± 0.2)	1.1 (± 0.2)	1.1 (± 0.2)
Frailty	5.25 (± 2.81)	4.52 (± 2.44)	5.35 (± 2.46)
IPAQ (total min/week)	591.3 (± 261.6) $^{>B}$	395.1 (± 229.8)	468.3 (± 218.4)

MMSE – Mini Mental State Examination; GDS – Geriatric Depression Scale; IADL – Instrumental Activities Daily Living; IPAQ – International Physical Activity Questionnaire.
$>B$ – significantly higher than group B. $>B>C$ – significantly higher than groups B and C.
[a] Groups differerences are calculated based on one-way ANOVA with Bonferroni correction.

As the men were significantly older than the women, and women outnumbered men, the women were divided into two age groups, with the median age as the cutoff point. The cutoff point was age 75 (young < 74, old ≥75), which actually fits the traditional cutoff point between "young old" and "old old" (e.g. [25]). Table 1 presents demographic and clinical data for the three groups: 33 men (aged 77.2 ± 5.5) and 38 older women (aged 78.6 ± 3.5) who are comparable in terms of age, and 41 younger women (aged 68.9 ± 3.7).

2.2. Dynamic balance assessment

2.2.1. The Functional Reach Test (FRT) [26]

While standing with one side of the body close to the wall, participants were asked to raise the arm of that side to a 90° angle and to lean forward as far as possible. This activity requires shifting the center of gravity (COG) within the base of support (BOS). Balance is maintained either by realigning the COG within the BOS or by evoking a step strategy and establishing a new BOS. If the appropriate movement strategy is not executed, the individual may stumble or fall in an attempt to regain balance [27]. The score is the distance an individual can reach forward beyond arm's length without falling over, measured in centimeters. The test was performed twice. The higher score was used for data analysis. The FRT proved to be reliable [26] and valid [27].

2.2.2. The Timed Up and Go (TUG) [28]

Participants were asked to stand up from a seated position in a chair, walk three meters, turn around, and sit down again. The score is the length of time it takes to perform the test, thus lower values indicate better balance ability. The test was performed twice. The better score (lower value) was used for data analysis. The TUG showed excellent test-retest reliability in older adults [28].

2.3. Static balance assessment

Static posturography was performed using the Tetrax© posterograph stabilometry system (BeamMed Ltd. [Sunlight], Petach Tikva, Israel). The Tetrax includes a specific program installed on a computer, and four platforms that record posturographic right and left heel and toe forces applied to the ground. The analysis is based on the vertical pressure applied via the heels and the toes while standing in an upright position on the platforms.

Measurements are made in eight different conditions, challenging