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Differences in Dynamic Posturography Results Between Older-Adult and Oldest-Old

Cristina Loureiro Chaves Soldera[1], Gabriela Guimaraes Oliveira[2], Angelo Jose Goncalves Bos[3, *]

[1]Department of Speech and Audiology, Federal University of Health Sciences of Porto Alegre, Porto Alegre, Brazil
[2]Institute of Geriatrics and Gerontology, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil
[3]Graduate Program on Biomedical Gerontology, Institute of Geriatrics and Gerontology, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil

Abstract

Background: Aging brings body functional and structural changes, reducing vitality and increasing multimorbidity, causing changes in the balance, characterized by dizziness, vertigo, imbalance, and fall. Basically three sensory systems are involved in maintaining body balance: visual, somatosensory, and vestibular. Adequate diagnosis allows better rehabilitation planning. Most fast growing age group in Brazil and many other countries are the oldest-old (80 years and older). *Objective*: compare body balance maintenance systems performance between oldest-old and younger older adults. *Design:* observational cross-sectional analytical study. *Settings:* from a Worker Association and Outpatient Clinic of a University Hospital. *Subjects*: involved two groups: older-adults (60 to 69 years-old) and oldest-olds. *Methods*: Subjects responded to a socio-demographic and clinical questionnaire and Foam-Laser Dynamic Posturography to perform the Sensory Organization Test (SOT) in six different conditions, to assess the three balance systems. *Results*: The sample included 62 participants, 32 older-adults and 30 oldest-old (80 to 96 y.o.). We observed that the oldest-old had worse performance and greater variability than the older-adults in all SOT conditions. There were significant differences between age groups in the visual and vestibular analysis (p<0.001) and in the visual preference (p=0.007), but not in the somatosensory system (p=0.741). *Conclusion:* the mechanisms for maintaining body balance most affected in the older-adult and oldest-old are vestibular and visual, which were higher than expected. Otherwise, the somatosensory system did not show the difference that would be expected to arise between the age groups.

Keywords

Oldest-Old, Aging, Body Balance Maintenance Systems, Dynamic Posturography

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1. Introduction

Statistics show an important increase in the Brazilian older adult population, particularly in the oldest-old group (80+ years-old), and an increase in mortality rates related to fall (1). Aging brings body functional and structural changes, reducing vitality and increasing multimorbidity, causing changes in the balance, characterized by dizziness, vertigo, imbalance, and fall.

The lack of balance is a frequent complaint of the older adult population. The oldest-old loses balance more often compared to younger older adult, indicating that factors related to aging contribute to loss of balance, independent of the existence of other conditions or diseases (2).

* Corresponding author
E-mail address: angelo.bos@pucrs.br (A. J. G. Bos)

Basically three sensory systems are involved in maintaining body balance: visual, somatosensory, and the vestibular systems. The afferent information of these systems is organized by the central nervous system, which plans responses of motor systems related to the information received (3).

Adequate diagnosis allows better rehabilitation planning by directing therapeutic strategies for the system most affected in each patient. The Foam-Laser Dynamic Posturography (FLDP) evaluates quantitatively all three sensory systems involved in maintaining balance (2). Recent researches have highlighted the lack of studies evaluating the association between the performance of the body balance maintenance systems and the risk of falls in older-adult (4). No studies were found comparing body balance maintenance systems performance in oldest-old and younger older adults using FLDP.

Due to the high prevalence of falls in the oldest-old people, it is important to evaluate which body balance maintenance systems might be impaired using, for instance, FLDP. The result of this assessment may lead to a more efficient vestibular therapeutic approach. Thus, this research had the main objective to compare the mechanisms of maintaining body balance in the older-adult and in the oldest-old.

2. Method

This is an observational cross-sectional analytical study involving two groups: older-adults (60 to 69 years-old) and oldest-olds (80 + years-old). Participants were invited from a Worker Association (Southern Brazilian Railroad Workers Association) and from two groups of the Pontifical Catholic University of Rio Grande do Sul, Brazil: the older-adults from a Senior Group at the University and the oldest-old were selected from those who took part in a health check-up project.

We excluded those subjects who reported being unable to stand for five minutes or more, failed to respond verbal commands; reported at least one fall in the last six months, had stroke history with motor or cognitive consequences or labyrinthopathy; had visual deficits without proper correction (glasses/lenses); were currently using anti-vertigo, anxiolytics, or antidepressants medication; had drunk alcohol 24 hours prior to evaluation; developed tremors and muscle stiffness, use of walking aids devices, and past history of alcoholism.

After receiving an explanation and accepting the procedures and objectives of the study, subjects responded to a questionnaire enquiring socio-demographic information (gender, years of formal education, smoking, alcohol consumption, regular physical activity, out-home activities, daily reading, self-assessment of health, vision, and hearing, symptoms of dizziness or vertigo, and loss of balance during walking, presence hypertension, dyslipidemia and Diabetes), and conducted the cognitive assessment (Mini-Mental State Examination) and body balance maintenance systems evaluation by FLDP (5). During the FLDP participants were asked to perform a method for body balance assessment called Sensory Organization Test (SOT). The SOT is carried out in six different conditions, testing tasks involving the three balance components. The SOT is performed in situations of visual and somatosensory conflict held in a standing position, feet together side by side in a comfortable position. It provides an average of analysis of body balance (6).

Data analysis was carried out the description of the independent variables noting the possible differences in their means or frequencies between the two age groups. The means were tested by Student's t test for homogeneous variances or when heterogeneous, the Kruskal-Wallis test for two groups. Frequencies were tested by chi-square or Fisher Exact test as the presence of fewer than 5 in each of the intersections. The tests were performed using the Epi Info version 3.3.5.

The project was approved by the Ethics Research Committee of the Pontifical Catholic University of Rio Grande do Sul under registration n° 11/05647.

3. Results

The sample included 62 participants, 32 older-adults (mean age 64.5 y.o.) and 30 oldest-old (ranging in age from 80 to 96 y.o.).

Table 1 shows the demographic characteristics and lifestyle habits by age groups. Most of the subjects were female in both groups (old-adults 59.4%, oldest-old 70.0%), with no significant difference ($p=0.382$). Most of the oldest-old ranged from zero to seven years of formal education (76.7%) and differed significantly from the older-adults group (31.3%) ($p<0.001$). There was a significant relationship between age groups and regular physical activity ($p<0.001$) and out-home activities ($p=0.011$). Older-adults reported higher frequency of physical activity and out-home activities than the oldest-old. There was no significant difference between the groups with respect to smoking, alcohol consumption and daily reading habit.

Table 1. Demographic characteristics and lifestyle habits by age group.

	Older-adults (%)	Oldest old (%)	Total	p
Sex				
Male	13(40.6%)	09(30.0%)	22(35.5%)	0.382
Female	19(59.4%)	21(70.0%)	40(64.5%)	
Years of education				
0 to 07 years	10(31.3%)	23(76.7%)	33(53.2%)	<0.001
≥08 years	22(68.7%)	7(23.3%)	29(46.8%)	
Smoking(current)				
Yes	10(31.3%)	07(23.3%)	17(27.4%)	0.485
No	22(68.7%)	23(76.7%)	45(72.6%)	
Alcohol consumption(current)				
Yes	08(25.0%)	13(43.3%)	21(33.9%)	0.127
No	24(75.0%)	17(56.7%)	41(66.1%)	
Regular physical activity				
Yes	22(68.7%)	08(26.7%)	30(48.4%)	<0.001
No	10(31.3%)	22(73.3%)	32(51.6%)	
Social activity				
Yes	24(75.0%)	13(43.3%)	37(59.7%)	0.011
No	08(25.0%)	17(56.7%)	25(40.3%)	
Daily reading habit				
Yes	26(81.3%)	23(76.7%)	49(79.0%)	0.658
No	06(18.7%)	07(23.3%)	13(21.0%)	

Chi-square test.

Data regarding clinical characteristics by age group are shown in Table 2. Most older-adults reported good hearing (75.0%), while this proportion was lower in the oldest-old (33.3%), (p=0.004). Oldest-old reported more frequent imbalance while walking (46.7%) than among older-adults (21.9%), (p=0.039). There was no significant difference between the groups with respect to dyslipidemia, hypertension, diabetes, self-assessment of health, self-reported of vision and symptoms of dizziness or vertigo.

Table 2. Clinical characteristics by age group.

	Older-adults	Oldest old	Total	p
Self-assessment of health				
Good	23 (71.8%)	21 (70.0%)	44 (71.0%)	0.871 [a]
Regular	09 (28.2%)	09 (30.0%)	18 (29.0%)	
Bad	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Self- assessment of hearing				
Good	24 (75.0%)	10 (33.3%)	34 (54.8%)	0.004 [a]
Regular	07 (21.9%)	15 (50.0%)	22 (35.5%)	
Bad	01 (3.1%)	05 (16.7%)	06 (9.7%)	
Self- assessment of vision				
Good	19 (59.4%)	15 (50.0%)	34 (54.8%)	0.585 [a]
Regular	11 (34.4%)	11 (36.7%)	22 (35.5%)	
Bad	02 (6.2%)	04 (13.3%)	06 (9.7%)	
Dizziness/vertigo symptoms				
Yes	06 (18.7%)	12 (40.0%)	18 (29.0%)	0.065 [a]
No	26 (81.3%)	18 (60.0%)	44 (71.0%)	
Imbalance while walking				
Yes	07 (21.9%)	14 (46.7%)	21 (33.9%)	0.039 [a]
No	25 (78.1%)	16 (53.3%)	41 (66.1%)	
Hypertension				
Yes	18 (56.3%)	16 (53.3%)	34 (54.8%)	0.817 [a]
No	14 (43.7%)	14 (46.7%)	28 (45.2%)	
Dyslipidemia				
Yes	15 (46.9%)	08 (26.7%)	23 (37.1%)	0.099 [a]
No	17 (53.1%)	22 (73.3%)	39 (62.9%)	
Diabetes				
Yes	06 (18.8%)	02 (6.7%)	08 (12.9%)	0.257 [b]
No	26 (81.2%)	28 (93.3%)	54 (87.1%)	

[a] Chi-square test.
[b] Fisher exact test.

Regarding the Mini-Mental State Examination (Table 3), there was significant difference between the group of older-adults and oldest-old (p<0.001), with the highest score in the group of older-adults with an average of 28.3±2.1 points. We highlight the greater variability in scores occurred in the oldest-old group, with an average of 23.3±4.0 points. In FLDP, we observed that the oldest-old had worse performance and greater variability than the older-adults in all Sensory Organization Test (SOT) conditions evaluated on dynamic posturography. There was a numerical difference, although not significant between the age groups, regarding the average percentage of the somatosensory analysis and SOT conditions I, II and III. There were significant differences between age groups in the average scores of the SOT conditions IV, V and VI, in the overall average of the test, in the visual and vestibular analysis (p<0.001) and in the visual preference (p=0.007), but not in the somatosensory system (p=0.741). It was observed that the SOT condition I to VI presented an increasing degree of difficulty and differences between groups of older-adults and oldest-old tended to be more significant with higher degrees of difficulty.

Table 3. Means and standard deviations of the MMSE score and Posturography Dynamic Foam-Laser findings by age group.

	Older-adults	**Oldest old**	**p**
MMSE	28.3 ± 2.1	23.3 ± 4.0	<0.001
Foam-Laser Dynamic Posturography			
SOT I (%)	80.6 ± 8.4	77.0 ± 9.5	0.153
SOT II (%)	69.9 ± 9.5	65.6 ± 16.1	0.490
SOT III (%)	58.7 ± 14.0	49.0 ± 21.1	0.056
SOT IV (%)	73.9 ± 8.8	42.7 ± 34.5	<0.001
SOT V (%)	61.6 ±9.5	30.6 ± 27.0	<0.001
SOT VI (%)	45.0 ± 18.3	14.9 ± 20.3	<0.001
SOT Mean (%)	65.2 ± 8.7	46.6 ± 17.3	<0.001
Somatosensory analysis (%)	86.8 ± 7.9	83.8 ± 17.3	0.741
Visual analysis (%)	91.1 ± 6.1	54.8 ± 43.7	<0.001
Vestibular analysis (%)	76.5 ± 9.8	38.3 ± 33.3	<0.001
Visual preference analysis (%)	78.9 ±17.8	64.2 ± 23.3	0.007

Mann-Whitney/Wilcoxon Two-Sample Test (Kruskal-Wallis test for two groups)
Label: MMSE: Mini-Mental State Exam; SOT: Sensory Organization Test.

4. Discussion

In this study, most participants were female (both age groups). The largest number of females in both groups can be explained by the predominance of females in Porto Alegre, especially in the oldest-old population (79.1%) (7). Moreover, the participation of older women in health promotion activities is greater than men (8). It is noteworthy that there was no significant association between the age groups and gender (p=0.382), therefore, a factor that did not interfere in the comparative analysis of evaluations carried out between the two groups.

There was a significant association between the groups and lifestyle parameters. The older-adults group performed more physical activity and participate more in social activities than the oldest-old (8). This finding was expected, since the older-adults tend to have higher disposition and physical conditions to perform such activities when compared to the oldest-old, due to sensory declines that get worse within aging.

The complaint of imbalance to walk was higher in the oldest-old (p=0.039). The aging process itself generates changes in sensory information that the central nervous system needs to maintain postural control, causing disorders of balance mainly in the oldest-old (9). This phenomenon was observed in a study that found in nonagenarians an inability to activate postural muscles in the expected speed, causing loss of balance (10).

The SOT and sensory analysis originated from it (11) are the most important parts of dynamic posturography and have been used (2, 4) to assess the balance and body balance maintain systems in the older-adult, seldom in the oldest-old. It is noteworthy that its realization varies mainly with regard to equipment used and such variation difficult the comparison of results among studies. The FLDP presents similar results, but more simple and inexpensive, than to those obtained with some more sophisticated equipment like the Computerized Dynamic Posturography with the Equitest System® (5).

In this research, using the balance evaluation through the FLDP, the oldest-old had worse performance than the older-adult in all conditions of the SOT, as well as overall balance index. This finding corroborates a research (12) which noted changes in the SOT scores with aging. The study data indicated that age-related changes in balance maintenance may reflect the anatomical changes that affect the entire vestibular system.

Both age studied groups behaved similarly with respect to average conditions I, II and III of the SOT scores. Age groups had similar performance in the condition I of SOT, which is the condition of lower difficulty, since participants can rely on all the information available from the peripheral maintenance balance systems. This finding corroborates previous studies (12-14) that noticed better performance in postural control of older people in the condition I, therefore, with greater ease of maintaining body equilibrium when there is no manipulation of the sensory systems (14).

Regarding the numerical differences, it appears that the scores were higher on SOT II compared to SOT I and on SOT III compared to SOT II. On SOT III the average difference of the scores between age groups tended to significance (p=0.056). Teixeira et al (14) assessed the balance through FLDP in old women and reported better scores on SOT I compared to the other balance conditions, highlighting the easiness of maintaining balance without sensory manipulation.

Gustafson et al. (15) conducted a longitudinal study with older-adult finding a significant difference on the SOT within aging only on condition III. The authors emphasize, therefore, the important role of vision in maintaining balance in the older-adult when the vestibular and somatosensory information are reduced (15). In condition III, the oscillation of the visual field occurs, significantly impairing the maintenance of balance in those older-adult who rely heavily on visual information. The same could be said about the SOT II in which there is absence of visual information. But, in SOT III it is more difficult for the central nervous system to process the information with the presence of a visual conflict. So, there would be an inability to suppress inaccurate visual cues to maintain balance on this condition. The differences in stability under the conditions I and III show the necessity of normal vision to maintain balance and the inability to suppress the influence of an oscillation of the visual field (6). The conditions with visual conflict (SOT III and VI) are more difficult than those with lack of vision (SOT II and IV), because they require longer central processing of sensorial information (16). Importantly, under the conditions I, II and III abnormalities of the vestibular system cannot be observed, because the balance control is predominantly done by the somatosensory system (6).

The final three conditions of the SOT (IV, V and VI) assess body sway to the disturbance of somatosensory information (in the case of FLDP, the subject remains standing on a cushion, which creates inaccuracy of somatosensory information). What differs the final three test conditions is the presence of visual information: eyes open without disturbance of visual field (SOT IV); no visual information: closed eyes (SOT V); and the presence of visual information with disruption of the visual field: open eyes and movement of the cabin (SOT VI). It was observed that under these conditions, the oldest-old presented scores below normal in all three conditions and the older-adult only under conditions IV and VI. There was significantly better performance of older-adult in these conditions, which had greater significance when comparing SOT V with SOT IV and SOT VI with SOT V. Another study with older-adult and oldest-old also found lower balance scores in all conditions with unstable platform (17).

In this survey the oldest-old had worse performance than the older-adult in all sensory analyses being statistically significant in the visual, vestibular and visual preference analyses. Similar results were reported in other study (18) in which it was observed worsening of the performance of maintaining balance with aging systems. This finding can be explained by the natural progression of aging that affects the major systems of maintaining body balance.

With regard to the visual system, aging causes a series of changes in vision function (18), as the decrease in light transmitted to the retina, visual field changes, decline in perceived contrast (contour and depth), loss of peripheral vision, slowness of ocular reflex movements, as well as pathologies such as cataracts and macular degeneration (19). These alterations reflect in changes in the vestibular-visual integration. The interaction between vestibular and visual information in the central nervous system originates the vestibular-ocular reflex (20), one of the most important reflex for the maintenance of equilibrium because it stabilizes the moving images on the visual field during linear and angular body acceleration. Therefore, decreased or altered visual perception affects negatively the balance.

The vestibular system, in turn, also undergoes changes within aging (2). Advancing age contributes to progressive cellular degeneration of the labyrinth (21), since there may be loss of receptor cells of the vestibular organ (18). Furthermore, there is reduced formation of otolith, reduction of excitability of the peripheral vestibular system, alteration of neurotransmitters and decreased in compensation vestibular reflexes (6).

With respect to the somatosensory system, we identified a lot of similarity in the performance of this system between the older-adult and oldest-old groups in this survey, the scores on both groups were near the normal range. This finding differs from several studies reporting on aging of somatosensory system. These studies describe that aging of the somatosensory system would reduce peripheral sensations, muscle weakness(18), decreased Achilles reflex, decreased vibratory sensation in the ankles, attenuation of tactile sensitivity, decreases of sensory fibers of peripheral receptors and loss large afferent fibers to stretch reflexes and proprioception(19). Barozzi et al. (22) found that the somatosensory system seems to be the most affected due to the multisensory decline. They reported that there is anatomic impairment in the older-adult muscles, joints and bones and neuromuscular dysfunction of receptors that induce a delay in the transmission of sensory information to the cerebellum. Moreover, muscle and joint functional deficit alters the responses conducted by the vestibule-spinal system, not only loss of afferent information, but also efferent.

In the present study, the somatosensory analysis showed not significant differences between age groups. Some hypotheses can be raised from this finding: a) the aging of the somatosensory system is not expressed so clearly apparent in the sample evaluated in this study for being, mostly older-adult and relatively long-lived assets and functionally independent or low-grade dependency and that would, therefore, this system better preserved; b) the sensory analysis of the SOT could not be sensitive enough to detect changes in the somatosensory system, as pointed out by Pedalini et al (2), who also found that the vestibular and visual systems were worse than the somatosensory performance in the older-adult.

It is considered important to emphasize that the results obtained in this study are derived from assessments conducted in relatively healthy older-adult and oldest-old and good enough mobility to move to the location in which the research was conducted participants. This might have been a selection bias in the sample, but is believed to have been a necessary selection for the proposed evaluations could be performed.

We conclude that the mechanisms for maintaining body balance most affected in the older-adult and oldest-old are vestibular and visual. These findings were obtained using the FLDP, which may not have been sensitive enough to detect possible changes in the somatosensory system.

The older-adult and the oldest-old differed significantly in mean percentage of performance of visual and vestibular systems and visual preference.

The differences between older-adult and oldest-old, with respect to body balance, were higher than expected, especially for vestibular and visual systems. Otherwise, the somatosensory system did not show the difference that would be expected to arise between the age groups.

The FLDP has proved a useful tool in assessing the balance giving important and unique clinical information to support and optimize rehabilitation strategies to balance in the older-adult and oldest-old.

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