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Use of posturography to identify the risk of falling in elderly people with dizziness

Uso da posturografia para identificação do risco de queda em idosos com tontura

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ABSTRACT

Purpose: the aim of this study is to determine whether posturography, an exam used to investigate the ability to maintain balance under conflicting sensory conditions, can identify the risk of falls in eldery patients with dizziness. **Methods:** to compare the posturographic results of elderly people with falls vs elderly people with no falls, paired by sex, age and dizziness etiology. **Results:** 18 fallers, and, of these, 14 with two or more falls in the last year were compared with 18 elderly people without falls. Comparing subjects without falls vs subjects with at least one fall in the last year, fallers obtain worse scores in conditions of visual dependence. Comparing non fallers with subjects with two or more falls, people with recurrent falls obtain worse score in several conditions: somatosensorial, vestibular, visual conflict, and in the main measure, the composite score. **Conclusion:** posturography appears to be a useful tool to identify those at high risk of recurrent falls.

Keywords: Postural balance; Aged; Accidental falls; Dizziness; Vestibular diseases

RESUMO

Objetivo: avaliar se a posturografia, exame que avalia a habilidade de manter o equilíbrio em condições sensoriais conflitantes, pode identificar risco de queda em idosos com tontura. **Métodos**: comparar os resultados posturográficos de idosos com e sem história de quedas, pareados por gênero, idade e diagnóstico etiológico da tontura. **Resultados**: dezoito idosos com quedas – 4 com único episódio e 14 com história de 2 ou mais quedas no último ano - foram comparados com 18 idosos sem quedas, pareados por gênero, idade e diagnóstico etiológico. Pacientes com quedas apresentaram resultados piores para as análises de dependência visual (p=0,04, p=0,01, p=0,03). Pacientes com quedas recorrentes (2 ou mais episódios) apresentaram piores resultados em diversas condições sensoriais: somatossensorial, vestibular, dependências visuais e índice de equilíbrio composto. **Conclusão**: a posturografia mostrou-se útil na identificação de idosos com quedas, principalmente em indivíduos com quadros recorrentes.

Palavras-chave: Equilíbrio postural; Idosos; Acidentes por quedas; Tontura; Doenças vestibulares

Study carried out at the Department of Otorhinolaryngology, "Faculdade de Ciências Médicas da Santa Casa de São Paulo" – FCMSCSP - São Paulo (SP), Brasil.

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INTRODUCTION

Population aging is increasing in the world, as a reflection of the increase in life expectancy, technological advances in medicine, accessibility, and improvements in health conditions. On the other hand, age can bring weaknesses that health professionals must be prepared to resolve[1-3].

Dizziness is among the most common complaints of the elderly population, reaching a prevalence of 85%, directly interfering with the quality of life and associated with the risk of falling, with high morbidity in this age group[2,4].

Body stability is maintained by the complex integration between the sensory system, which includes the vestibular, somatosensory, and visual senses, and the motor system. Deterioration of balance occurs both as a natural process associated with aging and due to the incidence of chronic degenerative diseases, which can affect any of these systems and predisposing to falls[1,5-9].

These multiple causes, associated with the aging of the vestibular system, characterize the multifactorial nature of dizziness in the elderly[2]. In Brazil, 25.1% of the elderly living in urban areas fall at least once a year, and this proportion increases to 31.4% over 75 years of age[10].

Falls have a great impact on the individual's quality of life and health costs. Some of the main consequences are fractures, increased dependence, fear of further falls, restriction of activities, hospitalization, and institutionalization, with high rates of morbidity and mortality[1,11], in addition to the psychosocial consequences, causing feelings of fear, fragility, and lack of confidence. All the aforementioned aspects can lead to the deterioration of the general condition of the elderly[12,13].

Considering the growing prevalence of the elderly in terms of population and the high rates of falls in this age group, especially those with dizziness, this topic becomes a public health issue[10,12].

Early detection of postural control abnormalities, followed by adequate rehabilitation, modification of the environment and recommendations could help prevent falls[9,14].

Posturography is a test in which a force platform is used for a general assessment of balance, providing a quantitative approximation of the oscillations of the individual's center of gravity, as it allows to isolate and quantify the participation of vestibular, visual, and proprioceptive information, as well as its sensory integration in the maintenance of postural stability, information that is precisely what must be evaluated in the aging of the elderly's sensory functions[15].

In this sense, some studies have already shown that healthy elderly individuals with a history of falls are less able to compensate for general balance challenges[9,14,15], suggesting that the use of posturography could verify changes in the vestibulospinal system and assess the decreased postural control with aging([9,13,16-23].

The present study aimed to analyze the response of posturography in patients with dizziness, with and without a history of falls, pairing them by gender, age, and etiological diagnosis, to assess whether this test can be used as a tool to identify the risk of fall in this at-risk population.

METHODS

The study subjects were recruited from a database of patients treated at the otoneurology outpatient clinic of the otorhinolaryngology service of a tertiary hospital. The initial database records date from April 2013 and a total of 305 individuals.

A case-control study was carried out. Patients aged 60 years or older, consulted for dizziness and with a history of at least one episode of fall in the last year, caused by a dizziness crisis, were included in the case group. The number of falls in the last 12 months was quantified, and two or more falls were defined as recurrent falls. The study was approved by the Ethics Committee for Research on Human Beings of "Santa Casa de São Paulo", under protocol number 4,151,493.

Falls were defined as an event that results from unintentional contact with the ground or lower level, not being the result of a major intrinsic event (such as a stroke or syncope)[16].

The following exclusion criteria were applied: patients who needed a device to maintain balance (such as a cane or walker), musculoskeletal disorders that caused pain in the lower limbs or impaired strength and mobility, cognitive decline that prevented comprehension of the exam, severe or uncompensated visual disturbances, height less than one meter and weight above 130 kg (the limit to the posturography platform).

For the control group, elderly patients were selected, being followed up at the same outpatient clinic, without any episode of fall, being matched with the case group by gender, age, and etiological diagnosis of dizziness.

All participants understood the purpose of the research and signed the Informed Consent Form (ICF). Patients underwent standardized clinical evaluation using an otoneurological care form, comprising an anamnesis directed to the characteristics of dizziness, associated symptoms and comorbidities, general physical and otoneurological examination, and posturography, in addition to tests relevant to each case.

The equipment used in this work to perform static posturography with dynamic tests was the Contronic Horus®. The posturography is composed of a force platform connected to a computer. The software records and analyzes the data provided by the platform. The system is also accompanied by a pad, which allows tests with an unstable surface, and by television that projects visual stimuli[15].

Two tests were performed: the limit of stability (LOS)and the sensory organization test (SOT). For the LOS, the participant is instructed to lean the body forward, return to the center, lean back, return to the center, lean to the right, return to the center, lean to the left, and return to the center, only with ankle movement, without hip and shoulder movement, this sequence being performed twice without interruption, aiming to achieve the maximum possible displacement without risk of falling. For the SOT, the participant is instructed to remain on the platform in an orthostatic position for 30 seconds under the following sensory conditions[15] (Figure 1):

- Condition 1 (C1): stay on a stable surface (directly on the platform, that is, without using the pad), with eyes open, looking at a fixed point (assess the integration of visual, vestibular, and somatosensory systems);

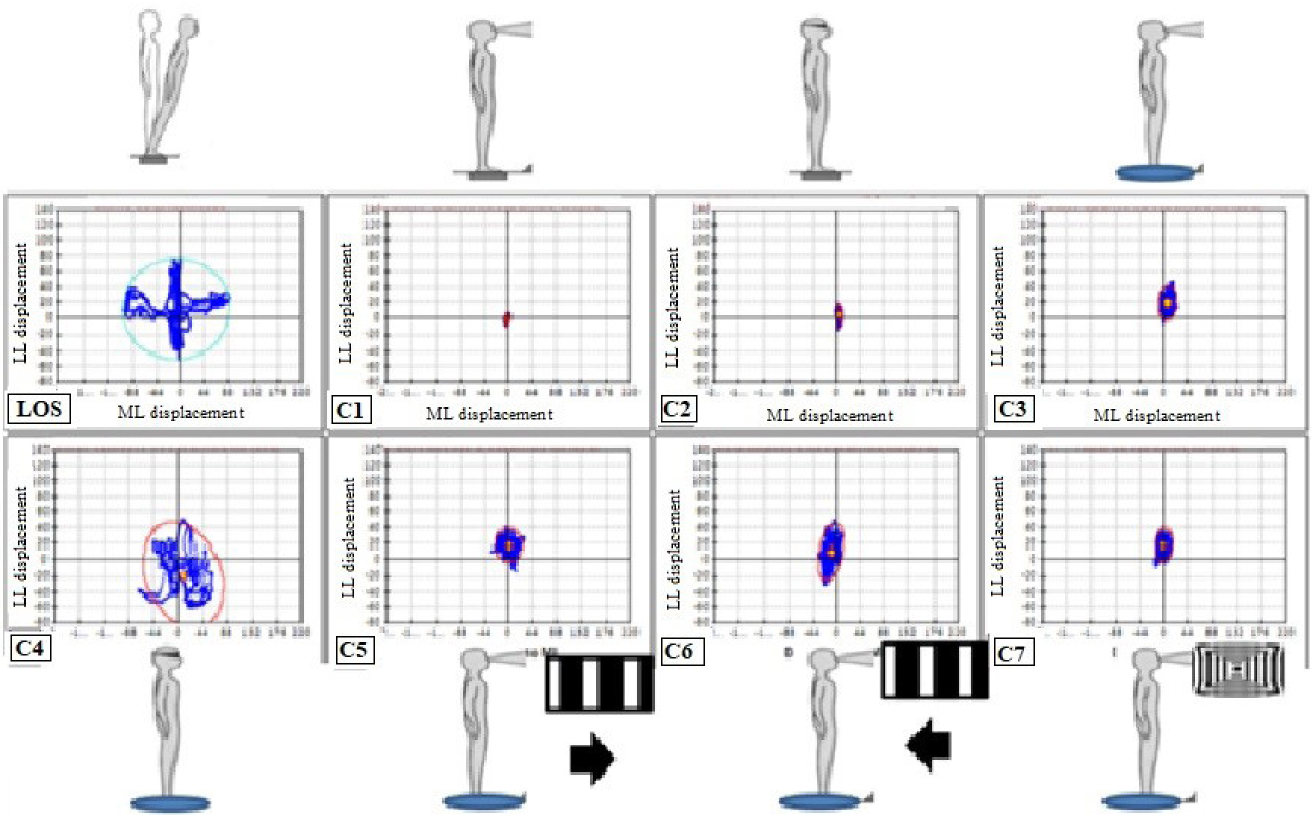

Figure 1. Statokinesigrams
LOS = limits of stability; C1 = condition 1 – eyes open and stable surface; C2 = condition 2 – eyes closed and stable surface; C3 = condition 3 – eyes open and unstable surface; C4 = condition 4 – eyes closed and unstable surface; C5 = condition 5 – right optokinetic visual stimulus and unstable surface; C6 = condition 6 – left optokinetic visual stimulus and unstable surface; C7 = condition 7 – tunnel visual stimulus and unstable surface

- Condition 2 (C2): stay on a stable surface, with eyes closed (exclusion of visual information; evaluates the vestibular and somatosensory systems);
- Condition 3 (C3): stay on an unstable surface (for example, on top of the cushion and the pad is on the platform), with eyes open, looking at a fixed point (inaccurate somatosensory information; assesses the vestibular and visual systems);
- Condition 4 (C4): stay on an unstable surface, with eyes closed (inaccurate somatosensory information and exclusion of visual information; assesses only the vestibular system);
- Condition 5 (C5): stay on an unstable surface, looking at a dynamic image that displays bars that cause an optokinetic effect, moving to the right;
- Condition 6 (C6): stay on an unstable surface, looking at a dynamic image that displays bars that cause an optokinetic effect, moving to the left;
- Condition 7 (C7): stay on an unstable surface, looking at a dynamic image that shows a tunnel composed of thin bars, with a forward direction. (In C5, C6, and C7 the somatosensory information is imprecise and promotes visual/vestibular conflict).

The software analyzes the confidence ellipse (CE), the mean mediolateral (MLV), and anteroposterior (APV) velocities and calculates the equilibrium score (ES) for each of these seven conditions. From the ES, the parameters of the sensory analysis are calculated: somatosensory (SOM), visual (VIS), vestibular (VEST), right visual dependence (VDep R), left visual dependence (VDep L), and tunnel visual dependence (VDep T). From the association of these sensory analyses, the composite equilibrium score (CES) is calculated, which reflects the general coordination of balance.

The values were analyzed according to the software's standardization, and the altered values were retested only once, for confirmation. The posturographic results of the case group and the control group were compared.

The Kolmogorov-Smirnov test was used to assess whether the different quantitative variables followed a normal distribution, which was compared by the mean, using the Student's t-test. Statistical significance was determined with a p less than 0.05 for all analyses.

RESULTS

Of the 305 patients treated, 36 individuals were included in the study, 18 of whom had a history of falls. Of these, 13 (72.2%) were female and 5 (27.8%) were male, the same as the control group. The mean age of patients who fell was 67.4

± 4.5 years, and that of those who did not fall was 68.3 ± 4.8 years (p=0.572).

Regarding the number of falls, 4 (22.2%) had 1 single episode of fall in the last 12 months, 5 (27.8%) had 2 episodes, and 9 (50%) had 3 or more episodes of falls.

Regarding the analysis of the quantitative variables of patients who fell and those who did not, there was a statistically significant difference between the groups for conditions C4 (p = 0.030) and C5 (p = 0.038), and the confidence ellipse area was higher for patients with falls (Table 1).

Sensory analysis of visual conflict showed a lower value for patients who had falls: VDep R (p = 0.040), VDep L (p = 0.019) and VDep T (p = 0.030). There was no significant difference in equilibrium score (ES) in any of the 7 conditions. Although it was possible to observe a higher average in the composite equilibrium score (CES) among the elderly who did not fall (84.26%) than those who suffered falls (69.14%), there was no significant difference in this parameter (p = 0.06). There was also no difference between the limits of stability(LOS) and the mediolateral (MLV) and anteroposterior (APV) velocities in any of the conditions.

Regarding patients with recurrent falls (2 or more episodes of falls in the last 12 months), statistically significant differences were observed in the group without falls, in conditions C1 (p=0.036), C4 (p=0.008), C5 (p=0.019) and C7 (p=0.031), the ES of conditions C2 (p=0.017), C4 (p=0.006), C5 (p=0.014), C6 (p=0.027) and C7 (p=0.023), and somatosensory (SOM) (p=0.029), vestibular (VEST) (p=0.022) and visual conflict

Table 1. Comparison of variables between patients without and with falls

Variables	Without falls	With falls		Recurrent falls	
	(mean ± SD)	(mean ± SD)	P-value	(mean ± SD)	P-value
CE LOS (mm²)	14,384 ± 3,478	15,603 ± 7,055	0.515	13,172 ± 5,427	0.449
CE C1-EOS (mm²)	486 ± 555	1,320 ± 1,930	0.087	1,618 ± 2,108	0.036*
CE C2-ECS (mm²)	809 ± 1,004	2,406 ± 4,218	0.127	3,020 ± 4,630	0.057
CE C3-EOU (mm²)	1,546 ± 2,016	2,185 ± 2,416	0.395	2,489 ± 2,661	0.262
CE C4-ECU (mm²)	4,011 ± 2,229	7,379 ± 5,891	0.030*	8,535 ± 6,229	0.008*
CE C5-OSD (mm²)	1,759 ± 1,010	3,124 ±2,483	0.038*	3,444 ± 2,668	0.019*
CE C6-OSL (mm²)	2,026 ± 1,304	3,461 ± 3,660	0.126	4,000 ± 4,008	0.058
CE C7-TU (mm²)	1,616 ± 1,203	2,859 ± 2,701	0.083	3,326 ± 2,903	0.031*
MLV C1-EOS (mm/s)	6.53 ± 4.72	10.11 ± 6.63	0.07	11.21 ± 7.12	0.033*
MLV C2-ECS (mm/s)	10.22 ± 10.38	15.92 ± 15.72	0.207	18.04 ± 17.09	0.119
MLV C3-EOU (mm/s)	16.97 ± 9.42	19.31 ± 8.74	0.445	20.35 ± 9.16	0.317
MLV C4-ECU (mm/s)	32.13 ± 14.55	37.54 ± 18.60	0.338	38.81 ± 19.68	0.278
MLV C5-OSD (mm/s)	21.54 ± 8,74	22.64 ± 9.11	0.713	23.41 ± 8.46	0.548
MLV C6-OSL (mm/s)	22.39 ± 10.95	22.54 ± 13.01	0.969	23.88 ± 14.12	0.739
MLV C7-TU (mm/s)	16.37 ± 7.42	17.19 ± 7.24	0.74	17.99 ± 7.86	0.557
APV C1-EOS (mm/s)	12.82 ± 7.95	14.69 ± 8.70	0.506	15.71 ± 9.43	0.355
APV C2-ECS (mm/s)	22.78 ± 17.84	22.87 ± 15.72	0.988	24.89 ± 17.35	0.74
APV C3-EOU (mm/s)	26.96 ± 18.43	27.07 ± 14.99	0.985	28.31 ± 16.60	0.832
APV C4-ECU (mm/s)	56.54 ± 36.79	68.43 ± 82.85	0.582	73.76 ± 93.76	0.481
APV C5-OSD (mm/s)	34.67 ± 21.71	35.12 ± 14.64	0.942	36.44 ± 16.10	0.801
APV C6-OSL (mm/s)	37.82 ± 32.84	35.52 ± 22.59	0.808	37.07 ± 25.13	0.944
APV C7-TU (mm/s)	30.36 ± 22.88	30.05 ± 12.09	0.96	31.67 ± 13.22	0.85
FRC C1-EOS (%)	96.37 ± 4.43	86.88 ± 25.42	0.128	83.46 ± 28.09	0.063
FRC C2-ECS (%)	93.47 ± 9.50	76.99 ± 34.44	0.059	70.75 ± 36.90	0.017*
FRC C3-EOU (%)	86.89 ± 22.07	78.33 ± 30.00	0.336	73.44 ± 32.56	0.174
FRC C4-ECU (%)	68.84 ± 24.57	46.95 ± 39.60	0.054	35.79 ± 38.02	0.006*
FRC C5-OSD (%)	86.65 ± 9.23	71.93 ± 29.34	0.05	66.61 ± 31.17	0.014*
FRC C6-OSL (%)	84.29 ± 14.05	69.83 ± 33.54	0.101	63.10 ± 35.37	0.027*
FRC C7-TU (%)	87.50 ± 11.18	72.16 ± 34.24	0.08	65.70 ± 36.47	0.023*
Somatosensory (%)	96.79 ± 6.70	82.19 ± 32.80	0.073	77.10 ± 35.79	0.029*
Visual (%)	89.95 ± 22.08	82.71 ± 29.66	0.412	78.74 ± 32.76	0.257
Vestibular (%)	70.76 ± 25.00	52.96 ± 39.32	0.114	43.21 ± 39.52	0.022*
VDep Right (%)	132.77 ± 102.33	73.06 ± 59.73	0.040*	63.89 ± 65.15	0.036*
VDep Left (%)	120.31 ± 54.18	72.86 ± 60.74	0.019*	62.65 ± 65.73	0.011*
VDep Tunnel (%)	132.75 ± 92.84	73.46 ± 60.46	0.030*	62.97 ± 65.17	0.023*
CES (%)	84.26 ± 13.79	69.14 ± 29.88	0.06	62.36 ± 30.72	0.011*

* Statistically significant values ($p \leq 0.05$)

Caption: SD = standard deviation; mm² = square millimeter; mm/s = millimeter per second; % = percentage; CE = confidence ellipse; LOS = limits of stability; MLV = mediolateral velocity; APV = anteroposterior velocity; FRC = functional residual capacity; C1-EOS = condition 1 – eyes open and surface stable; C2-ECS = condition 2 – eyes closed and surface stable; C3-EOU = condition 3 – eyes open and unstable surface; C4-ECU = condition 4 – eyes closed and unstable surface; C5-OSD = condition 5 – optokinetic stimulus to the right and unstable surface; C6-OSL = condition 6 –optokinetic stimulus to the left and unstable surface; C7-TU = condition 7 – tunnel stimulus and unstable surface; VDep = visual dependency; CES = composite equilibrium score analysis - VDep (p=0.036), VDep L (p=0.011) and VDep T (p=0.023) - in addition to the main variable, the CES, in which the average of those who did not fall was 84.26%, against 62.36% of those who fell (p = 0.011) (Table 1 and Figure 2).

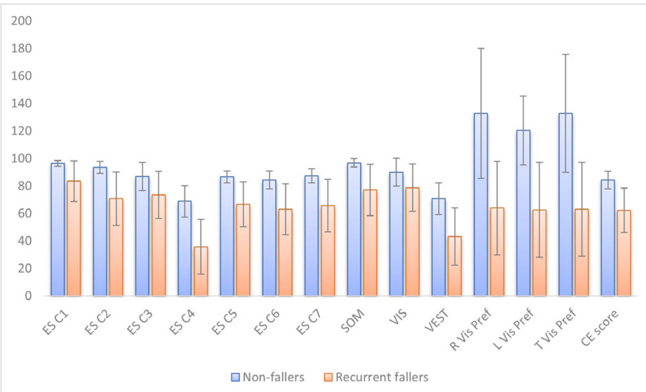

Figure 2. Posturographic parameter scores (non-fallers vs recurrent fallers).
* = Statistically significant differences; Erro bars = 95% confidence interval for average; ; ES = equilibrium scorer; C1 = condition 1 – eyes open and stable surface; C2 = condition 2 – eyes closed and stable surface; C3 = condition 3 – eyes open and unstable surface; C4 = condition 4 – eyes closed and unstable surface; C5 = condition 5 – right optokinetic visual stimulus and unstable surface; C6 = condition 6 – left optokinetic visual stimulus and unstable surface; C7 = condition 7 – tunnel visual stimulus and unstable surface; SOM = somatossensorial; VIS = visual; VEST = vestibular; R Vis Pref = right visual preference; L Vis Pref = left visual preference; T Vis Pref = tunnel visual preference; CE score = composite equilibrium score

DISCUSSION

In this study, when evaluating patients with a single episode of fall, despite the percentage of the ES of the seven conditions and the sensory analyzes being worse for the group with falls, there was a significant difference only for the visual conflict analyses. On the other hand, when evaluating individuals with two or more falls, posturography proved to be a good test to identify recurrent falls, with multiple parameters involved and with differences in the control group. As other papers[(13,24)], there was a significant difference in the composite equilibrium score, indicating that these elderly people are not able to compensate for the general balance challenges such as elderly people without falls[(24)].

The greater difficulty in identifying single falls can be understood as if these patients had less balance impairment, or even, understood this fall as an accidental event, being, therefore, more difficult to predict than multiple falls, which reflect the greater disorder of balance[(25)]. It is a fact that an isolated episode of fall already involves a risk of injury and should not be overlooked in the clinical practice of guidance and special care with this group at higher risk, although, obviously, the elderly who suffer recurrent falls are at greater risk of serious complications. Therefore, this group requires more rigorous preventive intervention[(13)].

Due to the high incidence of falls and their repercussions on the health of the elderly, tools, such as posturography, that could predict the risk of falls were evaluated so that measures could be taken to prevent their occurrence[(13)]. There are several models of static and dynamic posturography on the market. They differ in terms of the types of sensory information, such as the use of mobile platforms or virtual reality technology to recreate environments and situations capable of measuring the individual's postural responses to different stimuli.

In this paper, we used the Horus® equipment (Contronic brand) to perform static posturography with dynamic tests. This model is Brazilian, launched in 2017, and offers the advantages of lower cost compared to the international market, greater accessibility for maintenance as it is a national company and for its greater portability[(15)].

Since the posturographic evaluation program used - the SOT - manages to manipulate and analyze the input and dependence of information from the three sensory systems (visual, somatosensory, and vestibular) for postural balance[(17)], it was possible to evaluate the changes present in the different sensory conditions of posturography and to scrutinize the multiple factors that may be involved in recurrent falls.

Condition 2, stability with eyes closed on a stable surface (ES C2) and somatosensory analysis showed lower values in the group with recurrent falls, a finding also observed in a study[(25)], showing that patients had greater sway when visual afference was occluded. This suggests a greater contribution of visual afference and less confidence in somatosensory afference to the formation of strategies for postural stability in the elderly with recurrent falls[(25)].

Condition 4 values (ES C4) were also lower in the group with recurrent falls. In this condition, visual and somatosensory afferents were absent and reduced, respectively, evidencing the inefficiency of the vestibular system in developing strategies to maintain balance in patients with falls, which may reflect the vestibular dysfunction itself[(7,18)] and, equally, from a failure of central processing to deal with conflicting sensory information to maintain posture[(19)].

The present study also showed a difference in the variables that reflect the visual dependence for balance maintenance (VDep R, VDep L, and VDep T). In these tests, both visual and somatosensory afferents were distorted, suggesting that falls may be associated with decreased vestibular sensitivity, with a greater contribution of visual cues in balance regulation[(18,25)]. This variable was shown to be altered, even in individuals who had a single fall, making it possible to wonder whether it would be more sensitive and become important in earlier diagnoses.

Proprioceptive information, through spinal processing, generates a fast motor response, while visual information, from environmental references and with greater processing complexity, generates a more accurate, but slow response. Considering that situations of imbalance occur unexpectedly, quick and accurate responses are essential to avoid falls. Thus, it is argued that strategies involving a greater contribution of vision would be insufficient to prevent a fall, in contrast to those involving vestibular and proprioceptive preferences[(25)].

It should be noted that posturographic results vary according to gender[(7,15)] and age group[(15,20-22)], with different normality reference values for these variables. Few studies have studied posturography changes in different causes of dizziness. Authors[(23)] showed different results between central and mixed vertigo. Both the sensory systems (visual, somatosensory, and vestibular), as well as the motor and central processing, may undergo changes or decreases in function resulting from the physiological process of aging or specific dysfunctions[(22)]. The main difference of this study was that all the patients who fell were paired with the control group, according to gender, age, and diagnosis of dizziness, making the groups homogeneous.

With two homogeneous groups, it was possible to evidence, in this study, that posturography proved to be a good exam to identify patients with two or more episodes of falls. Thus, by identifying the potential risk and knowing the mechanisms that are related to balance deficit, it is possible to create appropriate interventions to prevent falls and their complications[13,22].

The sample number may have contributed to the lack of evidence of significant changes in the group with only one fall episode. With the increase in the number, more statistically significant results could be identified among the elderly with a single fall and those without falls. Another potential limitation is because the Horus® posturography is new equipment; studies of its alterations in patients with vestibular disorders are lacking. It is important to emphasize that the detection of the risk of falls should not be based exclusively on an exam. Posturography is complementary, not replacing the anamnesis and clinical evaluation of the patient.

CONCLUSION

Posturography proved to be useful in the identification of elderly people with falls, especially in individuals with recurrent conditions.

REFERENCES

1. Saftari LN, Kwon OS. Ageing vision and falls: a review. J Physiol Anthropol. 2018 Abr;37(1):11. http://dx.doi.org/10.1186/s40101-018-0170-1. PMid:29685171.
2. Cheng MH, Chang SF. Frailty as a risk factor for falls among community dwelling people: evidence from a meta-analysis. J Nurs Scholarsh. 2017 Set;49(5):529-36. http://dx.doi.org/10.1111/jnu.12322. PMid:28755453.
3. Park SH. Tools for assessing fall risk in the elderly: a systematic review and meta-analysis. Aging Clin Exp Res. 2018 Jan;30(1):1-16. http://dx.doi.org/10.1007/s40520-017-0749-0. PMid:28374345.
4. Scherer S, Lisboa HRK, Pasqualotti A. Dizziness in the elderly: otoneurological diagnosis and interference in quality of life. Rev Soc Bras Fonoaudiol. 2012;7(2):142-50. http://dx.doi.org/10.1590/S1516-80342012000200007.
5. Paiva SF, Silva CMB, Brito OEO, Soares ACS, Fraga WS. The risk of falling associated to dizziness in elderly. J Otolaryngol ENT Res. 2017;9(4):00293.
6. Ganança MM. Vestibular disorders in the elderly. Braz J Otorhinolaryngol. 2015;81(1):4-5. http://dx.doi.org/10.1016/j.bjorl.2014.11.001. PMid:25497851.
7. Oda DTM, Ganança CF. Posturografia dinâmica computadorizada na avaliação do equilíbrio corporal de indivíduos com disfunção vestibular. Audiol Commun Res. 2015;20(2):89-95. http://dx.doi.org/10.1590/S2317-64312015000200001469.
8. Hueb MM, Feliciano CP. Avaliação diagnóstica das síndromes vertiginosas. Rev Hosp Univ Pedro Ernesto. 2012;11(3):23-7.
9. Souza LF, Batista REA, Camapanharo CRV, Costa PCP, Lopes MCBT, Okuno MFP. Fatores associados ao risco, à percepção e ao conhecimento de quedas em idosos. Rev Gaúcha Enferm. 2022;43:e20200335. http://dx.doi.org/10.1590/1983-1447.2022.20200335. PMid:35043875.
10. Pimentel WRT, Pagotto V, Stopa SR, Hoffmann MCCL, Andrade FB, Souza PRB Jr, et al. Quedas entre idosos brasileiros residentes em áreas urbanas: ELSI-Brasil. Rev Saude Publica. 2018;52:12s. http://dx.doi.org/10.11606/s1518-8787.2018052000635. PMid:30379287.
11. Gasparotto LPR, Falsarella GR, Coimbra AMV. As quedas no cenário da velhice: conceitos básicos e atualidades da pesquisa em saúde. Rev Bras Geriatr Gerontol. 2014;17(1):201-9. http://dx.doi.org/10.1590/S1809-98232014000100019.
12. Alves RLT, Silva CFM, Pimentel LN, Costa IA, Souza ACS, Coelho LAF. Avaliação dos fatores de risco que contribuem para queda em idosos. Rev Bras Geriatr Gerontol. 2017;20(1):59-69.
13. Soto-Varela A, Faraldo-García A, Rossi-Izquierdo M, Lirola-Delgado A, Vaamonde-Sánchez-Andrade I, del-Río-Valeiras M, et al. Can we predict the risk of falls in elderly patients with instability? Auris Nasus Larynx. 2015;42(1):8-14. http://dx.doi.org/10.1016/j.anl.2014.06.005. PMid:25194853.
14. Lopes AL, Lemos SMA, Chagas CA, Araujo SG, Santos JN. Evidências científicas da reabilitação vestibular na atenção primária à saúde: uma revisão sistemática. Audiol Commun Res. 2018;23:e2032. http://dx.doi.org/10.1590/2317-6431-2018-2032.
15. Nishino LK, Rocha GD, Souza TSA, Ribeiro FAQ, Cóser PL. Protocol for static posturography with dynamic tests in individuals without vestibular complaints using the Horus system. CoDAS. 2021 Jun;33(3):e20190270. http://dx.doi.org/10.1590/2317-1782/20202019270. PMid:34161438.
16. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med. 1988;319(26):1701-7. http://dx.doi.org/10.1056/NEJM198812293192604. PMid:3205267.
17. Macedo C, Gazzola JM, Caovilla HH, Ricci NA, Doná F, Ganança FF. Posturografia em idosos com distúrbios vestibulares e quedas. ABCS Health Sci. 2013;38(1):1724. http://dx.doi.org/10.7322/abcshs.v38i1.4.
18. Gazzola JM, Caovilla HH, Dona F, Gananca MM, Gananca FF. A quantitative analysis of postural control in elderly patients with vestibular disorders using visual stimulation by virtual reality. Braz J Otorhinolaryngol. 2020;86(5):593-601. http://dx.doi.org/10.1016/j.bjorl.2019.03.001. PMid:31175041.
19. Gazzola JM. Controle postural de idosos vestibulopatas crônicos com e sem histórico de quedas submetidos à estimulação visual por realidade virtual [Tese]. São Paulo: Universidade Federal de São Paulo; 2010.
20. Baloh RW, Corona S, Jacobson KM, Enrietto JA, Bell T. A prospective study of posturography in normal older people. J Am Geriatr Soc. 1998;46(4):438-43. http://dx.doi.org/10.1111/j.1532-5415.1998.tb02463.x. PMid:9560065.
21. Baloh RW, Jacobson KM, Enrietto JA, Corona S, Honrubia V. Balance disorders in older persons: quantification with posturography. Otolaryngol Head Neck Surg. 1998;119(1):89-92. http://dx.doi.org/10.1016/S0194-5998(98)70177-9. PMid:9674519.
22. Müller DVK, Tavares GMS, Schneider RH. Análise do equilíbrio corporal em idosos classificados em diferentes faixas etárias através da posturografia dinâmica computadorizada (PDC). Revista Kairós Gerontologia. 2016;19(22):61-83. http://dx.doi.org/10.23925/2176-901X.2016v19iEspecial22p61-83.
23. Fedorowicz J, Bielińska M, Olszewski J. Posturography studies in patients with central and mixed vertigo. Otolaryngol Pol. 2018;72(3):19-25. http://dx.doi.org/10.5604/01.3001.0011.7256. PMid:29989559.
24. Wallmann HW. Comparison of elderly nonfallers and fallers on performance measures of functional reach, sensory organization, and limits of stability. J Gerontol A Biol Sci Med Sci. 2001;56(9):M580-3. http://dx.doi.org/10.1093/gerona/56.9.M580. PMid:11524452.
25. Vouriot A, Gauchard GC, Chau N, Benam-ghar L, Lepori ML, Mur JM, et al. Sensorial organisation favouring higher visual contribution is a risk factor of falls in an occupational setting. Neurosci Res. 2004;48(3):239-47. http://dx.doi.org/10.1016/j.neures.2003.11.001. PMid:15154670.