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Comparative analysis of postural balance by posturography in patients with isolated vertigo or associated with hearing loss

Análise comparativa do equilíbrio postural pela posturografia em pacientes com vertigem isolada ou associada com perda auditiva

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ABSTRACT

Purpose: To perform a comparative analysis of the balance of subjects with isolated vertigo and dizziness associated with hearing loss. **Methods:** The sample consisted of 29 patients with peripheral vertigo diagnosis selected by non-probabilistic sampling and convenience aged between 45 and 64 years. The diagnostic survey to hearing evaluation consisted of audiological anamnesis and assessment of postural balance; it was made in force platform, in the bipedal and semi tandem positions with open eyes. The analyzed balance parameters were: ellipse area, center of pressure in square centimeters, average speed in centimeters per second and average frequency, in Hertz, of swaying in both directions of movement: anteroposterior and mediolateral. **Results:** As for the population in general, the comparison between individuals with and without hearing loss has not shown to be there any damage to the maintenance of postural balance. There was difference in women in the speed parameter in mediolateral direction. **Conclusion:** Although no differences have been found which might have characterized a correlation between hearing loss and balance in patients, there was a worse performance in postural balance of women with vertigo associated with hearing loss in the mediolateral parameter.

Keywords: Dizziness; Vertigo; Postural balance; Vestibular diseases; Hearing loss

RESUMO

Objetivo: Realizar uma análise comparativa do equilíbrio de sujeitos com vertigem isolada e com vertigem associada à perda auditiva. **Métodos:** A amostra foi constituída por 29 pacientes com diagnóstico de vertigem periférica, selecionados pelo método de amostragem não probabilística e por conveniência, com idade entre 45 e 64 anos, sendo 9 do gênero masculino e 20 do gênero feminino. A pesquisa diagnóstica para avaliação da audição consistiu de anamnese audiológica e audiometria tonal liminar. A avaliação do equilíbrio postural foi feita em Plataforma de Força, nas posições bipodal e semi-tandem, com os olhos abertos. Os parâmetros de equilíbrio analisados foram: área elipse, centro de pressão em centímetros quadrados, velocidade média em centímetros por segundo e frequência média, em Hertz, de oscilações do centro de pressão, em ambas as direções dos movimentos: anteroposterior e mediolateral. **Resultados:** Na população geral, a comparação dos dados estabilométricos entre indivíduos com e sem perda auditiva não demonstrou prejuízo da manutenção do equilíbrio postural. Houve diferença no gênero feminino, em relação ao parâmetro velocidade, na direção mediolateral. **Conclusão:** Embora não tenham sido encontradas diferenças que possam caracterizar correlação entre perda auditiva e equilíbrio entre os pacientes, houve pior desempenho no equilíbrio postural das mulheres com vertigem associada à perda auditiva, no parâmetro mediolateral.

Descritores: Tontura; Vertigem; Equilíbrio postural; Doenças vestibulares; Perda auditiva

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INTRODUCTION

Beginning in 2025, Brazil will become the sixth country with the largest elderly population, some of which are presently in adulthood. Aging is considered a dynamic and progressive process, in which morphological, functional and biochemical changes occur, progressively affecting the organism, subjecting it to intrinsic and extrinsic aggressions that eventually lead it to death[1,2].

Dizziness is considered one of the most common symptoms and it includes a wide range of sensations and disturbances of body balance. The most common sensations are vertigo (dizziness with a spinning sensation), unbalance, instability, disorientation, swaying, turbid mind and an impression of drunkenness, of which vertigo was found to be one of the most recurrent symptoms in world population[3,4].

The type of hearing loss known as presbycusis occur beginning in middle age. It's usually sensorineural and it refers to the result of a long period of damages to the auditory system, a variety of physiological degenerations, including harms caused by exposure to noises, ototoxic agents and disorders caused by other medical treatments. Presbycusis may be related to altering balance[5-7].

Balance is made possible by means of three systems – visual, auditory and proprioceptive – that receive information from the environment and send it to the central nervous system which, in turn, processes, integrates, plans and generates a motor response for an adequate postural adjustment through the action of the muscular system. Biomechanically, balance control demands that the center of gravity be kept over the body support in static and dynamic situations of the human movement[8].

Some studies justify that changes in the ear occurred with the coming of age are related to a microcirculatory insufficiency resulting from vascular occlusion caused by embolism, hemorrhage or vasospasm. These, in turn, would be a result of a hyperviscosity syndrome or a microangiopathy, since systemic alterations and specific lifestyles may speed the degeneration process of the auditory system. Among these, are the inhaling of toxic substances, some circulatory and metabolic alterations, infections, different kinds of trauma and heredity[9].

Aging is directly proportional to the presence of multiple related otoneurological symptoms, such as vertigo and other types of dizziness, hearing loss, tinnitus, body balance alterations, gait abnormalities and occasional falls[10].

Functional balance associated with chronic vestibular dysfunction and the identification of variables associated to the deficit in balance in these individuals may promote the development of specific strategies for prevention, rehabilitation and assistance, aiming at the continuing autonomy and independence for as long as possible. Functional balance with chronic vestibular dysfunction is more undermined when associated with aging – eighty years of age and above –, increase in the number of diseases, presence of five or more diseases related to the vestibular status, polypharmacy, recurring falls, tendency to fall, central vestibular syndrome, daily dizziness, mobility loss and gait abnormalities. The body is responsible for responding to the variations in the center of gravity, either in a voluntary or involuntary way, and for constantly maintaining balance. Fortunately, it's possible to objectively quantify the lack of balance by means of a force platform, which calculates the force of body vertical response (inverse dynamics) applied to the ground and computes the corresponding parameters to the changes in the center of gravity and postural adjustments, such as the intensity of the center of pressure (CoP), displacement area of CoP and postural wavering in frequency and speed of adjustment[11].

Postural control may suffer influence from physiological changes, chronic diseases, pharmacological interactions or specific dysfunctions, just as the whole process of aging affects all components of postural control – sensorial (visual, somatosensory and vestibular), effector (force, range of movement, biomechanical aligning, flexibility) and central processing[12].

Since many of the structures are involved in the balance process, loss of body stability may often be related to alterations in the vestibular and/or auditory system, or even depend of changes occurred at distance in other organs, systems or external forces[12,13].

Exposure to occupational noises is related to poor results in balance assessment, in all conditions tested by dynamic posturography. A study assessed body balance in individuals exposed to occupational noise in a print shop. The results of 34 male individuals were assessed, being divided in two groups, one with 16 workers exposed to noise, in the age of 45.81 ± 7.38 years, and the other group with 16 individuals without exposure to occupational noises, in the age of 41.31 ± 5.58 years. The average exposure time was of 20.00 ± 8.46 years. Results were compared based on the T-test, considering as differential the value of p less than or equal to 0.05. All analysis show differences between the groups, being that the individuals exposed to occupational noises presented lower figures in the results for body balance in relation to those that were not exposed[13].

Another research assessed 80 elderly from two different groups: Group A, composed of 38 women and 2 men, belonging to an elderly group, and Group B, composed of 35 women and 5 men with effective complaints of alteration in body balance. They were subjected to anamnesis, in which the priority was to investigate aspects related to dizziness, tinnitus and hearing difficulty. They were also submitted to vestibular assessment, carried out by means of the computerized vectoelectronistagmography system, SCV 5.0. The results have shown a difference between the two groups in terms of complaints of dizziness and tinnitus, more prevalent among individuals of Group B[14].

Intending to assess the improvement in hearing, with the help of a hearing aid, in relation to balance and fear of falling among elderly with bilateral hearing loss, a clinical and experimental study was carried out[15] involving 56 elderly individuals with sensorineural hearing loss, subjected to the use of hearing aids. The elderly were subjected to the Short Form Health Survey, the International Falls Efficacy Scale and the Berg Balance Scale. After four months, those that were adapted to the use of the hearing aid were reassessed. It was observed that 50% of the elderly managed to adjust to the hearing aid. It was also observed that men had greater difficulty in adjusting to the hearing aid. The differences in age, degree of hearing loss, presence of tinnitus and vertigo did not interfere in adjustment to the hearing aid. There was an improvement in the quality of life in the areas of general health condition, functional capacity and tinnitus, as well as increase of self-confidence after adjustment to the hearing aid and, consequently, improvement in attention, reducing the risk of falls[15].

Even though there is an increasing use of statokinesiometry (which is part of posturography) in studies to quantitatively assess the vestibulospinal component of body balance[16-18], little is yet known about the relation between hearing problems and changes in postural balance verified through stabilographic parameters, such as CoP area and swaying speed.

The physiologic diminishing of sight, hearing, body stability, muscle power and joint alterations may change balance and bring about risks of accidents and falls, as a result of the slowing of defensive reactions[19].

In a cross-sectional study carried out in 2009 that assessed 61 individuals through anamnesis and audiological evaluation, the chi-squared test and the relative risk test were applied, with 95% of reliability and value of $p<0.05$ for the univariate analysis between hearing loss and related factors. From the results, 87.70% presented some kind of hearing loss or decrease in frequencies. In these individuals, the most prevalent hearing loss was sensorineural, with an occurrence of 63.93%. Among the hypertensive, 88.88% had hearing loss, a result equivalent to eight times more chances of hypertensives developing hearing loss. Among diabetics, 90% had hearing loss; that is, diabetics have chances nine times greater of presenting hearing loss. Among alcohol drinkers, 92.30% presented hearing loss; that is, they presented chances twelve times greater of having hearing loss. Among smokers, ex-smokers and passive smokers, 87.09% presented hearing loss, having therefore a chance nine times greater of having hearing loss, when compared to non-smokers[20].

The aim of this study was to carry out a comparative analysis of balance in individuals with isolated vertigo and with vertigo associated with hearing loss.

METHODS

Cross-sectional, observational and descriptive study. The sampling was composed of 29 middle age patients, diagnosed with peripheral vertigo, indicated by otorhinolaryngologists. All patients were sent by an otorhinolaryngologist and selected by the nonprobability sampling method and by convenience. For the inclusion criteria, individuals that took part in this study were from both genders, with ages ranging from 45 to 64 years old. For exclusion criteria, the individuals that did not take part were the ones that presented any kind of physical limitation that might have kept them from undergoing balance tests.

All individuals participated voluntarily in this research, after signing an Informed Consent Form. The research project was approved by the Ethics in Research Committee from the *Universidade Norte do Paraná* (UNOPAR), under the certificate number: 19134513.8.0000.01.08.

Patients were submitted to audiological anamnesis, tone threshold audiometry and balance test, through force platform fixed in bipedal position (P1) and semi-tandem stand (P2), with eyes opened. The analyzed balance parameters were: CoP elliptic area (95%) in square centimeters (A-CoP in cm^2), average speed in centimeters per second (cm/s) and average frequency in Hertz (Hz) of CoP oscillation, in both directions of movement: anteroposterior (A/P) and mediolateral (M/L).

Diagnostic research for hearing assessment consisted of audiological anamnesis, used in the treatment routine in the audiology department of the institution, based on Miller's anamnesis protocol[21], and the tone threshold audiometry, considered gold standard to hearing range assessment in adults[22,23]. For the criteria of hearing loss, Davis and Silverman classification was used, taking into consideration the average frequency of 500 Hz, 1000 Hz and 2000 Hz, for each tested ear[22-24].

Postural balance was assessed by means of the force platform, where all individuals stood for 60 seconds for the semi-tandem stand. Patients were subjected to the position of feet placement and visual condition. The adopted position was standing semi-tandem, with eyes opened, feet laterally separated by 2.5 cm and the heel of the front foot kept 2.5 cm distant from the big toe of the back foot.

Data was collected in the Functional Assessment and Human Motor Performance Lab of the institution. All individuals were assessed by means of the BIOMEC400 force platform (EMG System of Brazil, SP), which contains four charging cells in rectangular position, measuring 500X500X100 mm and weighing 22 kg.

The system uses a 16-bit analogical-digital converter and rejection filters of 50 Hz. The ground response vertical force is derived from a sampling of 100 Hz for data collecting. Digital data was transferred by USB universal cable to a computer. All signs of force registered by the force platform are filtered by a second order 35 Hz low-pass filter (Butter worth filter), in order to eliminate electrical noise.

For the acquisition and treatment of the balance parameters, the Bioanalysis software of the BIOMEC400 force platform was used, which is compiled with stabilographic analysis computing routines in the MATLAB program (The Mathworks, Naticks, MA). The analyses were carried out through the IBM SPSS program (version 20 for Windows). Parametrical

Table 1. Descriptive statistics of balance parameters (general average and standard deviation for groups G1 and G2)

	Patients	n	Average	Standard deviation	Average
A-CoP	HL	13	3.48	3.06	0.84
	WHL	16	2.45	1.47	0.36
SpeedAP	HL	13	4.51	12.47	3.45
	WHL	16	0.96	0.34	0.08
SpeedML	HL	13	1.00	1.50	0.41
	WHL	16	0.59	0.16	0.04
FrequencyAP	HL	13	0.28	0.09	0.02
	WHL	16	0.29	0.08	0.02
FrequencyML	HL	13	0.41	0.28	0.07
	WHL	16	0.39	0.15	0.03
Total displacement	HL	13	72.95	25.32	7.02
	WHL	16	70.76	15.78	3.94

Note: A-CoP = elliptic area (95%) of CoP; SpeedAP = Anteroposterior speed; SpeedML = mediolateral speed; FrequencyAP = Anteroposterior frequency; FrequencyML = mediolateral frequency; HL = Hearing loss; WHL = Without hearing loss

distribution of data were verified through the Shapiro Wilk test, using the T-test for independent sampling, in order to compare the performance averages between the groups, and p≤0.05 was adopted.

RESULTS

In this study, 29 adult individuals took part, being divided into two groups: G1 (with bilateral hearing loss), consisting of 16 individuals (averaging 56.06 years of age), of which 8 were women and 8 men; G2 (with isolated vertigo), consisting of 13 individuals (averaging 57.38 years of age), of which 12 were women and 1 man. Sensorineural hearing loss was found in 94% of all participants.

In the general population there was no difference between the variables in balance and hearing loss (Table 1).

There was no significance in the comparative analysis for bipedal standing between the groups with and without hearing loss (Table 2).

In the general descriptive statistics carried out between the groups, CoP elliptic area (95%) was specified in square centimeters (A-CoP in cm^2), average speed in centimeters per second (cm/s) and average frequency in Hertz (Hz) of CoP oscillation, in both directions of movement: anteroposterior (A/P) and mediolateral (M/L) (Table 3).

In the comparison between the men and women groups, there was a difference in speed M/L (Table 4).

Table 2. Comparative analysis for bipedal position between groups G1 and G2 with and without hearing loss

Bipedal Position	t-test (G1xG2)
A-CoP	0.28
SpeedAP	0.32
SpeedML	0.28
FrequencyAP	0.75
FrequencyML	0.89
Total displacement	0.77

Student's t-test (p≤0.05)
Note: A-CoP = elliptic area (95%) of CoP; SpeedAP = Anteroposterior speed; SpeedML = mediolateral speed; FrequencyAP = Anteroposterior frequency; FrequencyML = mediolateral frequency

DISCUSSION

The fact that there was no difference between the variables in balance and hearing loss in the general population of this study nor in the comparative analysis for bipedal standing between the groups with and without hearing loss, may be justified by the fact that some pathologies or dysfunctions don't affect simultaneously the cochlea and the labyrinth[25-28]. When the men and women groups were compared, there was significance in speed M/L, being considered the measure of greatest reliability among the repetitions[28].

Even though the postural balance assessment carried out by the fixed force platform BIOMEC400 has been showing to be valid and reliable, as far as sensibility is concerned, to discriminate the deficit of balance among middle age individuals and young adults[25], the correlation between problems related to balance, pathologies and therapeutic procedures over the different stabilographic parameters (e.g., CoP area, frequency and speed of swaying) and the sensorial part (sight and hearing) is not completely clear[25,26].

In some cases, the fact that some vestibulocochlear pathologies or dysfunctions progress slowly, especially regarding presbycusis, may cause the central vestibular system to compensate changes in balance, creating new postural patterns. That's demonstrated in a study that researched peripheral vestibular dysfunctions in relation to vestibular reflex compensation using posturography by means of a force platform, concluding that posturographic data from the force platform allows for a more reliable assessment of functional situations[26].

Besides this, literature infers that physiological impairment of sight, body stability, muscle power, as well as joint alterations, may facilitate risks of accidents and falls, as a result of

Table 3. General descriptive statistics of groups G1 and G2

	Patients	n	Average	Standard deviation
A-CoP (B)	1.00	8	1.74	1.03
	2.00	8	3.16	1.56
SpeedAP (B)	1.00	8	0.84	0.23
	2.00	8	1.07	0.42
SpeedML (B)	1.00	8	0.50	0.08
	2.00	8	0.68	0.17
B-FrequencyAP (B)	1.00	8	0.27	0.08
	2.00	8	0.31	0.07
B-FrequencyML (B)	1.00	8	0.42	0.16
	2.00	8	0.37	0.13
B-TotalDisplacement (B)	1.00	8	64.11	13.82
	2.00	8	77.41	15.54
A-CoP (ST)	1.00	8	5.46	3.00
	2.00	8	5.25	1.62
SpeedAP (ST)	1.00	8	1.61	0.65
	2.00	8	25.89	68.73
SpeedML (ST)	1.00	8	1.55	0.42
	2.00	8	1.60	0.33
FrequencyAP (ST)	1.00	8	0.59	0.24
	2.00	8	0.63	0.26
FrequencyML (ST)	1.00	8	0.39	0.09
	2.00	8	0.41	0.16
TotalDislacement (ST)	1.00	8	146.98	48.71
		8	149.52	42.03

Note: A-CoP = Elliptic area (95%) of CoP; SpeedAP = Anteroposterior speed; SpeedML = mediolateral speed; FrequencyAP = Anteroposterior frequency; FrequencyML = mediolateral frequency; B = Bipedal; ST = Semi-Tandem

Table 4. Comparative statistics between men and women

Bipedal Position	t-test (Men x Women)
SpeedML	0.021*

*Significant value (p≤0.05) – Student's t-test
Note: SpeedML = Mediolateral speed

the slowing of defensive reactions[7]. That is, body balance is significantly related to other systems that work together for such stability, and not only to the auditory system, which may justify the non-significance between patients with and without hearing loss.

Nevertheless, hearing disorders are common in patients with changes in balance, due to probable damages to the inner-ear system. The relatively high prevalence of audiovestibular dysfunctions may be related to systemic alterations in the auditory system, as a consequence of metabolic and circulatory changes, and also of autoimmune diseases. Therefore, a complete anamnesis and complementary exams for the verification of balance in patients with and without hearing loss may often furnish a clear orientation as to the diagnosis and future treatment. The correct diagnosis with the verification of associated problems allows for successful treatment for many of the vestibulopathies[27,28].

The worst performance in postural balance in women with vertigo associated with hearing loss, in the M/L speed parameter, may be related to damage in the inner-ear. In general, comparison of stabilographic data in this study, between individuals with and without hearing loss, did not affect the preservation of postural balance according to the parameters analyzed in a similar way, which did not give evidence of differences that could characterize a worsening caused by hearing loss between the two groups, not making evident the sub-clinic of these patients.

CONCLUSION

This study demonstrated the importance of the assessment of static posturography allied to auditory assessment and it revealed that stabilometric patterns may suffer alterations possibly associated with hearing loss. However, the preservation of balance depends on other sensorial systems properly functioning, which may also be responsible for balance disorders.

It is suggested that more studies be carried out, with greater sampling, in order to clear out whether there is body stability loss in relation to balance stabilometric parameters, as a result of hearing impairment.

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