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Correlation between vestibular dysfunction with the risk of falls and the impact of dizziness on the quality of life of older adults

Correlação entre a disfunção vestibular com risco de quedas e o impacto da tontura na qualidade de vida em idosos

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ABSTRACT

Purpose: To investigate the correlation between vestibular dysfunction and the risk of falls, and the impact of dizziness on the quality of life in older people. **Methods:** Cross-sectional, observational, analytical study with a sample of 42 older adults of both sexes with vestibular dysfunction confirmed by vestibular evoked myogenic potential (VEMP) and the Video Head Impulse Test (v-HIT). Subjective balance assessment was also performed using dizziness scales and questionnaires: the Berg Balance Scale (BBS), which assesses the risk of falls; the visual analog scale (VAS), which assesses the degree of discomfort caused by dizziness; and the Dizziness Handicap Inventory (DHI), which assesses the impact of dizziness on quality of life. The examinations, scales, and questionnaire were performed on the same day. **Results:** The gain of the semicircular canals was negatively correlated with VAS and positively correlated with BBS. The corrected cervical asymmetry index was negatively correlated with VAS. **Conclusion:** Reduced semicircular canal gain and greater asymmetry of the lateral semicircular canals in the v-HIT examination were correlated with a higher risk of falls and greater self-reported discomfort due to dizziness.

Keywords: Aged; Postural balance; Dizziness; Evoked potentials; Motor vestibular function tests

RESUMO

Objetivo: Verificar se existe correlação entre a disfunção vestibular com o risco de quedas e o impacto da tontura na qualidade de vida em idosos. **Métodos:** Estudo transversal, observacional e analítico. A amostra foi composta por 42 idosos, de ambos os sexos, com disfunção vestibular comprovada por meio dos exames Potencial Miogênico Evocado Vestibular (VEMP) e o Video Head Impulse Test (v-HIT). Realizou-se também avaliação subjetiva do equilíbrio por meio de escalas e questionários de tontura: Escala de Equilíbrio de Berg (EEB), que avalia o risco de quedas, Escala Visual Analógica (EVA), o grau de incômodo da tontura e Questionário Handicap para Tontura (QHT), o impacto da tontura na qualidade de vida. Os exames, escalas e o questionário foram realizados no mesmo dia. **Resultados:** Verificou-se correlação negativa entre o ganho dos canais semicirculares com a EVA e correlação positiva com a EEB, além de correlação negativa do índice de assimetria corrigido cervical com a EVA. **Conclusão:** Observou-se correlação entre o ganho reduzido dos canais semicirculares e maior assimetria dos canais semicirculares laterais no exame v-HIT com o maior risco de quedas e maior incômodo da tontura autorrelatada.

Palavras-chave: Idoso; Equilíbrio postural; Tontura; Potencial evocado motor; Testes de função vestibular

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INTRODUCTION

Vestibular assessment traditionally uses the caloric test (CT), which is the oldest method for functional assessment of the vestibular system. However, the examination only evaluates the lateral semicircular canals (SCC)[1,2]. The assessment uses low-frequency stimuli (around 0.002 to 0.004 Hz) at different temperatures to identify any labyrinth hypofunction[2,3].

Complementary tests such as the cervical and ocular vestibular evoked myogenic potential (VEMP) and the video head impulse test (v-HIT) currently assist in vestibular assessment[2-4]. They perform a topodiagnosis of the lesion to assess the vestibular system in detail[3,4].

Cervical VEMP (cVEMP) is captured in the sternocleidomastoid muscle (SCM) and assesses the otolithic organ saccule and the lower portion of the vestibular nerve, while ocular VEMP (oVEMP) is generated from extraocular muscles in response to high-intensity sounds, assessing the utricle and the upper portion of the vestibular nerve[5-7]. They find latency, amplitude, and response asymmetry when there is functional integrity of the saccular and utricular macula, nerves, nuclei, central vestibular pathways, and the neuromuscular junctions involved[6-8].

The v-HIT assesses all SCCs on each side of the labyrinth[9-11]. It represents the computerized quantitative analysis of the head impulse test, which assesses the angular gain of the vestibulo-ocular reflex (VOR)[11,12]. The assessment is performed using high frequencies, around 5 to 7 Hz[10,11]. Thus, v-HIT provides information on which channel has overt and/or covert corrective saccades (not observed with the naked eye), in addition to the asymmetry value of responses between the lateral, anterior, and posterior SCCs[10-12].

Subjective balance assessment can be performed using the Berg Balance Scale (BBS)[13], which verifies the risk of falls in different tasks. Subjective assessment of symptoms caused by dizziness can be performed with the visual analog scale (VAS)[14], which assesses the degree of discomfort from self-reported dizziness, and with the Dizziness Handicap Inventory (DHI)[15], which reveals the impact of dizziness on quality of life in functional, physical, and emotional aspects.

Objective tests used along with subjective assessment of balance and self-perception of dizziness symptoms through scales and questionnaires make it possible to analyze in detail the individual's vestibular system and the implications of dizziness in various aspects of their life[2,4,13-15]. Thus, this study aimed to verify whether vestibular dysfunction is correlated with the risk of falls and the impact of dizziness on older people's quality of life.

METHODS

The research procedures were approved by the Research Ethics Committee of the Federal University of Minas Gerais - CEP/UFMG, under number 49714221.0.0000.5149 (according to Resolution 466/12 of the Brazilian National Health Council – CONEP). The research was conducted at the Observatory for Functional Speech-Language-Hearing (SLH) Health of the Medical School of the Federal University of Minas Gerais (OSF/FM/UFMG). The sample consisted of 42 older adults residing in Belo Horizonte, Brazil, and its metropolitan region. The inclusion criteria were older adults (60 years or older) of both sexes with vestibular dysfunction confirmed by VEMP (absent or abnormal response)[5,6] and/or v-HIT (SCC gain less than 0.75)[8,9], and who voluntarily agreed to participate in the study by signing an informed consent form. This is a convenience sample; the Otorhinolaryngology Service of São Geraldo Hospital – UFMG's Clinics Hospital referred the selected individuals to the SLH Clinic due to vestibular dysfunction confirmed by caloric testing, regardless of an otoneurologic diagnosis. They were awaiting the start of vestibular rehabilitation treatment by the SLH service. The study excluded those with external ear abnormalities on otoscopy and/or middle ear abnormalities on tympanometry that prevented the VEMP examination, self-reported neurological and neurodegenerative alterations, self-reported ocular and cervical alterations, and self-reported significant emotional disorders that prevented the examinations.

Procedures

Initially, participants answered a questionnaire containing information regarding their otologic history and possible auditory and vestibular alterations. The DHI, Brazilian version, was applied to assess the impact of dizziness on quality of life. It consists of 25 questions, of which seven assess physical aspects, nine assess emotional aspects, and nine assess functional aspects[15]. The study used VAS[14] for participants to score the degree of dizziness discomfort on a numbered line, ranging from 0 (no discomfort) to 10 points (extreme discomfort). Participants also underwent the BBS[13] to measure fall risk, through 14 tests where responses were scored between 0 (unable to perform the task) and 4 (able to perform the task independently). The same trained evaluator administered all examinations, scales, and questionnaires in a single session lasting approximately 60 minutes. First, audiometry and tympanometry hearing tests were performed, followed by v-HIT and VEMP vestibular tests, and subsequently, the DHI, VAS, and BBS, all in that order. The evaluator asked the participants the questionnaire questions. The evaluation took place in an acoustically treated room with the participants seated for the tests and questionnaires, except for the BBS.

Otoscopy and tympanometry were performed in an acoustically treated room for the hearing assessment. Tympanometry used the Otoflex 100 equipment from Otometrics®; the individuals were instructed to remain seated in silence, and then the probe was introduced into the external auditory canal of each ear to capture the response. It should be noted that this study only considered individuals with type A tympanometry, according to Jerger's classification[16]. The participants' skin was prepared with gel to reduce electrical impedance before electrode placement.

Cervical and ocular VEMP testing used an Otometrics® auditory evoked potential equipment, model ICS Chartr EP 200, along with insert earphones and surface and self-adhesive electrodes. Stimuli were delivered via ER 3A insert earphones with disposable foam ear plugs[5-7]. For cervical VEMP testing, participants remained seated in a chair in an acoustically treated area. The ground electrode was positioned on the forehead, and the active electrodes were placed on the right and left sternocleidomastoid muscles. The second-channel electrodes were positioned below the active electrodes, right and left, for surface electromyography recording, and the reference electrode was fixed to the sternum. Insert earphones were used to produce the stimulus via air conduction. Participants were instructed to perform lateral head rotation to the opposite side of the tested ear to capture the inhibitory response of muscle contraction. Impedance values below 5 kiloohms were accepted. A tone burst with an intensity initially tested at 95 dBnHL, 500 Hz, monaurally[8] was used as the auditory stimulus. For ocular VEMP, the active electrode was positioned in the infraorbital region, contralateral to the tested side, and the reference electrode was positioned just below the active electrode[8]. Participants were instructed to keep their heads upright and look upwards, to the point of maximum reach, during the presentation of the stimulus with the same characteristics as cVEMP[8]. The examination lasted approximately 15 minutes.

The v-HIT[9] used the Otometrics® ICS IMPULSE device to capture vestibulo-ocular reflex. Participants remained seated in a chair, 120 cm from the target, with the device mask properly fitted to their heads to minimize possible slippage. Short, rapid head movements were performed randomly to the right and left to assess the lateral canals. For the vertical canal assessment, the head was displaced 45° to the right of the median plane of the head, placing the left anterior and right posterior (LARP) canals on the same stimulation plane. Then, the head was positioned at the same angle to the left, evaluating the synergistic pair of the right anterior and left posterior SCCs (RALP)[9-11]. Unpredictable frequency and direction movements were performed, with low amplitude (10-20°), high acceleration (1,000-2,500°/s2) and speed (100-250°/s), as required in the equipment manual[9]. The examination lasted approximately 15 minutes.

The collected data were entered into an Excel spreadsheet and subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS), version 22.0. Initially, a descriptive analysis of the frequency of age and sex was performed. Variables of VEMP, v-HIT, BBS, VAS, and DHI were the continuous variables. The study analyzed measures of central tendency (mean and median), dispersion (standard deviation), and position (maximum and minimum) of the continuous variables. The normality of the variables was observed using the Kolmogorov-Smirnov test. The correlation was performed using Pearson's test, considering a 5% significance level ($p < 0.05$) in all analyses.

RESULTS

The sample age ranged from 60 to 89 years, with a mean of 74.04 years, and a higher prevalence of females (76.2%) than males (23.8%). As for the affected side, 23.8% had labyrinth hypofunction on the right, 21.4% on the left, and 54.8% had bilateral hypofunction. Overall, 28 (67%) abnormal tests were observed in the cVEMP, 37 (88%) in the oVEMP, and 32 (76%) in the v-HIT.

Regarding the vestibular, auditory, and sociodemographic characteristics reported in the research questionnaire, the following was observed: prevalence of systemic arterial hypertension (72%), dizziness after head movement (28%), duration of dizziness in seconds (36%), chronic dizziness in more than half of the sample (67%), hearing impairment on the left (30%), tinnitus in more than half of the sample (62%), prior use of antivertigo medication by almost half of the sample (48%), lived with family members (70%), performed activities of daily living (ADLs) alone (82%), and did not use polypharmacy (84%).

Table 1 shows the data from the cervical and ocular VEMP exams and v-HIT. It was found in cVEMP that the P13 latency values were above the expected bilaterally, as was the right N23 latency. However, the latency, response amplitude, and asymmetry index values in oVEMP were within normal limits. In v-HIT, reduced gain was observed in the right anterior and posterior canals. The anterior canals showed response asymmetry.

It is worth noting that 11.90% of individuals showed no response in the cVEMP on the left, 11.90% on the right, and 30.95% bilaterally. In the oVEMP, 7.14% showed no response on the left, 9.52% on the right, and 57.14% bilaterally. In the v-HIT examination, a higher percentage of covert corrective saccades was observed in the left (14.3%) and right (31.0%) posterior SCCs. The examination identified no saccades.

Table 2 shows the descriptive BBS, VAS, and DHI values. The mean VAS score was high, dizziness had a greater impact on the functional aspect of the DHI, and the sample was at risk of falls.

Table 3 shows the correlation between examinations with the scales and the questionnaire. The gain of the left lateral and posterior SCCs in the v-HIT test was negatively correlated with the VAS, indicating that the smaller the gain in the SCC, the greater the discomfort self-reported by the participant. The gain in the SCC was also positively correlated with BBS, showing that the smaller the gain in the right lateral, left anterior, and posterior SCCs, the greater the risk of falls. The lateral asymmetry index was negatively correlated with BBS, revealing that the greater the asymmetry between the lateral canals, the greater the risk of falls. The VEMP test found that the corrected cervical asymmetry index was negatively correlated with VAS, indicating that the greater the asymmetry of responses, the less the self-reported discomfort from dizziness. The DHI did not correlate with the tests.

Table 1. Descriptive data of latencies (ms), amplitude (uV), asymmetry index (uV), and corrected asymmetry index (uV) in the vestibular evoked myogenic potential test, semicircular canal gain (°/s), and asymmetry (%) in the Video Head Impulse Test

Cervical VEMP	Minimum	Maximum	Mean	Standard deviation
Left ear				
P13	13.86	23.33	16.19	2.47
N23	4.17	33.0	23.40	4.89
Amplitude	11.52	389.39	76.05	93.60
Right ear				
P13	12.50	22.17	16.38	2.06
N23	21.50	30.67	25.21	2.88
Amplitude	8.82	252.79	56.39	53.65
Asymmetry index	1.31	69.32	24.88	20.79
Corrected asymmetry index	2.63	55.16	23.55	18.57
Ocular VEMP				
Left ear				
P15	10.83	17.08	15.03	1.68
N10	7.82	17.33	11.07	2.17
Amplitude	0.84	26.48	3.76	6.90
Right ear				
P15	14.38	18.50	15.97	1.20
N10	10.00	11.83	10.83	0.54
Amplitude	0.97	8.14	2.7	1.95
Asymmetry index	7.69	92.93	23.91	26.50
Gain of the semicircular canals (°/s)				
Left lateral	0.10	1.16	0.84	0.21
Right lateral	0.01	1.29	0.93	0.23
Left anterior	0.07	1.15	0.82	0.21
Right anterior	0.02	1.14	0.69	0.25
Left posterior	0.06	0.86	0.65	0.17
Right posterior	0.01	0.88	0.62	0.19
Lateral asymmetry	0	90	12.95	14.53
Anterior asymmetry	1	97	21.38	21.34
Posterior asymmetry	0	69	15.39	14.41

Subtitle: VEMP = vestibular evoked myogenic potential; ms = milliseconds; uV = microvolts; º/s = degrees per second; % = percentage; P13 = latency peaking at 13 seconds; N23 = latency peaking at 23 seconds; P15 = latency peaking at 15 seconds; N10 = latency peaking at 10 seconds

Table 2. Descriptive data from the visual analog scale, the Berg Balance Scale, and the Dizziness Handicap Inventory

Scales and questionnaire	Minimum	Maximum	Mean	Standard deviation
VAS	2	10	7.27	2.18
DHI total	2	90	40.20	24.49
DHI physical	0	28	13.51	7.66
DHI functional	0	34	14.49	9.22
DHI emotional	0	36	12.24	10.44
BBS	4	56	43.21	11.72

Subtitle: VAS = visual analog scale; DHI = Dizziness Handicap Inventory; BBS = Berg Balance Scale

Table 3. Correlation between the vestibular evoked myogenic potential examination and the Video Head Impulse Test with the visual analog scale, Berg Balance Scale, and Dizziness Handicap Inventory

v-HIT	VAS	DHI total	DHI physical	DHI functional	DHI emotional	BBS
Left lateral	**-0.042**	0.562	0.170	0.627	-0.975	0.097
Right lateral	-0.184	0.841	0.296	0.825	-0.643	**0.003**
Right anterior	-0.285	-0.800	0.555	-0.852	-0.385	0.260
Left anterior	-0.234	0.581	0.670	-0.627	-0.234	**0.033**
Left posterior	**-0.028**	0.734	0.202	0.802	-0.738	**0.025**
Right posterior	**-0.028**	-0.864	0.666	0.960	-0.450	**0.023**
Lateral asymmetry	0.090	0.880	-0.586	0.927	0.530	**-0.030**
Anterior asymmetry	0.899	0.602	-0.621	-0.675	-0.652	0.776
Posterior asymmetry	0.424	0.711	-0.756	0.830	0.361	-0.265
Cervical VEMP						
Left P13	-0.366	-0.819	-0.691	-0.840	0.318	-0.316
Left N23	-0.127	-0.164	-0.267	-0.090	-0.334	0.257
Left amplitude	-0.884	0.637	0.496	0.617	0.868	-0.434
Asymmetry index	0.535	-0.983	0.786	0.890	-0.736	-0.893
Corrected asymmetry index	**-0.036**	-0.608	0.685	-0.304	-0.552	0.562
Right P13	-0.782	-0.880	-0.327	0.999	0.746	0.938
Right N23	-0.253	-0.919	-0.321	-0.958	0.628	0.519
Right amplitude	0.497	0.713	0.996	0.329	0.974	0.624
Ocular VEMP						
Left P15	-0.376	0.851	0.298	-0.982	-0.768	0.135
Left N10	-0.542	-0.266	-0.230	-0.250	-0.457	0.066
Left amplitude	-0.214	-0.845	0.690	-0.354	0.998	-0.556
Asymmetry index	-0.157	-0.760	0.860	-0.337	-0.927	-0.634
Right P15	-0.813	0.728	-0.926	0.416	0.847	0.673
Right N10	-0.675	0.437	0.387	0.229	0.794	0.660
Right amplitude	-0.145	-0.678	-0.272	-0.444	0.738	0.849

Pearson correlation test

Subtitle: v-HIT = Video Head Impulse Test; VEMP = vestibular evoked myogenic potential; VAS = visual analog scale; BBS = Berg Balance Scale; DHI = Dizziness Handicap Inventory; P13 = latency peaking at 13 seconds; N23 = latency peaking at 23 seconds; P15 = latency peaking at 15 seconds; N10 = latency peaking at 10 seconds

DISCUSSION

The correlation analysis revealed that the lower the gain in the SCCs, the greater the discomfort from dizziness self-reported by the participant in the VAS. This finding agrees with the literature, which reports greater discomfort from dizziness in individuals with vestibular dysfunctions(10-12,17). Changes in the gain of the SCCs lead to changes in the processing of information from the vestibular pathway, triggering dizziness(11,12,17,18). Dizziness is among the main causes of risk for falls in older adults, which demonstrates the importance of a detailed assessment of the vestibular system in individuals with dizziness(18-21).

The gain of the SCCs was positively correlated with BBS and negatively correlated with lateral asymmetry, indicating that the lower the gain of the SCCs and the greater the asymmetry of the lateral canals, the greater the risk of falls in these older adults. This finding confirms studies that report worse body balance results in older people with bilateral vestibular alterations(11,12,20,21). Changes in the proper functioning of the vestibular system are manifested through dizziness, which can impair postural control(18-21). Moreover, the corrected cervical asymmetry index was negatively correlated with the VAS, revealing that the greater the asymmetry value, the less discomfort caused by dizziness. This finding should be approached with caution, as the literature reviewed reports that higher asymmetry results in cVEMP indicate greater vestibular alterations and, consequently, worse dizziness symptoms(6-8,20). This finding may also be because 67% of older adults had chronic dizziness, and 48% had previously used anti-vertigo medication, which reflects a possible central compensation of symptoms, even with altered vestibular function(6-8,20). Another important detail is that VEMP only assesses the otolithic organs, which may not be as sensitive to predicting the risk of falls as the SCCs, assessed by v-HIT(18-21).

In the cervical VEMP examination, an increase in latencies was observed bilaterally in P16 and on the right in N23. The increase in response latencies is due to either changes in the saccular macula because of vestibular diseases or aging of the vestibular system(4,6,7,22). The high percentage of absence of response in oVEMP points to the possibility of alteration in otolithic organs (utricle), caused by vestibular diseases or aging(4,6,7,22). The amplitude of the vestibulo-ocular reflex is more subtle when compared to the vestibulo-cervical reflex assessed by cVEMP, due to differences in the musculature where the reflex is captured(4,6,7,20,22). Thus, the absence of response in the oVEMP can be caused by either vestibular diseases or the aging of the vestibular system, agreeing with the profile of the study sample, composed of older people with vestibular symptoms(4,6,7,20,22).

This study observed reduced gain in the right anterior, left posterior, and right posterior SCCs, in addition to a higher percentage of corrective saccades in the posterior SCCs. The literature confirms these data, indicating the presence of corrective saccades in SCCs with reduced gain(9-12,23). Alterations of the vestibular system are due to either vestibular diseases or the aging of the vestibular system(9-12,23). Studies that analyzed the gain of the SCCs with aging found that the lateral canals are the least affected by advancing age(9-12,23).

According to the scales and questionnaires, the sample presented a high degree of discomfort from dizziness, risk of falls, and impact of dizziness on quality of life; the functional aspect was the most affected. This information agrees with the literature, which found worse results on the scales and questionnaires in individuals with vestibular dysfunction(20,21,24). Dizziness directly impacts older people's functioning, since it generally reflects multifactorial health conditions resulting from the cumulative effect of deficits in multiple systems, causing greater vulnerability to falls(19-22). It is associated with depressive symptoms, impaired self-perception of health conditions, restricted participation in social activities, and limited ADL performance(19,20,22,24,25). Subjective assessment through self-perception of vestibular symptoms is an important tool, providing a broader view of the person's balance and the extent to which dizziness impacts various aspects of their life(13-15,20,23,25).

The lack of correlation between DHI and the tests can be explained by the difference between the self-perception of dizziness and the vestibular function response, since the tests cannot assess the emotional issues caused by dizziness(15,20,23,25). However, it is worth noting that the sample had a history of chronic vestibular diseases with possible central compensation.

The small number of participants in the sample stands out among the limitations of the study. This occurred because the study was conducted during the COVID-19 pandemic, when older people were considered a risk group. The reduced number of males in the sample is also evident, which can be explained by the prevalence of dizziness in females(21).

CONCLUSION

Reduced gain in the SCCs and greater asymmetry of the lateral SCCs in the v-HIT examination were correlated with a higher risk of falls and greater discomfort from self-reported dizziness.

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