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Effectiveness of vestibular rehabilitation on balance, dizziness, functioning, and depressive symptoms in older adults

Efetividade da reabilitação vestibular no equilíbrio, tontura, funcionalidade e sintomas depressivos em idosos

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ABSTRACT

Purpose: To assess the effectiveness of vestibular rehabilitation on functioning, gains in semicircular canals in the Video Head Impulse Test (v-HIT), on responses to the vestibular evoked myogenic potentials (VEMP), depressive symptoms, balance, and dizziness in older adults. **Methods:** Longitudinal, quasi-experimental, analytical study conducted between December 2019 and July 2022, in 50 older adults with vestibular disorders, submitted to vestibular rehabilitation and examinations: VEMP, v-HIT, the questionnaires, visual analog scale, Dizziness Handicap Inventory, Berg Balance Scale, Pfeffer's Functional Activities Questionnaire, and Geriatric Depression Scale. All examinations and questionnaires were applied before and after eight weekly vestibular rehabilitation sessions. Statistical analysis was performed in SPSS, with the Wilcoxon test (p<0.05). **Results:** There was a gain in the anterior right semicircular canal (0.71/0.78), reduction in dizziness discomfort (7/5) and in the impact of dizziness on the quality of life (35/15), improvement in balance (45/51) and functioning (2/1), and reduction in depressive symptoms (5/3). **Conclusion:** Older adults with vestibular disorder submitted to vestibular rehabilitation improved their gain in vestibulo-ocular reflex, balance, and functional activities and reduced their depressive symptoms and the impact of dizziness on their quality of life.

Keywords: Postural balance; Dizziness; Aged; Rehabilitation; Quality of life

RESUMO

Objetivo: Avaliar a efetividade da reabilitação vestibular na funcionalidade, ganho dos canais semicirculares ao *Video Head Impulse Test* (v-HIT), nas respostas ao *Potencial Evocado Miogênico Vestibular* (VEMP), sintomas depressivos, equilíbrio e tontura em idosos. **Métodos:** Estudo longitudinal, quase experimental e analítico, realizado entre dezembro de 2019 e julho de 2022, com 50 idosos com disfunção vestibular, submetidos à reabilitação vestibular e à aplicação dos exames VEMP, v-HIT, dos questionários e escalas *Escala Visual Analógica*, *Dizziness Handicap Inventory* e *Escala de Equilíbrio de Berg*, além do Questionário de Atividades Funcionais de Pfeffer e Escala de Depressão Geriátrica. Todos os exames e questionários foram aplicados antes e após oito sessões semanais de reabilitação vestibular. A análise estatística foi realizada pelo programa SPSS, por meio do teste Wilcoxon (p<0,05). **Resultados:** Observou-se melhora do ganho do canal semicircular anterior direito (0,71/0,78), redução do incômodo da tontura (7/5), do impacto da tontura na qualidade de vida (35/15), melhora do equilíbrio (45/51), além de melhora da funcionalidade (2/1) e redução dos sintomas depressivos (5/3). **Conclusão:** Idosos com disfunção vestibular submetidos à reabilitação vestibular apresentaram melhora do ganho do reflexo vestíbulo-ocular, do equilíbrio, da funcionalidade, redução do impacto da tontura na qualidade de vida e dos sintomas depressivos.

Palavras-chave: Equilíbrio postural; Tontura; Idoso; Reabilitação; Qualidade de vida

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INTRODUCTION

The vestibular system comprises the saccule and utricle otolith organs (which are responsible for detecting linear head movements) and semicircular canals (sensitive to angular head movements)[1,2]. It interacts with the proprioceptive system through the vestibulospinal reflex (VSR) and with the visual system through the vestibulo-ocular reflex (VOR), maintaining body posture and nitid retinal images even when the head is moving[1,2].

The vestibular evoked myogenic potential (VEMP) can be used to assess the labyrinth in detail, addressing the said otolith organs along with the two portions of the vestibular nerve. It can also be assessed with the Video Head Impulse Test (v-HIT), which individually assesses all semicircular canals at high frequencies[3-5]. Together, these examinations can detect vestibular system disorders[3-5].

Changes in the vestibular system manifest as dizziness, defined as a mistaken perception of body or environment movement[6,7]. Dizziness is characterized by instability, fluctuation, falling sensation, and gait changes (when it is not rotatory), and it is called vertigo[6,7] when it is rotatory. In older adults, it usually reflects multifactorial health conditions that result from cumulative deficit effects in multiple systems, making them more vulnerable to falls[8-10]. It is associated with depressive symptoms, impaired self-perceptive assessments of health conditions, and limited participation in social activities[8,9]. The literature points out that older adults with vestibular diseases have a high prevalence of depressive and/or anxiety symptoms, affecting their quality of life and highlighting persistent negative feelings toward dizziness[8]. Vestibular disorders must be treated to reduce dizziness and improve postural balance and quality of life[11-13].

The main ways to treat dizziness and vertigo are the use of medication, surgical resources, and vestibular rehabilitation (VR)[11]. VR is a speech-language-hearing clinical method that aims at vestibular compensation and habituation through neuronal plasticity, thus improving spatial orientation and overall balance and, consequently, the patient's quality of life[12-15]. Its effectiveness has been proven, and it can completely cure 30% of individuals and provide different degrees of improvement in 85% of them[15]. Benefits include improved static and dynamic postural balance (and therefore reduced imbalance) and decreased depression and anxiety symptoms, as individuals manage to eliminate the negative symptoms they had due to dizziness episodes[11-15]. Hence, they increase their self-confidence and quality of life[14-16].

The literature lacks studies that investigate functioning and depressive symptoms in older adults submitted to VR. Most research focuses on quality-of-life assessments and dizziness questionnaires[8,9,11-16]. Hence, the present study aimed to assess VR effectiveness to improve functioning, gains in semicircular canals in v-HIT, VEMP responses, and balance and decreased depressive symptoms in older adults with vestibular disorders.

METHODS

This longitudinal, quasi-experimental, analytical study was conducted between December 2019 and July 2022 at the Speech-Language-Hearing Functional Health Observatory of the Medical School at the Federal University of Minas Gerais (OSF/UFMG). The procedures were approved by the UFMG Research Ethics Committee under CAAE no. 49714221.0.0000.5149.

The sample comprised 50 older adults residing in Belo Horizonte, MG, Brazil, and in its metropolitan area. It included individuals aged 60 years or above, with peripheral vestibulopathy verified with vestibular tests (VEMP or v-HIT), who voluntarily agreed to participate in the study and signed an informed consent form. The Otorhinolaryngology Service at the São Geraldo Hospital (UFMG Clinics Hospital) referred selected individuals to the Speech-Language-Hearing Outpatient Service, due to the vestibular disorder confirmed with caloric tests, regardless of an otoneurologic diagnosis. They were waiting for the beginning of VR treatment at the Speech-Language-Hearing Outpatient Service.

The study excluded participants with a diagnostical hypothesis of benign paroxysmal positional vertigo (BPPV), outer ear changes (verified with otoscopy), conductive hearing loss (verified with acoustic immittance measures), self-reported cervical rotation difficulties, mental disorders, self-reported severe sensory impairment, and those who did not complete all VR sessions proposed by researchers.

Procedures

The assessment, treatment, and reassessment were conducted by the same researcher because of the restrictions imposed by the COVID-19 pandemic. All older adults were immunized and did not have COVID-19 during their participation in the research. The whole assessment battery was conducted on a single day, in an acoustically treated room. Participants remained seated in the tests, except for the balance scale.

All participants answered the research questionnaire to collect sociodemographic data and information on vestibular and auditory symptoms. The otoscopy was performed with a Mikatos® otoscope; acoustic immittance was measured with Otoflex 100 Otometrics® equipment; and audiometry was conducted with Itera II-Otometrics® equipment. The vestibular function and body balance were assessed with the following tests: Dizziness Handicap Inventory (DHI) – Brazilian version[17], dizziness/vertigo visual analog scale (VAS)[18], and Berg Balance Scale (BBS)[19]. Depressive symptoms were assessed with the Geriatric Depression Scale-Short Form (GDS-15)[20], and functioning was assessed with Pfeffer's Functional Activities Questionnaire[21]. The questions were read aloud to research participants, except for those in Pfeffer's questionnaire, which were answered by their companion, when possible.

VEMP was examined with the auditory evoked potential equipment manufactured by Otometrics®, model ICS Chartr EP 200. For cervical VEMP (cVEMP), participants remained seated on a chair in an acoustically treated room. Their skin was first cleaned with an abrasive paste where the electrodes would be placed. The ground electrode was placed on the forehead; the active electrodes, on the right and left sternocleidomastoid muscles; and the reference electrode, on the sternum. Insert earphones were placed in the participants' ears to produce air-conduction tone-burst stimuli at 95 dBHL, keeping electrode impedance below 5 kOhms[3].

Ocular VEMP (oVEMP) was examined with the same parameters as cVEMP, except that the ground electrode was placed on the forehead; the active electrodes, on the infraorbital region contralateral to the tested side; and the reference electrode, right below the active one on the ipsilateral side of the records[3]. Participants remained seated, their heads upright, and looking forward at a minimum angle of 30° until the end of the sound stimuli.

V-HIT examination used ICS IMPULSE equipment manufactured by Otometrics® to pick up VOR. Participants remained seated on a chair, 120 cm away from the target positioned at eye level, and the goggle elastic band well-fitted to their heads to minimize possible slides[4]. After calibrating the eye positioning signal, they were instructed to fix their eyes on a target on the wall while the examiner conducted the head impulses in the specific stimulation planes of the six semicircular canals. The frequency and direction of the movements were unpredictable, made with low amplitude (10-20°) and at high acceleration (1,000-2,500°/s^2) and speed (100-250°/s), as required by the equipment handbook[4].

Dizziness was treated with an individual 8-session VR program, with one session a week lasting 10 to 15 minutes, following the method proposed by Cawthorne and Cooksey (individualized and personalized). It consists of static and dynamic balance and oculomotor exercises, aiming at the vestibular system compensation and habituation[22,23]. Participants were instructed to do the proposed exercise at home, at least once a day, for 10 to 15 minutes. They also received control sheets to monitor the home exercises. The degree of difficulty of the exercises gradually changed, according to each person's weekly progress. After VR, participants were again submitted to tests and vestibular questionnaires, DHI, VAS, BBS, VEMP, v-HIT, GDS-15, and Pfeffer. Five older adults withdrew from the treatment and did not complete the eight VR sessions. Thus, the final study sample comprised 45 subjects.

Statistical analysis

Collected data were recorded in an Excel table and submitted to statistical analysis with the Statistical Package for the Social Sciences (SPSS), version 22.0. Initially, a descriptive analysis of the frequency of categorical variables (age and sex) was performed to describe the sample, presented as absolute (n) and relative frequencies (%). The measures of central tendency (mean and median), dispersion (standard deviation), and position (maximum and minimum) of the continuous variables were also analyzed.

The normality of the variables was verified with the Shapiro-Wilk test. They did not have a normal distribution and received adequate statistical treatment with nonparametric tests. Pre-VR and post-VR variables were compared using the Wilcoxon test, setting the significance level at 5% ($p < 0.05$).

RESULTS

The participants' ages ranged from 60 to 86 years, with a mean of 73.86 (±7.41); 82% of them were females, and 18% were males. regarding the vestibular deficit, there was a greater prevalence of bilateral disorder (66%), followed by right-side (20%) and left-side disorder (14%). According to the mean auditory data, the sample had bilateral mild sensorineural hearing loss, with a speech recognition threshold of 34.36 dBHL in the right ear and 34.11 dBHL in the left ear, and a monosyllable speech recognition index of 88.66% in the right ear and 86.58% in the left ear.

There was a prevalence of systemic arterial hypertension (72%); dizziness after head movement (28%), dizziness lasting for a few seconds (36%); auditory difficulties in the left ear (30%). More than half of the participants had tinnitus (62%); almost half of them had taken antivertigo drugs before VR (48%). They lived with their families (70%), performed activities of daily living independently (82%), and did not use polypharmacy (84%).

Participants with VEMP responses had normal values according to those suggested by the literature for older adults. On the other hand, in v-HIT, the sample presented hypofunction in the anterior right and posterior right and left semicircular canals. In DHI, the dizziness had a greater impact on the quality of life, with higher scores in the functional aspect, and BBS revealed that the sample was at risk of falls. The sample was independent and had few depressive symptoms.

There was a higher percentage of covert compensatory saccades in posterior canals: 14.3% on the right and 36.6% on the left side. In cVEMP, responses were absent in 28 (56%) individuals on the left and 26 (52%) on the right side, while in oVEMP, they were absent in 43 (86%) individuals on the left and in 42 (84%) on the right.

Table 1 presents descriptive VEMP examination data, and Table 2 shows v-HIT examination, scales, and vestibular questionnaire data.

There was no difference in c-VEMP and o-VEMP examinations. However, the gain improved in the anterior right semicircular canal in v-HIT, the dizziness discomfort (VAS) and the impact of dizziness on the quality of life (DHI) decreased, the balance improved (EEB), the depressive symptoms decreased (GDS-15)

Table 1. Descriptive data of the cervical and ocular vestibular evoked myogenic potential examinations

Cervical VEMP	Mean (standard deviation)	Minimum	Maximum
Right ear			
P13	16.24 (2.41)	13.86	26.33
N23	24.58 (2.67)	20.50	33.00
Amplitude	67.83 (86.39)	11.52	389.39
asymmetry index	25.90 (19.85)	1.31	69.32
Corrected asymmetry index	26.54 (20.14)	2.63	66.34
Left ear			
P13	16.19 (2.02)	12.50	22.17
N23	25.00 (2.94)	20.83	31.00
Amplitude	52.15 (50.33)	8.82	252.79
Ocular VEMP			
Right ear			
P15	14.93 (1.69)	10.83	16.50
N10	11.12 (2.37)	7.82	17.33
Amplitude	4.29 (7.42)	0.97	26.48
Asymmetry index	26.94 (29.67)	7.69	92.93
Left ear			
P15	16.29 (1.06)	14.83	18.53
N10	10.91 (0.70)	10.00	12.33
Amplitude	2.91 (1.91)	0.97	8.14

Subtitle: VEMP = vestibular evoked myogenic potentials; P13 = positive peak latency; N23 = negative peak latency; P15 = positive peak latency; N10 = negative peak latency

Table 2. Descriptive data of the Video Head Impulse Test, visual analog scale, Dizziness Handicap Inventory, balance, functioning, and depressive symptoms examination before the intervention

v-HIT	Mean (standard deviation)	Minimum	Maximum
Lateral left	0.85 (0.19)	0.10	1.16
Lateral right	0.92 (0.23)	0.01	1.29
Anterior left	0.81 (0.22)	0.07	1.19
Anterior right	0.71 (0.26)	0.02	1.15
Posterior left	0.67 (0.19)	0.60	0.98
Posterior right	0.62 (0.19)	-0.01	0.92
Lateral asymmetry	11.71 (13.71)	0	90
Anterior asymmetry	19.62 (20.37)	0	97
Posterior asymmetry	15.93 (15.00)	0	69
VAS	7.30 (2.18)	2	10
DHI Total	39.56 (22.91)	6	90
Physical	13.40 (7.26)	0	28
Functional	14.04 (8.74)	0	34
Emotional	12.12 (9.82)	0	36
BBS	44.02 (9.17)	11	56
Pfeffer	3.44 (4.13)	0	14
GDS-15	5.32 (3.00)	0	11

Subtitle: v-HIT = Video Head Impulse Test; VAS = visual analog scale; DHI = Dizziness Handicap Inventory (Brazilian version); BBS = Berg Balance Scale; Pfeffer = Pfeffer's Functional Activities Questionnaire; GDS-15 = Geriatric Depression Scale

and the functioning improved (Pfeffer). The pre-VR and post-VR comparison is described in Tables 3 and 4.

One participant's gain in semicircular canals before and after VR is shown in Figures 1 and 2. It improved in the anterior right and posterior left semicircular canals; the symmetry between the canals improved as well.

DISCUSSION

The functioning improved with the treatment, confirming the literature, which points out the improved quality of life and functioning in individuals submitted to VR[12-16]. Consequently, the depressive symptoms decreased, demonstrating that most older adults with dizziness have emotional symptoms. Hence, when dizziness is diminished or eliminated through VR, the negative symptoms associated with it decrease, improving their quality of life[24,25].

Another possibility that may have contributed to this outcome was the older adults' contact with another environment and other people, receiving treatment during the COVID-19 pandemic – during which they remained isolated. None of the subjects was undergoing psychological treatment during VR. However, after they had finished the eight sessions, those with depressive symptoms were referred to the psychology service in a reference primary healthcare service.

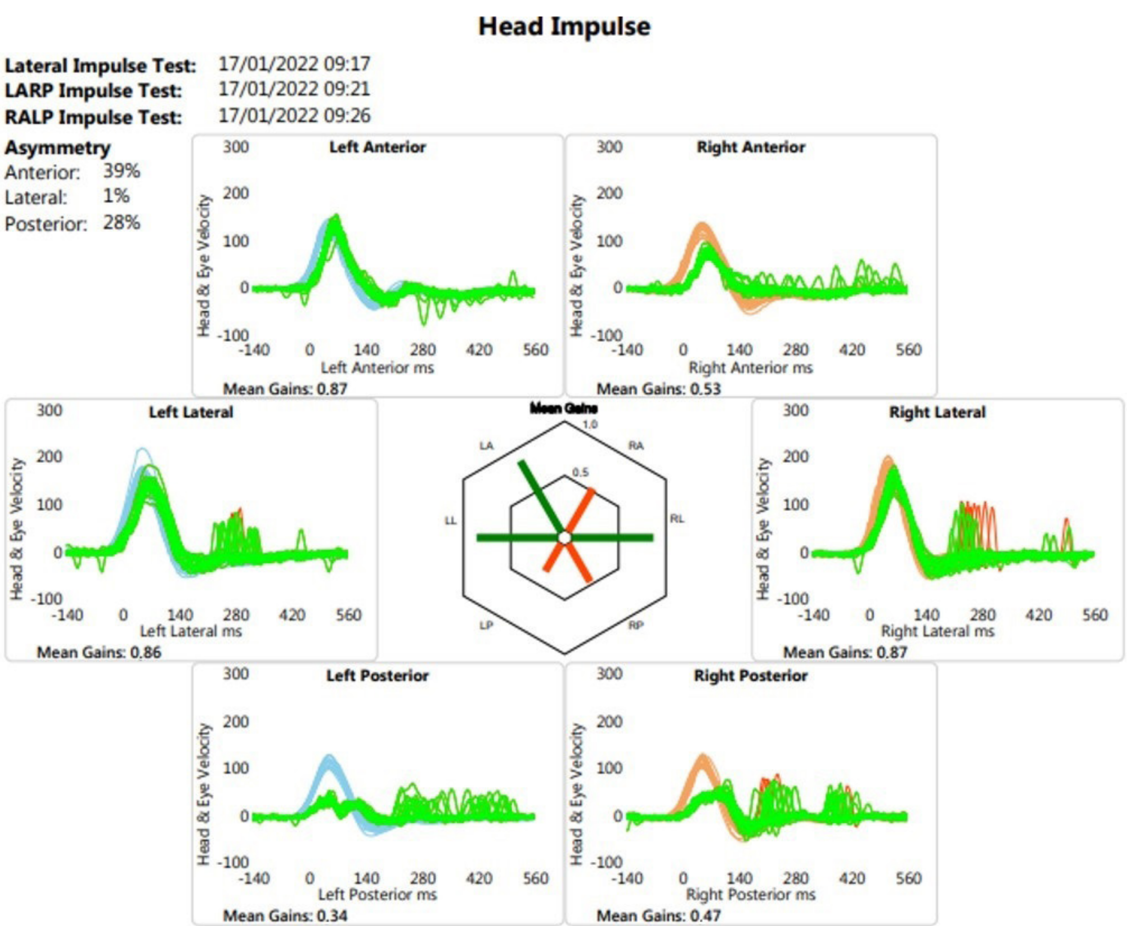

Figure 1. Gains in semicircular canals before vestibular rehabilitation

Table 3. Difference between parameters of cervical and ocular vestibular evoked myogenic potentials before and after vestibular rehabilitation

Cervical VEMP	Before VR			After VR			p-value*
	Median	Q_1	Q_3	Median	Q_1	Q_3	
Left P13	15.33	15.17	15.33	15.83	14.74	15.83	0.310
Left N23	23.67	22.83	23.67	24.33	22.16	24.33	0.752
Left amplitude	42.13	17.21	42.13	30.65	16.99	30.65	0.063
Asymmetry index	20.87	10.64	20.87	30.73	19.89	30.73	0.686
Corrected asymmetry index	20.29	9.69	20.29	27.77	15.75	27.77	0.893
Right P13	16.00	14.95	16.00	16.67	16.17	16.67	0.799
Right N23	24.50	22.70	24.50	25.17	22.67	25.17	0.878
Right amplitude	44.10	15.74	40.10	26.26	9.00	11.42	0.959
Ocular VEMP							
Left P15	15.50	14.67	15.50	15.29	13.50	15.29	0.273
Left N10	10.92	10.00	10.92	11.42	9.29	11.42	1.000
Left amplitude	2.11	1.10	2.11	2.93	1.46	2.93	0.144
Asymmetry index	17.91	9.27	17.21	20.78	2.11	20.78	0.655
Right P15	16.25	15.33	16.25	15.75	13.92	15.75	0.581
Right N10	10.67	10.50	10.67	10.50	9.50	10.50	1.000
Right amplitude	2.31	1.60	2.31	3.12	1.55	3.12	0.068

*Wilcoxon test

Subtitle: VR = vestibular rehabilitation; VEMP = vestibular evoked myogenic potentials; Q = quartile; P13 = positive peak latency; N23 = negative peak latency; P15 = positive peak latency; N10 = negative peak latency

Table 4. Difference between gains in semicircular canals, asymmetry, visual analog scale, Dizziness Handicap Inventory, balance, functioning, and depressive symptoms before and after vestibular rehabilitation

v-HIT	Before VR			After VR			p-value*
	Median	Q_1	Q_3	Median	Q_1	Q_3	
Lateral left	0.85	0.81	0.89	0.87	0.82	0.87	0.969
Lateral right	0.92	0.87	0.97	0.97	0.88	0.97	0.479
Anterior left	0.81	0.73	0.84	0.84	0.75	0.84	0.343
Anterior right	0.71	0.57	0.74	0.78	0.67	0.78	**0.041**
Posterior left	0.72	0.58	0.72	0.73	0.58	0.73	0.252
Posterior right	0.66	0.51	0.66	0.71	0.55	0.71	0.116
Lateral asymmetry	11.71	4.00	9.50	13.00	6.00	13.00	0.318
Anterior asymmetry	13.00	7.00	13.00	12.00	7.00	12.00	0.371
Posterior asymmetry	12.00	6.00	12.00	8.00	4.00	8.00	0.213
VAS	7.00	6.00	7.00	5.00	3.00	5.00	**0.000**
DHI Total	36.00	20.00	37.00	15.00	6.00	15.00	**0.000**
DHI Physical	14.00	8.00	14.00	2.00	0.00	2.00	**0.000**
DHI Functional	12.00	8.00	12.00	8.00	4.00	8.00	**0.000**
DHI Emotional	8.00	4.00	8.00	3.00	0.00	3.00	**0.000**
BBS	45.00	40.00	45.00	54.00	51.00	54.00	**0.000**
Pfeffer	5.00	3.00	5.00	3.00	1.25	3.00	**0.000**
GDS-15	2.00	0.00	2.00	1.00	0.00	1.00	**0.007**

*Wilcoxon test

Subtitle: VR = vestibular rehabilitation; v-HIT = Video Head Impulse Test; Q = quartile; VAS = visual analog scale; DHI = Dizziness Handicap Inventory (Brazilian version); BBS = Berg Balance Scale; Pfeffer's Functional Activities Questionnaire; GDS-15 = Geriatric Depression Scale

VEMP responses did not improve after VR. On the other hand, the anterior right semicircular canal had increased VOR gain in v-HIT after VR, which agrees with the literature(25). The improvement in only this semicircular canal may be explained by the few individuals in the study sample, as it does not provide robust data on vestibular gain. This may also be explained by post-VR central postural balance compensation due to neuroplasticity(11,12,15,16). The central compensation could not be measured with the examinations used in this research, as they assessed the peripheral vestibular system(3-5).

Nevertheless, individuals improved their balance and decreased the impacts of dizziness on the quality of life, confirming the literature, which reports better postural results and improved quality of life after VR(14-16,24-28). It must be highlighted that there is a difference between vestibular system examination and dizziness self-perception(21). Thus, despite the lack of significant changes in the physical labyrinth examination, the sample presented decreased self-perceived dizziness results and improved balance, due to central compensation(11,12,15-17).

The sample's mean VEMP latencies, amplitudes, and asymmetry indices were normal for older adults. However, more than half of them had absent responses, which agrees with the sample's profile in this study – i.e., individuals with peripheral vestibular disorder(3,5). This finding agrees with the literature,

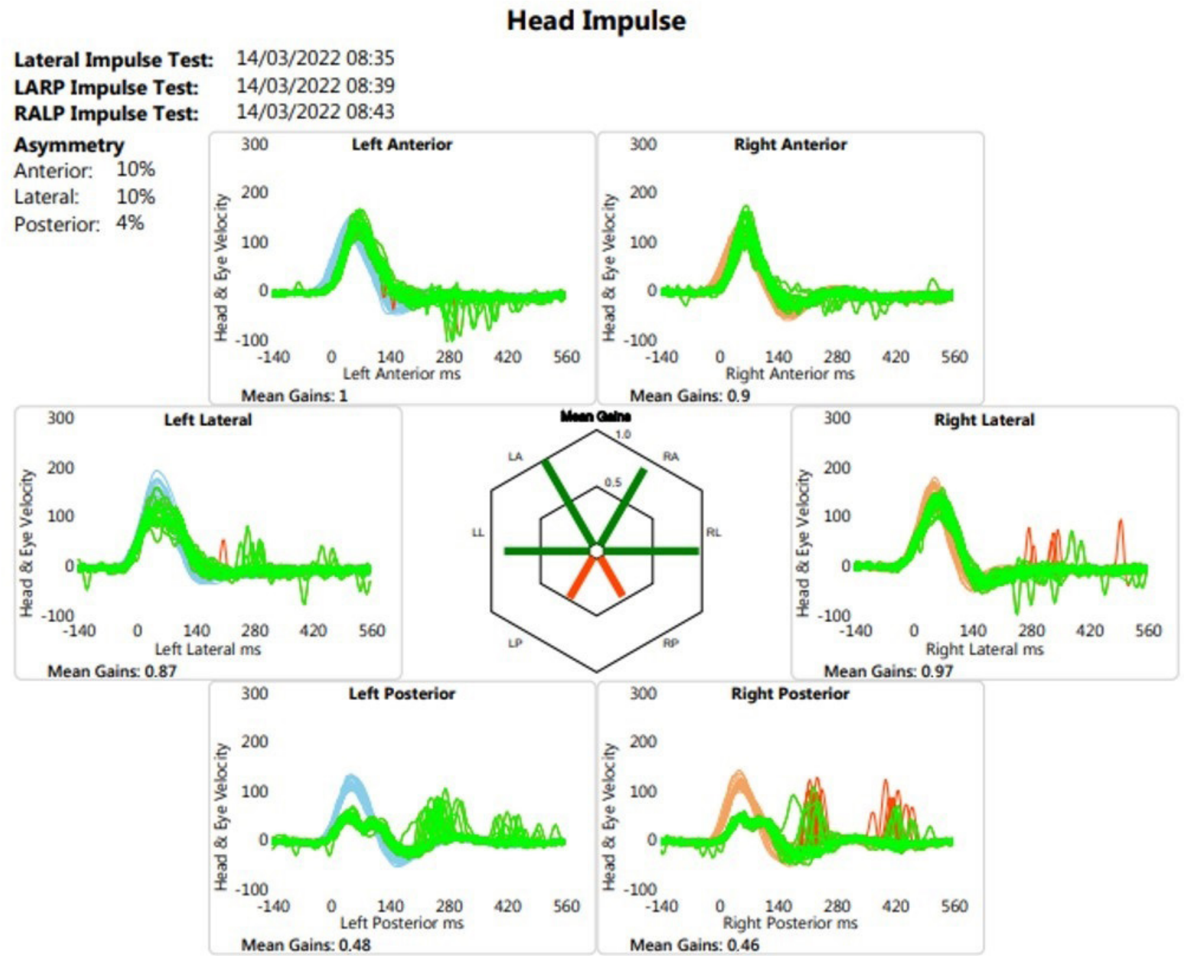

Figure 2. Gains in semicircular canals after vestibular rehabilitation

which states that absent VEMP responses indicate changes in otolith organs and the vestibular nerve, which may therefore cause dizziness and imbalance[3,5]. There was also reduced gain in anterior right and posterior right and left semicircular canals, with compensatory saccades. This agrees with the literature, which reports such saccades in individuals with semicircular canal hypofunction[4,29].

According to DHI, the dizziness had a greater impact on the sample's functional and physical aspects; BBS also indicated they were at risk of falls[17,18]. These data reinforce the hypothesis that vestibular disorders affect older adults' quality of life and expose them to a risk of falls – one of the main causes of morbimortality and traumas in this population[17,18,30].

The limitations of this study include the impossibility of blinding the evaluator before and after VR, as it was the researcher who assessed, treated, and reassessed the older adults. This occurred because researchers were careful not to expose the older adults to contact with more people, as the research took place during the COVID-19 pandemic and the older adults are considered a risk group. Other limitations were the small sample and the lack of companions on the part of some participants to answer Pfeffer's Functional Activities Questionnaire. Five older adults withdrew from the treatment because they had difficulties attending the outpatient center, as they were from a low-income population, and some lived in another city. The researchers tried to contact them to resume treatment, but they could not be reached. Furthermore, it was difficult to control home VR exercises. This bias was minimized by giving the subjects and/or companions a control sheet to take notes of the frequency of VR exercises.

CONCLUSION

After VR, VOR gain, balance, and functioning improved and the impact of dizziness on the quality of life and the depressive symptoms of the older adults decreased.

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