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ARTICLES

Cognitive skills in older people with vestibular dysfunction undergoing vestibular rehabilitation – A pilot study

Habilidades cognitivas em idosos com disfunção vestibular submetidos à reabilitação vestibular – estudo piloto

Habilidades cognitivas en ancianos con disfunción vestibular en rehabilitación vestibular – estudio piloto

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Abstract

Introduction: Studies have reported improved cognitive skills after vestibular rehabilitation (VR). However, they used cognitive screening tests or other ones that assess specific cognitive skills, not assessing cognition in detail. **Objective:** To assess cognitive skills, depressive symptoms, functioning, and sociodemographic aspects in older adults with vestibular dysfunction before and after vestibular rehabilitation. **Method:** Longitudinal, analytical, quasi-experimental study. The sample had 11 older adults aged 60 to 89 years, of both sexes, all of them with vestibular dysfunction verified with VEMP and/or vHIT examination. Participants were submitted to cognitive, functioning, and depressive symptoms assessment before and after eight weekly VR sessions. **Results:** MMSE was associated with educational attainment and DHI; the Pfeffer questionnaire was correlated with DHI; GDS-15 was correlated with VAS and BBS. After VR, there were improvements in gain in the right anterior semicircular canal, VAS, DHI and its physical, functional, and emotional subscales, GDS-15, and Neupsilin total score and

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its perception, memory, and praxis subscales. **Conclusion:** After VR, the vestibulo-ocular reflex gain increased, the impacts of dizziness on the quality of life and the psychological suffering decreased, and the overall cognitive function and perception, memory, and praxis skills improved.

Keywords: Cognition; Rehabilitation; Aged; Postural Balance; Dizziness

Resumo

Introdução: estudos relatam melhora de habilidades cognitivas após a reabilitação vestibular, porém estes estudos utilizaram testes de rastreio cognitivo ou avaliaram habilidades cognitivas específicas, não contemplando uma avaliação cognitiva detalhada. **Objetivo:** avaliar as habilidades cognitivas, sintomas depressivos, funcionalidade e aspectos sociodemográficos de idosos com disfunção vestibular antes e após a reabilitação vestibular. **Método:** estudo longitudinal, quase experimental e analítico. A casuística foi composta por 11 idosos com idade entre 60 e 89 anos, ambos os sexos, todos com disfunção vestibular comprovada por meio dos exames VEMP e/ou v-HIT. Os participantes foram submetidos à avaliação cognitiva, da funcionalidade e dos sintomas depressivos antes e após oito sessões semanais de RV. **Resultados:** encontrou-se associação entre o MEEM com a escolaridade e com o DHI; o questionário de Pfeffer correlacionou-se com o DHI; a GDS-15 com a EVA e a EEB. Após a RV observou-se melhora do ganho do canal semicircular anterior direito, da EVA, do DHI e suas subescalas físico, funcional e emocional; GDS-15, Neupsilin total e suas subescalas percepção, memória e praxia. **Conclusão:** após a reabilitação vestibular houve aumento do ganho do reflexo vestíbulo-ocular, diminuição dos impactos causados pela tontura na qualidade de vida e do sofrimento psicológico, além da melhora da função cognitiva geral e das habilidades de percepção, memória e praxia.

Palavras-chave: Cognição; Reabilitação; Idoso; Equilíbrio Postural; Tontura

Resumen

Introducción: los estudios informan mejoría en las habilidades cognitivas después de la rehabilitación vestibular, pero estos estudios utilizaron pruebas de detección cognitiva o evaluaron habilidades cognitivas específicas, no contemplando una evaluación cognitiva detallada. **Objetivo**: evaluar habilidades cognitivas, síntomas depresivos, funcionalidad y aspectos sociodemográficos de ancianos con disfunción vestibular antes y después de la rehabilitación vestibular. **Método**: estudio longitudinal, cuasi-experimental y analítico. La casuística estuvo constituida por 11 ancianos con edades entre 60 y 89 años, de ambos sexos, todos con disfunción vestibular comprobada mediante exámenes VEMP y/o v-HIT. Los participantes se sometieron a una evaluación de síntomas cognitivos, funcionales y depresivos antes y después de ocho sesiones semanales de rehabilitación vestibular. **Resultados**: se encontró asociación entre el MMSE con la educación y con el DHI; el cuestionario de Pfeffer correlacionó con el DHI; el GDS-15 con el EVA y el EEB. Después de la RV, hubo una mejora en la ganancia del canal semicircular anterior derecho, la EVA, el DHI y sus subescalas física, funcional y emocional; GDS-15, Neupsilina total y sus subescalas percepción, memoria y praxis. **Conclusión**: después de la rehabilitación vestibular, hubo aumento en la ganancia del reflejo vestíbulo-ocular, disminución de los impactos causados por el mareo en la calidad de vida y el sufrimiento psicológico, mejoría en la función cognitiva general y en las habilidades de percepción, memoria y praxis.

Palabras clave: Cognición; Rehabilitación; Anciano; Equilibrio Postural; Mareo

Introduction

Dizziness is a manifestation of changes in the vestibular system and an important cause of falls in older adults. Falls, in their turn, are the main cause of morbimortality and fatal and nonfatal traumas among older people[1]. Moreover, the imbalance is associated with a partial and total incapacity to perform occupational, social, and family activities, increased physical and psychological damage, loss of self-confidence, depression, and deficit in concentration and performance, significantly impacting the quality of life of individuals with changes in the vestibular system[1,2].

The vestibular system interacts with various cognitive functions, including processes of spatial navigation, spatial perception, body representation, mental images, attention, memory, risk perception, and social cognition[3,4]. The visuospatial function is the most studied neurocognitive domain in individuals with vestibular dysfunctions[3,4,5]. The vestibular function involves neural connections of the vestibular nucleus with limbic and cortical areas related to both spatial memory and other cognitive functions[3,4,5,6]. In the last years, various studies have demonstrated an association between vestibular dysfunction and cognitive impairment, confirmed with neuroimaging tests that reveal hippocampal atrophy and impairment in spatial navigation tasks in individuals with bilateral vestibular changes[3,6]. In its turn, cognitive impairment is an important risk factor for changes in motor performance and body balance[3,7,8,9]. Hence, it is necessary to treat vestibular dizziness in older adults[9,10].

Vestibular rehabilitation (VR) is a method based on static and dynamic balance and oculomotor exercises that stimulate the vestibular system through the vestibulospinal and vestibulo-ocular pathways with central neuroplasticity mechanisms[10,11]. It also promotes vestibular compensation with activities aimed at vestibulovisual interaction during head movements, increasing static and dynamic postural stability, and stimulating the labyrinth, sight, and proprioception in conditions that produce conflicting sensory information[10,11,12,13]. VR is indicated in patients with peripheral or central vestibular changes and older people with multisensory impairment[9,10,11]. It is the most used method to treat dizziness and has proved to effectively improve postural balance and prevent falls. VR also has indirect benefits, reducing symptoms of depression and anxiety and increasing self-confidence and quality of life[11,12,13].

Studies that assessed cognition in individuals with vestibular changes before and after VR found significantly improved overall cognition, visuospatial capacity, attention, spatial working memory, executive function, dizziness indices, and psychological suffering[14,15,16,17,18]. Other benefits were also found, with improved posturography parameters and increased vestibulo-ocular reflex (VOR) gain and hand coordination after the treatment[16,17]. However, these studies used only cognitive screening tests or other ones that assess specific cognitive skills, not assessing cognition in detail[14,15,16,17,18]. Thus, the present study aimed to assess the cognitive skills, depressive symptoms, functioning, and sociodemographic aspects in older adults with vestibular dysfunction before and after VR.

Method

This pilot longitudinal quasi-experimental analytical study was conducted between December 2019 and March 2020 at the Speech-Language-Hearing Functional Health Observatory of the Medical School at the Federal University of Minas Gerais (UFMG). The study sample was selected by convenience, comprising subjects who were waiting for treatment at the Speech-Language-Hearing Outpatient Center of the UFMG Clinics Hospital, which is a reference center for individuals with vestibular dizziness in Belo Horizonte and its metropolitan area.

This study included individuals aged 60 or more years with peripheral vestibular dysfunction, confirmed with absent or abnormal latency, amplitude, and symmetry in vestibular evoked myogenic potentials (VEMP) responses and VOR gain lower than 0.75 in the Video Head Impulse Test (vHIT), who voluntarily agreed to participate in the study and signed an informed consent form. Participants with a suspected diagnosis of benign paroxysmal positional vertigo (BPPV), outer ear changes verified with otoscopy, conductive hearing loss verified with acoustic immittance and audiometry, self-reported neck rotation difficulties, diagnosed dementia, mental disorder, or self-reported severe sensory impairment, or who did not attend all VR sessions proposed by the researchers were excluded from the study.

Procedures

Sociodemographic data and dizziness characteristics were collected with a research questionnaire. After the clinical assessment, the diagnosis of vestibular dysfunction was confirmed with vestibular tests (VEMP and/or vHIT). All participants were submitted to auditory assessment in an acoustically treated room. Otoscopy was performed with a Mikatos® otoscope; acoustic immittance, with Otoflex 100, by Otometrics®; and audiometry, with Itera II, by Otometrics®.

Before the intervention, the vestibular function and body balance were assessed with the following tests: the Dizziness Handicap Inventory (DHI) – Brazilian version[19], dizziness/vertigo visual analog scale (VAS)[20], Berg Balance Scale (BBS)[21], cervical and ocular VEMP[22], and vHIT[23] (using ICS-impulse®, by Otometrics®).

Cognitive assessment was performed with the Mini-Mental State Examination (MMSE)[24]; the Neupsilin Brief Neuropsychological Test[25], to assess temporospatial orientation, focused attention, visual perception, memory, arithmetic skills, oral and written language, ideomotor, constructive, and reflexive praxis, and executive functions; the Pfeffer Functional Activities Questionnaire[26], to assess functioning, and the 15-item Geriatric Depression Scale (GDS-15), to assess depressive symptoms[27].

Dizziness was treated with a personalized VR program with eight 20-minute weekly sessions, based on the method proposed by Cawthorne and Cooksey[11,12], in which the degree of difficulty is gradually increased. After VR, participants were again submitted to the vestibular questionnaires and tests (DHI, VAS, and BBS), vestibular examinations (VEMP and vHIT), and the cognitive assessment battery (MMSE, Neupsilin, GDS-15, and Pfeffer). Due to the COVID-19 pandemic, only seven participants could attend all VR sessions and comprise the final research sample. The assessment, treatment, and reassessment were carried out by the same researcher, who had been trained to avoid exposing older adults to contact with other people because of the COVID-19 pandemic. Subjects with impaired visual acuity wore correction lenses during the vestibular and cognitive tests.

Ethical considerations

All participants, after being informed of the study procedures, signed an informed consent form. The procedures of this research were approved by the UFMG Ethics Committee under no. CAAE 56877316.1.0000.5149 (complying with Resolution 466/12, of the National Health Council).

Statistical analysis

The analysis addressed the frequency of age and sex and the measures of central tendency (mean and median), dispersion (standard deviation), and position (maximum and minimum) of the variables, in SPSS, version 22.0. To describe the sample, the categorical variables were presented in absolute (n) and relative frequency (%). The Kolmogorov-Smirnov test verified the distribution of the variables, the Wilcoxon test compared the variables before and after VR, and the Spearman test was used for correlation analysis. The variables with correlation ≤ 0.02 were selected for multivariate linear regression analysis. The level of significance was set at 5% ($p < 0.05$).

Results

The sample had 11 older adults aged 60 to 89 years, with a mean of 69.6 years (± 8.72 years); eight participants were females (73%). They attended school for a mean of 4 years (±3.46 years). The clinical and sociodemographic characteristics of the sample are described in Table 1.

Table 1. Clinical and sociodemographic characteristics of the sample.

Underlying disease	**n**	**%**
Systemic arterial hypertension	8	73
Diabetes	3	27
Glaucoma	2	18
Abnormal cholesterol	1	10
Osteoporosis	1	10
Vestibular dysfunction		
Right	4	36
Left	3	28
Bilateral	4	36
Dizziness characteristics		
After movement	4	36
Spontaneous	4	36
When standing up	2	18
When reading	1	10
Dizziness duration		
Seconds	6	54
Minutes	4	36
Hours	1	10
Auditory difficulties		
Right	2	18
Left	1	10
Bilateral	1	10
Tinnitus		
Yes	4	36
No	7	64
Physical activity		
Yes	5	45
No	6	55
Live alone		
Yes	4	36
No	7	64

Table 2 shows the vestibular, cognitive, functioning, and depressive symptoms assessment results before the intervention. Only six participants (54%) had cervical and ocular VEMP responses, which were normal for their age. All semicircular canals had decreased VOR gain. Also, MMSE and Neupsilin values were below the expected for the mean age and educational attainment of the sample.

Table 2. Descriptive data of vestibular examinations and scales and cognitive tests (n = 11).

Examinations and scales	Mean	Standard deviation	Median	Minimum	Maximum
Cervical VEMP					
Left P13	15.72	1.07	15.67	14.00	17.67
Left N23	23.37	1.52	23.17	20.50	25.17
Left amplitude	53.22	39.19	43.15	11.52	115.33
Right P13	16.33	2.62	16.17	12.50	22.17
Right N23	24.31	2.84	23.33	21.83	30.67
Right amplitude	43.07	34.15	48.42	8.82	113.66
Asymmetry index	22.18	22.03	15.42	1.31	69.32
Corr. asymmetry index	20.54	18.49	11.58	2.86	53.54
Ocular VEMP					
Left P15	14.37	1.83	14.67	10.83	16.580
Left N10	11.18	2.82	10.29	7.82	17.33
Left amplitude	1.93	1.25	1.31	0.86	4.21
Right P15	15.51	0.87	15.33	14.42	16.92
Right N10	10.76	0.62	10.58	10.00	11.83
Right amplitude	1.88	0.57	1.89	1.02	2.60
Asymmetry index	16.08	6.16	16.95	8.51	23.64
vHIT					
Left lateral	0.65	0.28	0.79	0.10	0.87
Right lateral	0.49	0.33	0.84	0.01	1.03
Left anterior	0.73	0.32	0.85	0.07	1.07
Right anterior	0.64	0.25	0.73	0.13	1.04
Left posterior	0.54	0.24	0.58	0.06	0.82
Right posterior	0.50	0.25	0.54	0.01	0.73
VAS	8.27	1.95	9.00	5.00	10.00
DHI total	28.00	20.72	20.00	8.00	74.00
DHI physical	11.14	6.91	10.00	2.00	22.00
DHI functional	13.42	8.30	12.00	6.00	26.00
DHI emotional	10.57	10.30	6.00	0.00	26.00
BBS	41.91	18.20	49.00	4.00	56.00
MMSE	22.27	18.41	22.00	19.00	28.00
Neupsilin	116.82	135.16	108.00	91.00	165.00
Orientation	7.14	3.47	8.00	3.00	8.00
Attention	11.00	11.03	5.00	1.00	24.00
Perception	10.85	4.14	9.00	8.00	20.00
Memory	28.00	15.59	27.00	8.00	48.00
Arithmetic skills	3.00	3.31	2.00	0.00	8.00
Oral language	19.42	1.61	20.00	17.00	22.00
Written language	21.00	10.18	24.00	0.00	29.00
Praxis	9.57	2.50	9.00	6.00	12.00
Executive functions	3.42	1.27	4.00	1.00	5.00
GDS-15	5.00	3.22	4.00	1.00	11.00
Pfeffer	4.45	7.11	2.00	0.00	14.00

Caption: VEMP: vestibular evoked myogenic potentials; Corr.: corrected; vHIT: Video Head Impulse Test; VAS: Visual Analog Scale; DHI: Dizziness Handicap Inventory; BBS: Berg Balance Scale; MMSE: Mini-Mental State Examination; Neupsilin: Brief Neuropsychological Assessment Instrument; GDS-15: Geriatric Depression Scale; Pfeffer: Pfeffer Functioning Scale.

Table 3 presents the correlation between cognitive and vestibular tests. The cognitive screening test was significantly correlated with educational attainment and the dizziness questionnaire; functioning was significantly correlated with the dizziness questionnaire; and depressive symptoms were significantly correlated with the degree of dizziness discomfort and imbalance. The sex, type of vestibular dysfunction, and VEMP and vHIT responses were not correlated with the cognitive tests.

Table 3. Multivariate analysis of vestibular tests and cognitive tests variables.

Vestibular and cognitive tests	Coefficient B	Standard error	Confidence interval	p-value*
MMSE				
Education	0.67	0.18	0.26; 1.09	**0.006**
DHI	-0.10	0.30	-0.17; -0.04	**0.008**
Pfeffer				
DHI	0.32	0.04	0.22; 0.41	**-0.001**
GDS-15				
VAS	1.01	0.12	0.73; 1.28	**-0.001**
BBS	-0.08	0.02	-0.13; -0.03	**0.006**

*Multivariate analysis. Adjusted R square: MMSE = 0.862; Pfeffer = 0.852; GDS-15 = 0.912. Caption: MMSE: Mini-Mental State Examination; DHI: Dizziness Handicap Inventory; Pfeffer: Pfeffer Functioning Scale. GDS-15: Geriatric depression Scale; VAS: Visual Analog Scale; BBS: Berg Balance Scale.

Seven participants finished the treatment and were reassessed. The final sample comprised five women (71%) and two men (29%), whose ages ranged from 60 to 89 years, with a mean of 77.71 years (± 9.30 years). School attendance ranged from 1 to 11 years, with a mean of 3.85 years (± 3.57 years). Three individuals had vestibular dysfunction on the left side (43%), one on the right side (14%), and three on both (43%).

After VR, the gain in the right anterior semicircular canal improved significantly, the dizziness discomfort decreased, the impact of dizziness on the quality of life decreased in three aspects (physical, functional, and emotional), depressive symptoms diminished, the overall cognition improved (according to Neupsilin), and the perception, memory, and praxis skills also improved (Table 4). There was no significant change in VEMP responses after the treatment.

Figures 1 and 2 illustrate the overall cognition improvement verified with Neupsilin.

Table 4. Difference between vestibular and cognitive variables before and after vestibular rehabilitation, n = 7 (p <= 0.05).

	Before VR			After VR			p-value*
Variable	**Median**	**Q1**	**Q3**	**Median**	**Q1**	**Q3**	
Cervical VEMP							
Left P13	15.25	14.29	16.35	15.50	14.92	16.21	0.715
Left N23	23.67	22.41	24.91	22.84	21.67	24.50	0.102
Left amplitude	57.29	18.37	108.32	45.50	6.96	99.64	0.068
Right P13	16.17	16.00	16.92	16.50	14.33	17.00	0.715
Right N23	23.25	22.33	25.17	24.92	22.83	26.25	0.465
Right amplitude	35.03	12.32	59.34	24.88	15.42	47.06	0.715
Asymmetry index	33.08	28.31	51.20	24.06	23.43	41.13	0.109
Corr. asymmetry index	9.74	6.30	31.64	16.67	15.94	36.01	0.108
Ocular VEMP							
Left P15	14.08	13.00	14.83	15.50	14.67	17.67	0.225
Left N10	10.42	10.00	12.67	11.58	10.17	13.83	0.893
Left amplitude	1.10	0.89	2.06	3.08	1.85	3.79	0.078
Right P15	15.08	14.75	15.33	16.08	14.87	16.25	0.596
Right N10	10.67	10.58	10.87	10.50	10.00	11.66	1.000
Right amplitude	1.58	1.30	1.86	1.55	1.34	2.56	1.000
Asymmetry index	9.27	8.89	13.59	4.63	2.95	17.54	1.000
vHIT							
Left lateral	0.79	0.42	0.81	0.79	0.58	0.87	0.345
Right lateral	0.84	0.52	0.98	0.82	0.36	1.05	0.799
Left anterior	0.87	0.62	0.95	0.84	0.71	0.87	0.799
Right anterior	0.71	0.57	0.74	0.81	0.65	0.85	**0.018**
Left posterior	0.56	0.52	0.59	0.67	0.58	0.76	0.127
Right posterior	0.54	0.50	0.70	0.71	0.45	0.74	0.108
VAS	10.00	7.00	10.00	2.00	2.00	6.00	**0.027**
DHI total	22.00	18.00	60.00	12.00	4.00	32.00	**0.018**
DHI physical	10.00	6.00	18.00	0.00	0.00	6.00	**0.046**
DHI functional	12.00	6.00	24.00	4.00	4.00	12.00	**0.018**
DHI emotional	6.00	4.00	24.00	2.00	0.00	12.00	**0.042**
BBS	49.00	10.00	56.00	56.00	47.00	56.00	0.109
GDS-15	6.00	3.00	10.00	2.00	1.00	4.00	**0.027**
MMSE	22.00	19.00	25.00	26.00	19.00	28.00	0.074
Pfeffer	3.00	0.00	10.00	2.00	0.00	10.00	0.109
Neupsilin	108.00	93.00	158.00	131.00	95.00	175.00	**0.028**
Orientation	8.00	7.00	8.00	8.00	8.00	8.00	0.317
Attention	5.00	1.00	23.00	11.00	1.00	23.00	0.462
Perception	9.00	9.00	11.00	9.00	8.00	10.00	**0.046**
Memory	27.00	15.00	48.00	37.00	15.00	55.00	**0.027**
Arithmetic skills	2.00	0.00	6.00	5.00	0.00	8.00	0.144
Oral language	20.00	18.00	20.00	20.00	17.00	21.00	0.317
Written language	24.00	19.00	29.00	23.00	20.00	29.00	0.336
Praxis	9.00	7.00	12.00	12.00	10.00	16.00	**0.027**
Executive functions	4.00	3.00	4.00	4.00	3.00	6.00	0.102

*Wilcoxon test. Caption: VR: vestibular rehabilitation; VEMP: vestibular evoked myogenic potentials; Corr.: corrected; vHIT: Video Head Impulse Test; VAS: Visual Analog Scale; DHI: Dizziness Handicap Inventory; BBS: Berg Balance Scale; MMSE: Mini-Mental State Examination; GDS-15: Geriatric Depression Scale; Pfeffer: Pfeffer Functioning Scale; Neupsilin: Brief Neuropsychological Assessment Instrument.

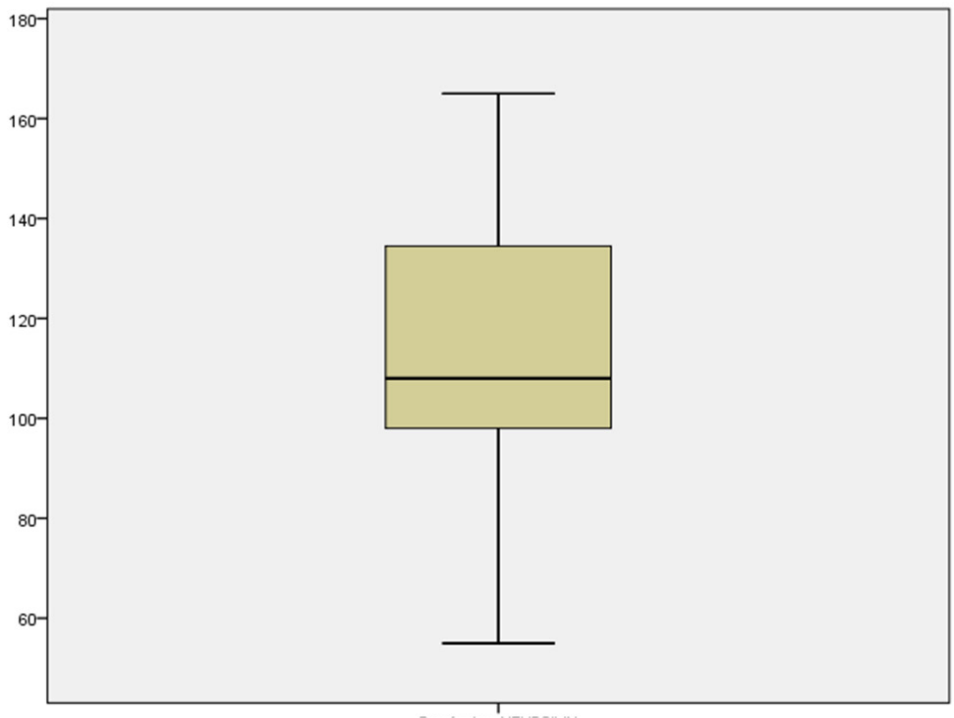

Figure 1. Neupsilin boxplot before the intervention.

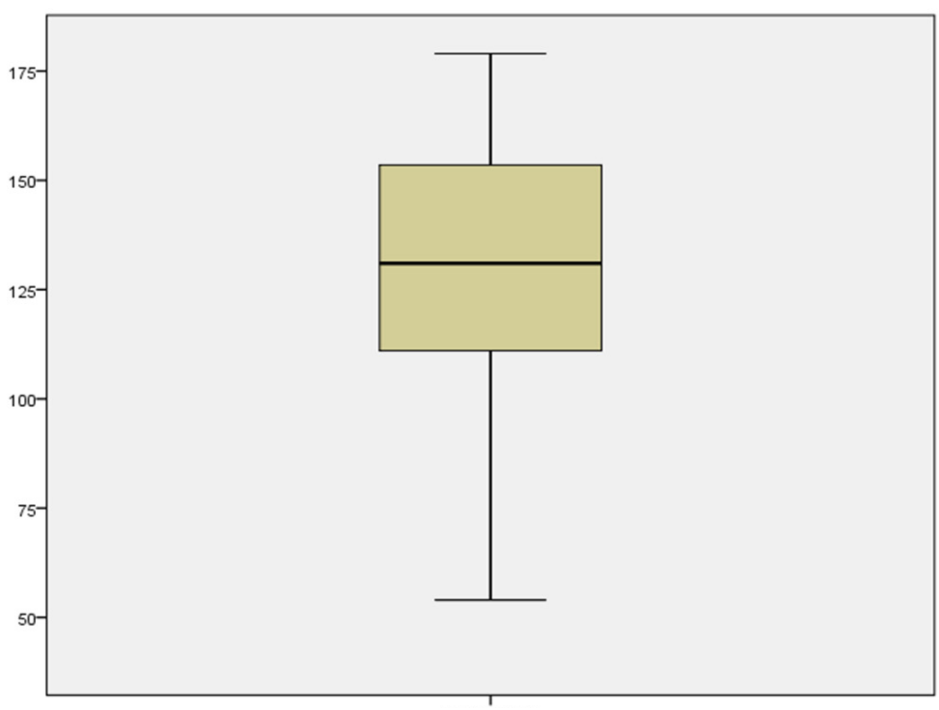

Figure 2. Neupsilin boxplot after the intervention.

Discussion

Among the neurocognitive domains assessed before and after VR, there were improvements in overall cognition and specifically in perception, memory, and praxis. Improvements in these cognitive domains agree with studies that found improved overall cognitive functions, visuospatial functions, spatial working memory, executive functions, attention, and eye and hand coordination[14,16,18]. It is important to point out that perception and praxis skills work together with visuospatial function and memory, as cognitive skills do not work separately. The visuospatial function and memory are activated during VR exercises[6,8,9]. Thus, improvements in these skills can be explained by the relationship between the vestibular system and cognitive areas such as the hypothalamus because when the vestibular pathway is activated, central vestibular areas – and therefore cognitive skills – are stimulated[3,4,5,6,14,15,16,17,18].

The overall cognition was correlated with educational attainment, demonstrating that the longer the time spent in school, the better the cognitive results[28]. Educational attainment is a determining factor in cognitive assessment, which may be justified by the hypothesis that education has protective effects on the cognitive reserve[28]. The overall cognition of the sample was negatively correlated with the dizziness questionnaire, agreeing with the literature that found worse cognitive results in individuals with greater imbalance[3,7,8,28,29] – which reinforces the relationship between imbalance and cognitive impairment. The values in the cognitive profile of the sample are below the expected for the educational attainment[24,25].

Depressive symptoms diminished after VR, reinforcing the findings of a study that used the depression scale to assess this item[15]. There is a correlation between dizziness and emotional symptoms; therefore, when dizziness is treated, negative feelings related to it also decrease, maximizing older people's perception of their quality of life[1,2,28,29,30]. Participants with greater imbalance reported more depressive symptoms, confirming the findings of studies that found an association between imbalance and emotional factors[1,2,28,29,30]. Depressive symptoms are correlated with dizziness discomfort because it negatively interferes with the quality of life, causing psychological suffering[1,2,28,29,30].

The functioning in the sample was correlated with the dizziness questionnaire, revealing that the greater the impact of dizziness on older adults' quality of life, the lower their degree of independence. This corroborates the literature that reports the impact of dizziness on older people's functioning, which increases the risk of falls in this population[3,7,8,29]. The sample of this study was classified as independent, due to the heterogeneity of the group, with subjects of different ages and functioning[26].

BBS, DHI, and VAS data collected in the assessment indicate the degree of imbalance and the impact of dizziness on the quality of life of the sample subjects, affecting emotional, functional, and physical aspects. These results agree with the literature that demonstrates the impact of imbalance and dizziness on the quality of life[19,20,21]. DHI has excellent reliability and is the most used questionnaire in the national and international literature because it identifies the influence of dizziness on functional, physical, and emotional aspects[19].

After VR, VOR increased in the right anterior canal, corroborating the study that found increased gain in the semicircular canals after treating dizziness[16]. Also, dizziness discomfort and its impacts on the quality of life decreased, agreeing with the literature[16,17,18]. The decreased impacts of dizziness and increased gain in the semicircular canals confirm VR effectiveness in symptom reduction, vestibular compensation, and quality of life[11,12,28,29]. There were no changes in VEMP responses after the treatment, as vestibular compensation occurs through central neuroplasticity mechanisms[10,11,28,29], not assessed by this examination (which provides only peripheral data of the vestibular system. Thus, VR must go beyond dizziness symptoms, aiming to benefit postural balance and, indirectly, emotional health and cognition.

The limitations of this study include the few older adults who could attend all eight VR sessions proposed by the researchers – nonetheless, it must be pointed out that this is a pilot study. The absence of examiner blinding due to limitations imposed by the COVID-19 pandemic also compromised the results of this study. Further studies with larger samples are needed to confirm or contrast the findings of the present one.

Conclusion

In this pilot study, older people's cognition was associated with educational attainment and the impact of dizziness on the quality of life. Functioning and psychological suffering in the sample were correlated with the impact of dizziness on the quality of life and body balance. After VR, older adults' VOR increased in the right anterior semicircular canal, the impact of dizziness on the quality of life decreased, the overall cognition, perception, memory, and praxis improved, and the psychological suffering diminished.

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