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ORIGINAL RESEARCH

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The effect of self-management vestibular rehabilitation on persistent postural-perceptual dizziness

Chisato Fujimoto MD, PhD[1] | Mineko Oka MD[1] | Kentaro Ichijo MD[1] | Makoto Kinoshita MD, PhD[1] | Teru Kamogashira MD, PhD[1] | Keiko Sugasawa MD, PhD[1] | Takuya Kawahara MPH, PhD[2] | Tatsuya Yamasoba MD, PhD[1]

[1]Department of Otolaryngology and Head and Neck Surgery, Graduate School of Medicine, The University of Tokyo, Bunkyo-ku, Tokyo, Japan

[2]Clinical Research Promotion Center, The University of Tokyo Hospital, Bunkyo-ku, Tokyo, Japan

Correspondence
Chisato Fujimoto, Department of Otolaryngology and Head and Neck Surgery, Graduate School of Medicine, The University of Tokyo 7-3-1, Hongo, Bunkyo-ku, Tokyo 113-8655, Japan.
Email: cfujimoto-tky@umin.ac.jp

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Abstract

Objective: To investigate the effects of self-management vestibular rehabilitation (VR) on the subjective symptoms of dizziness and postural stability in persistent postural-perceptual dizziness (PPPD).

Study design: Retrospective case review.

Methods: The medical records of 30 patients newly diagnosed with PPPD based on the Bárány Society's diagnostic criteria were reviewed. Nineteen patients (4 males and 15 females; age range 27–84 years, mean age ± standard deviation 57.4 ± 14.2 years) who was newly instructed to self-management VR were included and instructed to perform self-management VR for 2 months.

Results: One patient did not visit the outpatient clinic again, and in the remaining 18 patients, 4 (22%) discontinued VR at their own discretion. In the 12 patients who completed 2 months of VR (67%), there was a significant improvement in Niigata PPPD Questionnaire (NPQ) and Dizziness Handicap Inventory (DHI) scores after VR compared to those before VR ($p < .05$). However, the mean velocity of center of pressure (COP) movement (velocity) and the envelopment area traced by COP movement (area), as well as the Romberg ratio and foam ratio of velocity and area, did not differ significantly after VR when compared to those before VR ($p > .05$).

Conclusions: For PPPD, self-management VR improved subjective symptoms of dizziness, but not stability of standing posture. It is necessary to improve patients' adherence to the treatment.

Level of evidence: 4.

KEYWORDS
dizziness, posture, rehabilitation, self-management, self-report

1 | INTRODUCTION

Persistent postural-perceptual dizziness (PPPD) is a chronic functional disorder in which one or more symptoms of dizziness, unsteadiness, or non-spinning vertigo are present most days for 3 months or more.[1] These symptoms are exacerbated by upright posture, active or passive movement, and exposure to moving visual stimuli or complex visual patterns. PPPD is precipitated by preceding conditions that cause balance disorder. Many of its clinical features have been described under different diagnostic names such as phobic postural vertigo,[2] space-motion discomfort,[3] visual vertigo,[4] and chronic subjective dizziness.[5,6] PPPD is a novel clinical entity that integrates these previous concepts. It was added to the 11th of International Classification of Diseases beta draft (ICD-11 beta draft), and a consensus document of the Bárány Society with its diagnostic criteria was published in 2017.[1]

PPPD is a relatively new disease concept, and there is still no treatment with a high level of evidence for PPPD. However, vestibular rehabilitation (VR), along with selective serotonin reuptake inhibitors (SSRIs) and serotonin–norepinephrine reuptake inhibitors (SNRIs), and cognitive-behavioral therapy (CBT), has recently been advocated as a promising treatment method.[1] Its efficacy has been reported in various clinical studies.[7–11]

In general, VR can be performed in a medical institution or at home. Although home-based methods basically require patient self-management, self-management rehabilitation seems to be important in situations where access to medical resources is difficult for patients. An example of such a situation is when the patients' residence is far from a medical institution making it difficult for them to visit it. Another example is the impact of the spread of COVID-19, which has caused patients to feel uncomfortable about visiting medical institutions and medical institutions to limit the number of patients who can visit.[12] Yet another example is that in countries where vestibular rehabilitation as an outpatient treatment is not covered by insurance, such as Japan, the number of medical institutions that can provide adequate programs is limited.

In the present study, we conducted a preliminary investigation of the effects of self-management VR on the subjective symptoms of dizziness and postural stability in PPPD. The diagnostic criteria for PPPD state that the duration of disease should be at least 3 months. In this study, the duration of self-management VR was set to 2 months in order to determine whether a shorter rehabilitation period than the duration of the disease would be effective. Since the dizziness symptom of PPPD is exacerbated by standing posture, we used posturography to assess the effect of self-management VR on standing postural stability. Since the dizziness symptom of PPPD is also exacerbated by visual stimuli, we considered the possibility that the dependence on visual and/or somatosensory inputs in postural control may change and decided to investigate the dependence on visual and somatosensory inputs in standing posture using foam posturography.

TABLE 1 Specific examples of habituation exercises.

1. Standing or walking without support.
2. Sitting upright in a seat without back or arm support.
3. Performing any movement that would aggravate the patient's dizziness.
4. Looking at books or mobile electronic devices.
5. Using a computer.
6. Watching television.

2 | METHODS

2.1 | Research ethics

The present study was approved by Research Ethics Committee of Graduate School of Medicine and Faculty of Medicine at the University of Tokyo (2487) and was conducted in accordance with the tenets of the Declaration of Helsinki. Since data were collected retrospectively from medical records, written informed consent was waived.

2.2 | Study design and subjects

Medical records were reviewed for 30 newly diagnosed PPPD cases at the Department of Otolaryngology, Head and Neck Surgery, The University of Tokyo Hospital between November 2019 and December 2021. We diagnosed these patients with PPPD based on the diagnostic criteria of the Bárány Society.[1] Five were prioritized for treatment of recurrent preceding conditions causing balance disorders. Three had already performed VR. One wanted to be treated with SSRI. One wanted to be treated with cognitive behavioral therapy. One did not want to be treated with PPPD. Excluding these 11 patients, 19 patients (4 males and 15 females; age range 27–84 years, mean age ± standard deviation 57.4 ± 14.2 years) were instructed to perform self-management VR.

2.3 | Procedures

As for VR, the doctors verbally explained the method to the patient at the outpatient clinic. Each patient was instructed to perform adaptive exercises in a sitting posture, reaching forward and moving their head from side to side and up and down while gazing at their thumb (VOR x1 exercises). Detailed instructions regarding the speed, frequency, and displacement of head movements were not given, but the patient was instructed to perform them at a level that would make the load less painful. The patients were also instructed to perform habituation exercises, in which they repeated movements that aggravated their dizziness. For the movements that aggravated their dizziness in habituation exercises, active movement and exposure to visual stimuli that can be incorporated into rehabilitation were extracted from the factors that aggravate dizziness, which were interviewed in detail from each patient. Specific examples of habituation exercises were shown

TABLE 2 Clinical characteristics of PPPD patients who completed the 2-month self-management VR program and those who did not.

Age (years)	Sex	Preceding balance disorders	Disease duration	NPQ scores		DHI scores		Reason for discontinuation
				Before VR	After VR	Before VR	After VR	
Patients who completed 2 months of VR								
42	F	Probable MD	13 months	58	8	54	4	
43	M	Positional vertigo	6 months	39	37	70	52	
45	F	Spontaneous vertigo	7 months	29	12	34	12	
45	F	Probable MD	2 years	33	17	54	52	
52	F	Definite MD	3 months	32	16	24	30	
53	F	BPPV	10 months	57	10	64	44	
54	F	Definite MD	11 months	18	2	30	6	
57	F	Positional vertigo	10 months	46	48	46	38	
60	F	DEH	3 months	43	51	75	52	
62	M	BPPV	9 months	48	Not completed	70	Not completed	
71	F	VN	6 months	44	28	30	22	
77	F	VBI	3 months	28	10	50	60	
Patients who did not complete 2 months of VR								
27	F	BPPV	3 months	37		Not completed		Scoliosis
49	F	Positional vertigo	8 months	43		48		Self-determination
60	M	VBI	8 months	35		52		Self-determination
64	F	VN	11 months	43		72		Self-determination
72	F	MdDS	6 years	34		56		Self-determination
74	F	Head trauma	2 years	33		50		Lower extremity surgery

Abbreviations: BPPV, benign paroxysmal positional vertigo; DEH, delayed endolymphatic hydrops; DHI, Dizziness Handicap Inventory; F, female; M, male; MD, Meniere's disease; MdDS, Mal de Debarquement Syndrome; NPQ, Niigata PPPD Questionnaire; PPPD, persistent postural-perceptual dizziness; VBI, vertebrobasilar insufficiency; VR, vestibular rehabilitation; VN, vestibular neuritis.

in Table 1. These exercises were instructed to be performed as much as possible every day for 2 months under their own supervision. The Niigata PPPD Questionnaire (NPQ)[13] and the Japanese version of the Dizziness Handicap Inventory (DHI)[14] were used to assess subjective symptoms of dizziness. The NPQ is a questionnaire developed based on the three exacerbating factors (upright posture/walking, movement, and visual stimulation) of PPPD. The NPQ consists of 12 questions regarding these exacerbating factors and evaluates the degree of symptoms. For evaluation of postural stability, we used posturography was used to assess postural stability. The NPQ, DHI, and posturography were tested before and 2 months after VR. For patients taking SSRIs, benzodiazepines, sleep medications, and medications used for dizziness at the start of VR, those who changed, added, or discontinued medications during the VR program were considered dropouts.

2.4 | Posturography

Instantaneous fluctuations of the center of pressure (COP) were obtained at a sampling frequency of 20 Hz using a Gravicorder G-620 (Anima, Tokyo, Japan) with or without foam rubber. The material of the foam rubber was made of natural rubber, with a tensile strength of 2.1 kgf/cm^2, an elongation stretch percentage of 110%, a density of 0.06 g/cm^3, and a thickness of 3.5 cm. The sway path of COP was calculated from these data. Two-legged stance tasks were performed under four conditions: eyes open without foam rubber, eyes closed without foam rubber, eyes open with foam rubber and eyes closed with foam rubber.[15] The distal ends of the toes were placed 45° apart with the heels of both feet close together. The recording time was 60 s or until the subject needed assistance to prevent falling. In the eyes-open condition, the subjects were asked to watch a small red circle 2 m away from the subject's standing position. Two outcome measurements were made: the mean velocity of COP movement over 60 s (velocity) and the envelopment area traced by COP movement (area). The Romberg's ratio was defined as the ratio of a measured value with the eyes closed to that with the eyes open. The Romberg's ratio for both velocity and area, with and without the foam rubber were calculated. The foam ratio was defined as the ratio of a measured value with the foam rubber to that without the foam rubber. The foam ratio for both velocity and area, with the eyes open and closed were calculated. The Romberg's ratio and the foam ratio may reflect dependence on visual and somatosensory perception in maintaining an upright posture, respectively.

TABLE 3 NPQ and DHI scores before and after VR in PPPD patients.

	Before VR		After VR			
	Mean	SD	Mean	SD	*p* (a)	*p* (b)
NPQ score	39.8	12.5	21.7	16.8	.0101*	.0114*
Upright posture/walking	10.5	5.7	5.7	6.7	.0366*	.0366*
Movement	12.5	5.0	5.8	5.8	.0031**	.0066**
Visual stimulation	14.8	4.8	9.3	5.8	.0189*	.0087**
DHI score	48.3	17.2	33.8	20.2	.0166*	.0209*

Abbreviations: DHI, dizziness handicap inventory; NPQ, Niigata PPPD questionnaire; PPPD, persistent postural-perceptual dizziness; SD, standard deviation; VR, vestibular rehabilitation.
*$p < .05$.**$p < .01$ (a) = paired sample *t*-test, (b) = Wilcoxon signed-rank test.

2.5 | Statistics

Comparisons between before and after VR in NPQ score, DHI score and the values of each parameter of posturography were made using paired sample *t*-test and Wilcoxon signed-rank test, and $p < .05$ was considered significant. JMP Pro 16 (SAS Institute, Cary, NC) was used for all analyses.

3 | RESULTS

Of the 19 patients who were instructed to perform self-management VR, one did not visit the outpatient clinic again. Of the remaining 18 patients (3 males and 15 females; age range 27–77 years, mean age ± standard deviation 55.9 ± 13.1 years, Table 2), none changed, added, or discontinued SSRIs, benzodiazepines, sleeping pills, or medications used for dizziness during the VR program. Four (22%) felt bothered by having to perform VR and discontinued it at their own discretion. One (5%) gave up continuing VR due to scoliosis. One (5%) was admitted to the orthopedic department for lower extremity surgery, which interrupted VR. Twelve patients (67%) completed 2 months of VR. The preceding balance disorders in the 12 PPPD patients included 2 with definite Meniere's disease, 2 with probable Meniere's disease, 2 with benign paroxysmal positional vertigo, 2 with positional vertigo of unknown cause, 1 with vestibular neuritis, 1 with delayed endolymphatic hydrops, 1 with vertebrobasilar insufficiency, and 1 with spontaneous vertigo of unknown cause.

The changes in NPQ and DHI scores after VR were investigated. Of the 12 patients who completed the VR, one did not complete NPQ and DHI after VR. There was a significant improvement in NPQ and DHI scores after VR compared to before VR. (Table 3, $p < .05$, paired sample *t*-test and Wilcoxon signed-rank test). With regard to the NPQ subscales, all 3 subscales improved significantly after VR (Table 3, $p < .05$, paired sample *t*-test and Wilcoxon signed-rank test), suggesting that there was no particular trend in the effect of VR on the NPQ subscale.

Then, changes in posturographic findings after VR were investigated. Of the 12 patients who completed VR, one did not have a posturography test before and after VR, and one did not have a posturography test after VR. For velocity and area, there was no significant difference between the values before and after VR in all four conditions: eyes open without foam rubber, eyes closed without foam rubber, eyes open with foam rubber, and eyes closed with foam rubber (Table 4, $p > .05$, paired sample *t*-test and Wilcoxon signed-rank test). For the Romberg ratio of velocity and area, there was no significant difference between the values before and after VR in both the conditions without and with foam rubber (Table 5, $p > .05$, paired sample *t*-test and Wilcoxon signed-rank test). For the foam ratio of velocity and area, there was also no significant difference between the values before and after VR in both eyes open and eye closed conditions (Table 6, $p > .05$, paired sample *t*-test and Wilcoxon signed-rank test).

4 | DISCUSSION

In the present study, 67% of the PPPD patients who were instructed to perform 2 months of self-management VR completed the program, and 22% discontinued the VR program at their own discretion. We found that self-management VR reduced DHI and NPQ scores in the patients who completed the VR program, suggesting that self-management VR improves subjective symptoms of dizziness. On the other hand, self-management VR did not improve postural stability as measured by posturography.

In PPPD patients, improvement of subjective symptoms by VR has been previously reported.[7–11] Among them, one study using web-based VR, which is not conducted in a medical institution, reported an improvement in the subjective symptoms of PPPD.[7] Self-management VR is considered to be particularly useful in situations where patients have difficulty accessing medical resources. However, since these previous studies and our present study have not been randomized controlled trials with untreated groups, clinical studies with a high level of evidence demonstrating the efficacy of self-management VR for PPPD are desirable.

The effect of VR on postural stability in PPPD has not been well documented, although postural instability in patients with PPPD has been previously reported.[16] In the present study, we also evaluated

TABLE 4 Velocity and area before and after VR in PPPD patients.

			Before VR		After VR			
	Eyes	Foam rubber	Mean	SD	Mean	SD	*p* (a)	*p* (b)
Velocity	Open	Without	1.42	0.31	1.46	0.39	.681	.719
	Closed	Without	2.40	0.82	2.54	0.91	.350	.242
	Open	With	1.98	0.51	1.99	0.53	.926	.881
	Closed	With	4.50	2.17	4.04	1.27	.370	.575
Area	Open	Without	4.50	1.84	4.32	2.00	.772	.881
	Closed	Without	7.56	4.44	8.97	5.54	.281	.242
	Open	With	7.73	3.88	9.03	6.35	.371	.575
	Closed	With	21.14	15.57	17.88	8.74	.380	.575

Note: Velocity, the mean velocity of center of pressure movement over 60 s, Area, the envelopment area traced by center of pressure movement. (a) = paired sample *t*-test, (b) = Wilcoxon signed-rank test.
Abbreviations: PPPD, persistent postural-perceptual dizziness; SD, standard deviation; VR, vestibular rehabilitation.

TABLE 5 Romberg's ratios before and after VR in PPPD patients.

		Before VR		After VR			
	Foam rubber	Mean	SD	Mean	SD	*p* (a)	*p* (b)
Velocity	Without	1.738	0.683	1.743	0.377	.970	.646
	With	2.294	0.950	2.071	0.561	.183	.222
Area	Without	1.938	1.446	2.217	1.192	.418	.447
	With	2.981	2.183	2.365	1.253	.146	.0930

Note: Velocity, the mean velocity of center of pressure movement over 60 s, Area, the envelopment area traced by center of pressure movement. (a) = paired sample *t*-test, (b) = Wilcoxon signed-rank test.
Abbreviations: PPPD, persistent postural-perceptual dizziness; SD, standard deviation; VR, vestibular rehabilitation.

TABLE 6 Foam ratios before and after VR in PPPD patients.

		Before VR		After VR			
	Eyes	Mean	SD	Mean	SD	*p* (a)	*p* (b)
Velocity	Open	1.436	0.525	1.474	0.375	.844	.803
	Closed	1.874	0.622	1.600	0.144	.185	.263
Area	Open	2.042	1.677	2.057	0.729	.973	.332
	Closed	2.747	1.474	2.132	0.537	.130	.0672

Note: Velocity, the mean velocity of center of pressure movement over 60 s, Area, the envelopment area traced by center of pressure movement. (a) = paired sample *t*-test, (b) = Wilcoxon signed-rank test.
Abbreviations: PPPD, persistent postural-perceptual dizziness; SD = standard deviation; VR, vestibular rehabilitation.

whether VR improves standing postural stability, but no significant improvement was observed. Exacerbation of dizziness symptoms induced by visual stimuli is a characteristic finding of PPPD.[1] A previous study using functional magnetic resonance imaging showed that DHI score correlated positively with activity in the visual cortex in PPPD patients.[17] We investigated the possibility that VR could improve visual dependence in PPPD patients, but we did not find any improvement in the Romberg ratio with VR. In self-management VR, the medical staff does not directly observe the patient's rehabilitation process. In addition, in the present study, we instruct patients to perform VR as daily as possible, but we do not give strict instructions on the frequency of VR. Therefore, the intensity of the VR performed by the patients may have varied. In the present study, postural stability may not have improved due to the weak intensity of the VR performed by the patients. On the other hand, the symptoms of dizziness in PPPD do not occur only in the standing posture, which may be the reason why measuring COP sway in the standing posture is not enough to know the symptoms.

Our institution has previously reported the posturographic data from healthy subjects (mean age ± standard deviation 50.9 ± 22.9 years) and peripheral vestibulopathy patients (mean age ± standard deviation 54.5 ± 15.5 years).[18] These data and the data from the PPPD patients in the present study are summarized in Table S1. For the velocity and area with eyes closed with foam

rubber, the median for PPPD, both before and after VR, was between that of healthy subjects and peripheral vestibulopathy patients. For the Romberg's ratios of velocity and area with foam rubber, the median for PPPD, both before and after VR, was also between that of healthy subjects and peripheral vestibulopathy patients. On the other hand, for the foam ratios of velocity and area with eyes closed, the median for PPPD, both before and after VR, was lower than those of healthy subjects and peripheral vestibulopathy patients. In postural control, PPPD patients may tend to rely more on visual input but less on somatosensory input than healthy subjects.

In the present study, 22% of the patients discontinued the VR program at their own discretion. Self-management rehabilitation has been noted to decrease adherence due to prolonged treatment, lack of monitoring by others, and worsening of symptoms due to rehabilitation.[19,20] In a large prospective study on chronic vertigo, 34% of participants randomized to a booklet-based self-management VR reported adherence to the full program of exercises.[21] Since decreased adherence may lead to poor treatment outcomes, it was thought that in order for the self-management VR program to be fully effective, it would be necessary to devise a way for patients to maintain adherence and complete the program. Further research is warranted to identify the characteristics of PPPD patients who discontinue VR, such as age, frequency of visits, duration of disease, severity of disease, and preceding balance disorders.

The present study has several limitations. First, the present study is a retrospective single-arm trial and is therefore only a preliminary study. In the future, it is desirable to conduct clinical trials with a high level of evidence to demonstrate the effectiveness of self-management VR for PPPD, such as a randomized controlled trial with an untreated group. Second, whether VR was completed or discontinued was left to self-report. Third, patients who discontinued VR may have done so because they did not feel the effects, and this may have contributed to the selection bias. Fourth, since the frequency of VR was not strictly specified, the effect of VR may have varied. Fifth, since the Romberg ratio and foam ratio are only semi-quantitative measures of visual and somatosensory dependence, studies such as functional magnetic resonance imaging should be conducted to examine changes in activity in visual and somatosensory cortices after VR for PPPD patients.

In conclusion, for PPPD, self-management VR improved subjective symptoms of dizziness, but did not improve standing postural stability. In self-management VR, patients' adherence to treatment needs to be improved.

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CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. This work received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ORCID

Chisato Fujimoto https://orcid.org/0000-0001-5822-1795
Teru Kamogashira https://orcid.org/0000-0001-8410-930X

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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