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Original Article

Efficacy of supervised vestibular rehabilitation on functional mobility in patients with chronic vestibular hypofunction

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Abstract. [Purpose] This study aimed to compare the effects of different intervention frequencies on walking ability and balance in patients with chronic unilateral vestibular hypofunction. [Participants and Methods] Participants included in this case-control study were assigned to one of two groups: the multiple-intervention (once a week) and single-intervention groups. Results for the Timed Up and Go test, Dynamic Gait Index, Functional Gait Assessment, and Activities-specific Balance Confidence scale were determined at baseline and four weeks after initiating the vestibular rehabilitation program. Thereafter, intra- and inter-group differences in the rates of change of these parameters were determined. [Results] The Timed Up and Go test values, Dynamic Gait Index, and Functional Gait Assessment scores improved significantly after four weeks in the multiple-intervention group. The improvement rate in the Timed Up and Go test differed significantly between the two groups. The Activities-specific Balance Confidence scale scores did not significantly change in either group after four weeks. [Conclusion] Compared to a single intervention, multiple interventions by a physical therapist produced significantly greater benefits in a relatively shorter period of time in patients with chronic unilateral vestibular hypofunction.
Key words: Vestibular rehabilitation, Gait, Supervision

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INTRODUCTION

Vestibular rehabilitation (VR) is a commonly used therapy for dizziness and vertigo. A Cochrane review showed that evidence supporting VR was moderate to strong[1)]. VR involves adaptation, habituation, and substitution exercises[2)]. Common therapies provide a combination of these exercises based on the patients' symptoms and function. VR for chronic dizziness due to vestibular hypofunction is often used for outpatients and home-based programs[3–5)]. In general, home-based VR involves patients receiving a booklet and performing 30–40 min of exercises once or twice a day[3–6)]. The program outlined in the VR booklet for home-based therapy has been shown to be effective in treating chronic dizziness[6)]. However, reports have shown that VR should be customized to fulfill the individual needs of patients[3)]. Another study suggested that supervised exercise was more effective than home-based exercise[5, 7)].

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Guidelines published by the American Physical Therapy Association has strongly recommended supervised VR for unilateral or bilateral peripheral vestibular hypofunction[2)]. These guidelines have reported that supervised VR promotes adherence and continued performance of vestibular exercises[2)]. However, it remains unclear whether different frequencies of supervised VR affect the recovery of dizziness and physical function. Supervised VR also involves spending time on hospital visits and can be financially taxing. Therefore, researchers should examine the impact of the frequency of VR interventions on rehabilitation outcomes in peripheral vestibular hypofunction.

Our previous study compared the effects of vestibular rehabilitation with and without VR intervention by physical therapists in chronic patients with peripheral vestibular hypofunction. One month of weekly VR intervention by a physical therapist (PT) promoted a significant improvement in the dizziness handicap inventory (DHI), dynamic gait index (DGI), and functional gait assessment (FGA), whereas 1 month of home exercise alone promoted no improvement in DHI, DGI, or FGA[8)]. We inferred that the effectiveness achieved in as short a period as 1 month was due to regular supervision. The current study sought to examine the efficacy of VR provided by a PT on walking ability and balance by comparing once a week interventions with first-time only intervention in patients with chronic unilateral vestibular hypofunction.

PARTICIPANTS AND METHODS

Prior to study initiation, participants received an explanation regarding the purpose and content of the research, as well as handling of data, after which written consent was obtained. This study was approved by the Ethical Review Committee for Human and Animal Studies at our institution (approval number: 15 medicine-002).

This retrospective cohort study included 22 patients (age: 70.4 ± 10.8 years) diagnosed with chronic unilateral peripheral vestibular disorder at our institution between August 2017 and January 2019 (Table 1). A previous study defined the chronic phase as that ≥3 months after the onset of dizziness[2)]. The inclusion criteria were as follows: 20 years of age and older, diagnosis of unilateral peripheral vestibular hypofunction, symptoms of dizziness ≥3 months. The neuro-otologists diagnosed unilateral peripheral vestibular hypofunction based on an ocular motor-vestibular function test, including caloric test, video head impulse test, vestibular evoked myogenic potential, and brain magnetic resonance imaging. The exclusion criteria were as follows: neck disease, neck pain, cognitive impairment, impairment of the cardiovascular system, and history of central nervous system disease.

Participants were then assigned to two groups: a once a week intervention group (multiple intervention group; n=12) and a first-time only intervention group (single intervention group; n=10). Among the 12 participants in the multiple intervention group, 6 had overlapping data with a previous study[8)]. Participants included herein had never received VR by a PT. The two groups underwent a 4-week VR program.

In the multiple intervention group, a PT provided individual VR intervention for 40 min and home program instruction once per week over a period of 4 weeks. In the single intervention group, individual VR intervention and home program instruction by a PT was performed only once at the beginning of the VR program, and a home program was continued for 4 weeks. The VR intervention consisted of gaze stabilization, habituation, substitution, balance, and gait exercises, which were provided individually by the PT. The PT provided a customized VR program for each intervention, which was selected according to the symptoms and functions of the patients. Moreover, the position during task performance, the speed of movement, and the number of times per session were adjusted. For the home program, the patients were instructed to perform approximately two sets of the exercises taught per day.

The Timed Up and Go test (TUG), DGI, FGA, and activities-specific balance confidence scale (ABC scale) were used to assess gait function at baseline and 4 weeks after VR program initiation.

Table 1. Patient characteristics

	Multiple intervention group (n=12)	Single intervention group (n=10)	Total (n=22)
Age (years, mean ± SD)	66.4 ± 12.1	75.1 ± 7.0	70.4 ± 10.8
Gender (male/female)	3/9	3/7	6/17
Time since onset (days, mean ± SD)	1,522.3 ± 1,746.5	1,159.8 ± 1,826.0	1,357.5 ± 1,749.5
Diagnosis			
Vestibular neuritis	5	1	6
Hunt syndrome	2	-	2
Acoustic neuroma	1	1	2
Idiopathic sudden deafness	2	3	5
Chronic otitis media	-	1	1
Inner ear dizziness	1	3	4
Unknown cause	1	1	2

SD: Standard deviation.

The TUG is a gait measurement tool has been used as a screening test for fall risk in the elderly and individuals with vestibular dysfunction. A stopwatch was used to measure the time required to stand up from a seated position, walk for 3 m, turn, walk back, and sit down[9)]. This study measured each of the clockwise and counter-clockwise turns once and used the average value given that the participants had unilateral vestibular disorders. A TUG >11.1 s was set as the cutoff value for increased fall risk in patients with vestibular dysfunction[10)].

The DGI, which consists of eight items, namely gait level surface, change in gait speed, gait with horizontal head turns, gait with vertical head turns, gait and pivot turn, step over obstacles, step around obstacles, and steps (stairs), was used to evaluate dynamic balance during walking. Each item is scored from 0 to 3 points for a total of 24 points[11)]. A DGI score of <19 points was set as the cutoff value for increased fall risk in patients with vestibular dysfunction[10)].

The FGA, which consists of ten items, including tandem gait, closed eye gait, and backward gait added to the DGI, excluding the slalom gait, has been developed as an evaluation index for individuals with higher balance ability than those assessed via DGI[12)]. Each item is scored from 0 to 3 points, for a total of 30 points. An FGA score of <23 points was set as the cutoff value for increased fall risk in the elderly[13)].

The ABC scale consists of 16 items and evaluates confidence levels in activities of daily life[14)]. An ABC scale score of <67% was set as the cutoff value for increased fall risk in the elderly[15)].

All statistical analyses were performed using SPSS Statistics version 24.0 (IBM Corp, Armonk, NY, USA). Data normality was assessed using the Shapiro–Wilk test. Differences in age and time of dizziness onset between the two groups were analyzed using the Mann–Whitney test, whereas differences in sex distribution were analyzed using Fisher's exact test. An independent t-test was used to compare baseline outcome measures between the groups. The rate of change was calculated to clarify differences in change between the two groups (4 weeks after VR program initiation/baseline ×100). An independent t-test was used to compare the rates of change in TUG, DGI, and ABC scale between the two groups, whereas the Mann–Whitney test was used to compare differences in the rate of change in FGA between the two groups. The paired t-test (for normally distributed data) and the Wilcoxon signed-rank test (for non-normally distributed data) were used for intragroup comparisons at baseline and 4 weeks after VR program initiation. The threshold for significance was set at p<0.05.

RESULTS

No significant differences (p≥0.05) at baseline were observed between the multiple and single intervention groups in terms of age, time of dizziness onset, and gender (Table 1).

The mean TUG and ABC scale score of each group at baseline and 4 weeks after VR program initiation were normative data (Table 2). The mean DGI and FGA scores of the multiple intervention group at baseline and 4 weeks after VR program initiation were also normative data. However, the mean DGI and FGA scores of the single intervention group at baseline and 4 weeks after VR program initiation were lower than the cutoff value (Table 2). The number of participants at high risk of falling is shown in Table 3.

No significant differences in TUG and ABC scale scores (p≥0.05) at baseline were observed between the multiple and single intervention groups (Table 2). However, significant differences in DGI and FGA scores (p<0.05) at baseline were observed between the multiple and single intervention groups (Tables 1 and 2).

Table 2. Changes in mean values from baseline to 4 weeks after the VR program initiation and the rate of change between baseline and 4 weeks after VR program initiation

Outcome measure	PT intervention	Baseline	4 weeks	Rate of change (%)
TUG (s)	Multiple intervention group (n=12)	9.4 ± 2.0	7.7 ± 1.4†	83.2 ± 9.2
	Single intervention group (n=10)	10.4 ± 2.1	10.71 ± 2.6	102.6 ± 12.2#
DGI (points)	Multiple intervention group (n=12)	20.0 ± 2.8**	22.1 ± 1.8†	111.6 ± 11.0
	Single intervention group (n=10)	14.5 ± 2.6¶	16.6 ± 3.7¶	117.9 ± 36.0
FGA (points)	Multiple intervention group (n=12)	23.9 ± 4.2**	26.6 ± 3.2†	112.5 ± 10.4
	Single intervention group (n=10)	16.8 ± 3.7¶	19.8 ± 4.0¶	122.2 ± 33.7
ABC scale (%)	Multiple intervention group (n=12)	70.0 ± 21.1	76.3 ± 18.9	112.1 ± 20.4
	Single intervention group (n=9)	77.5 ± 14.0	85.9 ± 15.0	112.8 ± 23.8

Values are mean ± SD.
*p<0.05, **p<0.01: Significant difference at baseline between the two groups; †p<0.01: Significant difference between baseline and 4 weeks after VR program initiation; #p<0.01: Significant difference in rate of change between the two groups; ¶: Scores are lower than the cutoff value.
VR: vestibular rehabilitation; PT: physical therapist; TUG: Time Up & Go test; DGI: dynamic gait index; FGA: functional gait assessment; ABC scale: activities-specific balance confidence scale.

Table 3. Number of participants at high risk of falling

Outcome measure	PT intervention	Baseline	4 weeks
TUG, n	Multiple intervention group (n=12)	2	0
	Single intervention group (n=10)	3	5
DGI, n	Multiple intervention group (n=12)	3	1
	Single intervention group (n=10)	9	6
FGA, n	Multiple intervention group (n=12)	4	1
	Single intervention group (n=10)	10	7
ABC scale, n	Multiple intervention group (n=12)	5	4
	Single intervention group (n=9)	2	1

PT: physical therapist; TUG: Time Up & Go test; DGI: dynamic gait index; FGA: functional gait assessment; ABC scale: activities-specific balance confidence scale.

In the multiple intervention group, TUG values, DGI, and FGA scores showed significant improvement 4 weeks after VR program initiation (Table 2). ABC scale scores did not significantly change 4 weeks after VR program initiation in the multiple intervention group (Table 2).

In the single intervention group, TUG values, DGI, FGA, and ABC scale scores did not significantly change 4 weeks after VR program initiation (Table 2).

The rate of change in TUG values significantly differed between the two groups (Table 2), however no significant difference in the rate of change in the DGI, FGA, and ABC scale scores was noted between the two groups (Table 2).

DISCUSSION

Studies have shown that VR exercises promote central compensation and adaptation of the vestibulo-ocular and vestibulo-spinal reflexes[16, 17)]. VR improves walking ability, postural control, and vestibulo-ocular reflex gain through vestibular compensation and reduces the risk of falls[3, 18–25)]. Previous studies have demonstrated that individualized and supervised VR are more effective for treatment[3, 5, 7)]. Early customized VR facilitates postural control recovery in patients >50 years old[25)]. As mentioned in the Introduction, however, supervised VR also involves spending time on hospital visits and financial costs.

Previous studies have reported that supervised VR was more effective in improving balance and walking ability than unsupervised VR among patients with acute vestibular disorders[24, 25)]. In the chronic phase, supervised VR promoted better improvements in dizziness symptoms, gait speed, and balance function compared to unsupervised rehabilitation[7)]. Another study in the chronic phase suggested that rehabilitation should be supervised to improve postural stability and psychological compliance[26)]. We examined the efficacy of supervised VR on walking ability and balance by comparing weekly and one-time interventions after 4 weeks. TUG values, DGI, and FGA scores significantly improved in weekly interventions, however TUG values, DGI, FGA, and ABC scale scores in the single intervention group showed no significant change 4 weeks after VR program initiation. The TUG results revealed that the multiple intervention group exhibited greater rates of change than the single intervention group. In other words, among patients with chronic vestibular hypofunction, regular multiple interventions over a period of 4 weeks significantly improved walking ability, whereas a single intervention had insufficient effects on walking ability and balance. Providing supervision and customizing of home exercises in short intervals have been shown to improve walking ability and postural control. We previously found that 3 months of continued training was required to induce a significant improvement in vestibular function and home exercises when interventions were provided once a month[27)]. Training may exhibit immediate results if patients continue to receive instructions at appropriate intervals and in a manner suitable to their individual abilities. Weekly supervision may have been improved by assessing the patient's condition in the second and subsequent interventions and providing VR tailored to their condition.

Subjects included here were relatively old, with an average age of 70.4 ± 10.8 years. During rehabilitation of elderly patients, supervised exercise has been found to be more effective than unsupervised exercise[25, 28)]. A previous study suggested that VR for the elderly should provide customized activities and problem-oriented home programs based on individual complaints and balance assessments[25)]. Elderly patients generally have good adherence rates to supervised programs[29)]. Previous studies have shown that supervision was directly related to motivation and compliance and that unsupervised rehabilitation had a higher probability of dropout[6)]. A systematic review showed that supervision was most likely essential in exercises requiring technically correct execution in the elderly[28)]. Our results also suggested that it may be better to provide supervised VR, especially in elderly patients.

The ABC scale did not improve significantly in either group. The duration of the VR program in the previous studies showing the effect of supervised VR for chronic phase was approximately 2 months[7, 26)], which was longer than in the current study. Additionally, the current study targeted outpatients in the chronic phase, who had a relatively higher walking ability even before VR program initiation.

This study has some limitations. First, this study did not examine adherence with regard to the number of home program implementations during the study period. A previous study reported that supervision promoted greater compliance and improvements in postural stability and psychological state[26]. Future studies should clarify adherence as well as the minimum the VR program duration necessary to improve dizziness and balance. Second, we were unable to match participants' DGI and FGA scores at baseline given the retrospective cohort study design of this study. Moreover, the sample size was small. However, our findings showed that the multiple intervention group showed a significant improvement in walking ability measures, particularly TUG, DGI, and FGA, whereas the single intervention group showed no significant improvement in TUG, DGI, and FGA 4 weeks after VR program initiation. The TUG results showed that multiple interventions promoted significantly better effects compared to a single intervention. Third, the diseases that caused unilateral vestibular disorders were not uniform and included various pathological conditions. Although we cannot rule out the potential effects of these points on our results, the data presented in this paper can be considered valuable.

The current study compared changes in walking ability and balance during walking between the weekly and single intervention groups. Notably, the multiple intervention group showed improvements in TUG, DGI, and FGA. Regarding TUG, the rate of change was greater in the multiple intervention group than in the single intervention group. These results revealed that walking ability and balance improved when weekly interventions were continued for 4 weeks. A previous study showed that a pamphlet-based VR program without PT intervention for 4 weeks was not effective[8]. This suggests that increasing the frequency of PT intervention improved walking ability and balance in a relatively short period.

Conference presentation

A part of this research was previously presented at the 78th Annual Meeting of the Japan Society for Equilibrium Research, Equilibrium Research Vol.78(5), p545.

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None of the authors have any conflicts of interest to declare.

REFERENCES

1) McDonnell MN, Hillier SL: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction. Cochrane Database Syst Rev, 2015, 1: CD005397. [Medline]
2) Hall CD, Herdman SJ, Whitney SL, et al.: Vestibular rehabilitation for peripheral vestibular hypofunction: an updated clinical practice guideline from the Academy of Neurologic Physical Therapy of the American Physical Therapy Association. J Neurol Phys Ther, 2022, 46: 118–177. [Medline] [CrossRef]
3) Giray M, Kirazli Y, Karapolat H, et al.: Short-term effects of vestibular rehabilitation in patients with chronic unilateral vestibular dysfunction: a randomized controlled study. Arch Phys Med Rehabil, 2009, 90: 1325–1331. [Medline] [CrossRef]
4) Ricci NA, Aratani MC, Caovilla HH, et al.: Effects of vestibular rehabilitation on balance control in older people with chronic dizziness: a randomized clinical trial. Am J Phys Med Rehabil, 2016, 95: 256–269. [Medline] [CrossRef]
5) Topuz O, Topuz B, Ardiç FN, et al.: Efficacy of vestibular rehabilitation on chronic unilateral vestibular dysfunction. Clin Rehabil, 2004, 18: 76–83. [Medline] [CrossRef]
6) Yardley L, Barker F, Muller I, et al.: Clinical and cost effectiveness of booklet based vestibular rehabilitation for chronic dizziness in primary care: single blind, parallel group, pragmatic, randomised controlled trial. BMJ, 2012, 344: e2237. [Medline] [CrossRef]
7) Kao CL, Chen LK, Chern CM, et al.: Rehabilitation outcome in home-based versus supervised exercise programs for chronically dizzy patients. Arch Gerontol Geriatr, 2010, 51: 264–267. [Medline] [CrossRef]
8) Kamo T, Ogihara H, Tanaka R, et al.: Effects of the individualized vestibular rehabilitation on patients with dizziness/vertigo in Japan. Phys Ther Jpn, 2019, 46: 242–249 (in Japanese).
9) Podsiadlo D, Richardson S: The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc, 1991, 39: 142–148. [Medline] [CrossRef]
10) Whitney SL, Marchetti GF, Schade A, et al.: The sensitivity and specificity of the Timed "Up & Go" and the Dynamic Gait Index for self-reported falls in persons with vestibular disorders. J Vestib Res, 2004, 14: 397–409. [Medline] [CrossRef]
11) Shumway-Cook A, Woollacott MH: Motor control: theory and practical applications. Baltimore: Williams & Wilkins, 1995.
12) Wrisley DM, Marchetti GF, Kuharsky DK, et al.: Reliability, internal consistency, and validity of data obtained with the functional gait assessment. Phys Ther, 2004, 84: 906–918. [Medline] [CrossRef]
13) Wrisley DM, Kumar NA: Functional gait assessment: concurrent, discriminative, and predictive validity in community-dwelling older adults. Phys Ther, 2010, 90: 761–773. [Medline] [CrossRef]
14) Powell LE, Myers AM: The activities-specific balance confidence (ABC) scale. J Gerontol A Biol Sci Med Sci, 1995, 50A: M28–M34. [Medline] [CrossRef]
15) Lajoie Y, Gallagher SP: Predicting falls within the elderly community: comparison of postural sway, reaction time, the Berg balance scale and the Activities-specific Balance Confidence (ABC) scale for comparing fallers and non-fallers. Arch Gerontol Geriatr, 2004, 38: 11–26. [Medline] [CrossRef]
16) Strupp M, Arbusow V, Maag KP, et al.: Vestibular exercises improve central vestibulospinal compensation after vestibular neuritis. Neurology, 1998, 51: 838–844. [Medline] [CrossRef]
17) Herdman SJ, Clendaniel RA, Mattox DE, et al.: Vestibular adaptation exercises and recovery: acute stage after acoustic neuroma resection. Otolaryngol Head Neck Surg, 1995, 113: 77–87. [Medline] [CrossRef]

18) Loader B, Gruther W, Mueller CA, et al.: Improved postural control after computerized optokinetic therapy based on stochastic visual stimulation in patients with vestibular dysfunction. J Vestib Res, 2007, 17: 131–136. [Medline] [CrossRef]
19) Michel L, Laurent T, Alain T: Rehabilitation of dynamic visual acuity in patients with unilateral vestibular hypofunction: earlier is better. Eur Arch Otorhinolaryngol, 2020, 277: 103–113.
20) Millar JL, Gimmon Y, Roberts D, et al.: Improvement after vestibular rehabilitation not explained by improved passive VOR gain. Front Neurol, 2020, 11: 79. [Medline] [CrossRef]
21) Whitney SL, Alghwiri AA, Alghadir A: An overview of vestibular rehabilitation. Handb Clin Neurol, 2016, 137: 187–205. [Medline] [CrossRef]
22) Alsalaheen BA, Mucha A, Morris LO, et al.: Vestibular rehabilitation for dizziness and balance disorders after concussion. J Neurol Phys Ther, 2010, 34: 87–93. [Medline] [CrossRef]
23) Chang WC, Yang YR, Hsu LC, et al.: Balance improvement in patients with benign paroxysmal positional vertigo. Clin Rehabil, 2008, 22: 338–347. [Medline] [CrossRef]
24) Teggi R, Caldirola D, Fabiano B, et al.: Rehabilitation after acute vestibular disorders. J Laryngol Otol, 2009, 123: 397–402. [Medline] [CrossRef]
25) Vereeck L, Wuyts FL, Truijen S, et al.: The effect of early customized vestibular rehabilitation on balance after acoustic neuroma resection. Clin Rehabil, 2008, 22: 698–713. [Medline] [CrossRef]
26) Pavlou M, Bronstein AM, Davies RA: Randomized trial of supervised versus unsupervised optokinetic exercise in persons with peripheral vestibular disorders. Neurorehabil Neural Repair, 2013, 27: 208–218. [Medline] [CrossRef]
27) Tanaka R, Kamo T, Ogihara H, et al.: Effectiveness of vestibular rehabilitation on improving the gait in patients with chronic unilateral vestibular disorder. Equilib Res, 2019, 78: 581–589 (in Japanese). [CrossRef]
28) Lacroix A, Hortobágyi T, Beurskens R, et al.: Effects of supervised vs. unsupervised training programs on balance and muscle strength in older adults: a systematic review and meta-analysis. Sports Med, 2017, 47: 2341–2361. [Medline] [CrossRef]
29) Picorelli AM, Pereira LS, Pereira DS, et al.: Adherence to exercise programs for older people is influenced by program characteristics and personal factors: a systematic review. J Physiother, 2014, 60: 151–156. [Medline] [CrossRef]