

Home exercise program adherence strategies in vestibular rehabilitation: a systematic review

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Objective: The aim of this systematic review was to investigate for effective strategies to improve home exercise program (HEP) adherence in vestibular rehabilitation (VR).

Design: Systematic review.

Methods: A systematic review was conducted to identify effective strategies used to improve HEP adherence of patients in VR. Six databases, Academic Search Premier, Cochrane Library, CINAHL, PUBMED, PsycINFO, and Web of Science were searched from their inception to December 31, 2015. The keywords used for search were 'home program', 'home intervention', 'compliance', 'adherence', 'vestibular rehabilitation', 'motion sickness', and 'motion sensitivity'.

Results: A total of eight studies were selected to be included in the review. There was 95.2% agreement between the two reviewers who reviewed the studies using a quality assessment tool. The overall inter-rater agreement ($\kappa=0.73$) showed good agreement between the reviewers. Strong evidence was identified for 3 major categories of effective HEP adherence strategies, 1) providing patient with written summary of HEP; 2) asking patient to maintain a record of HEP and symptoms; and 3) providing tele-rehabilitation in form of email and/or telephone support along with in person treatment sessions. Also, based on strong evidence, computerized technology was not found to be superior to other strategies for improving patients' HEP adherence in VR.

Conclusions: The effective strategies for improving HEP in VR include written summary of exercise, maintenance of log of HEP and symptoms and tele-rehabilitation along with in person treatment sessions.

Key Words: Adherence, Compliance, Home intervention, Home program, Vestibular rehabilitation

Introduction

Home exercise programs (HEPs) are an integral part of physical therapy interventions. However, HEP prescription is not sufficient, but patient's adherence to HEP is critical for overall treatment outcome [1]. Adherence is defined as "the extent to which a person's behavior-taking medications, following a diet, and/or executing life-style changes, corresponds with agreed recommendations from a health care provider" [2]. This adherence and its level are influenced by patient's perceptions about their injuries, symptoms, and

coping mechanism [3]. Adherence to HEP is even more critical for dysfunctions that may demand long-term intervention such as vestibular dysfunctions.

Vestibular rehabilitation (VR) involves exercises that are administered for the intervention of vestibular dysfunction by promoting vestibular adaptation and substitution [4]. VR focuses on utilizing the plasticity of the balance system to improve the natural compensation process [5]. The aim of VR is to improve gaze and postural stability, reduce symptoms of vertigo, and to improve activities of daily life [4]. Decreased gain of vestibular response to head movements

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gives rise to gaze instability in patients with vestibular dysfunction [6]. Inducing retinal slip by horizontal or vertical head movements while maintaining visual fixation on a target, increases the gain of the vestibular response [7,8]. For vestibular adaptation to occur, retinal slip needs to be induced repeatedly [7]. Gaze stability exercises induce this retinal slip and they are prescribed as much as four to five times daily for a total duration of 20-40 minutes [9].

Vestibular exercises require regular and consistent repetition for vestibular adaptation to occur, thus, patient's adherence to the HEP is a critical factor. Various HEP adherence strategies have been implemented in the field of VR to ensure patient's adherence to HEP. Examples of these strategies include a recording calendar [9], booklet-based VR and telephone support [10], and written summary and homework assignment [11]. Among the HEP strategies available to physical therapists for providing effective VR, it is unclear which HEP strategy is most effective for improving adherence. To the best of our knowledge, there has been no systematic review conducted for investigating the HEP adherence in VR. The aim of this systematic review was to determine the most effective strategies to ensure maximum adherence to HEP among patients undergoing VR.

Methods

Data sources and search strategies

An individualized search strategy was developed for each of the 6 databases in collaboration with a librarian. The following databases were searched from their inception to December 31, 2015: Academic Search Premier, Cochrane Library, CINAHL, PUBMED, PsycINFO, and Web of Science. The following keywords were used: 'home program', 'home intervention', 'compliance', 'adherence', 'vestibular rehabilitation', 'motion sickness', and 'motion sensitivity'. The references of the studies that were identified were reviewed for further relevant citation.

Study selection

This systematic review included studies that were: 1) published in English language, 2) randomized controlled trials, case control studies, observational studies and cross-sectional surveys that were published in peer-reviewed journals, 3) related to VR and motion sensitivity intervention, and 4) related to implementation of HEP adherence strategies. The studies that investigated pediatric population were excluded.

Six databases were searched to identify potential relevant studies based on titles and abstracts. Also, the references of studies were reviewed to find more relevant citations. Two investigators (SG and EJ) reviewed the relevant studies to confirm whether or not they met the selection criteria. Based on the agreement of both investigators, SG and EJ, studies that met the selection criteria were included in the review.

Quality assessment of studies

Two reviewers (TM and PS) independently reviewed each study based on a quality assessment tool adapted from Jack *et al.* (Table 1) [12]. This systematic review focused on investigating adherence to HEP and we chose to use the modified form of quality assessment tool, which consists of a standardized set of 13 predefined criteria [12]. The criteria used in the quality assessment tool checks for both internal and external validity of a study [13]. A score of 0 was given to criteria that did not meet the quality standard while a criterion that met the quality standard was given a score of one. We summed the scores of 13 criteria; the tool scoring range

Table 1. Quality assessment tool

Criteria	Score
Study population	
(A) Description of source population	+ / - / ?
(B) Description of inclusion and exclusion criteria	+ / - / ?
Study design	
(C) Prospective study design	+ / - / ?
(D) Study size \geq 300	+ / - / ?
Drop-outs	
(E) Information completers versus loss of follow up/drop-outs	+ / - / ?
Prognostic factors	
(F) Description of potential prognostic factors	+ / - / ?
(G) Standardized or valid measurements	+ / - / ?
(H) Data presentation of most important prognostic factors	+ / - / ?
Outcome measures	
(I) Relevant outcome measures	+ / - / ?
(J) Standardized or valid measurements	+ / - / ?
(K) Data presentation of most important outcome measures	+ / - / ?
Analysis and data presentation	
(L) Appropriate univariate crude estimates	+ / - / ?
(M) Appropriate multivariate analysis techniques	+ / - / ?

Adapted from the articles of Jack *et al.* (Man Ther 2010;15:220-8) [12]; Borghouts *et al.* Pain 1998;77:1-13) [13].

+: positive (design/conduct adequate, scores 1 point), -: negative (design or conduct inadequate, scores 0 points), ?: unclear (item insufficiently described, scores 0 points).

was 0 to 13. A study was considered to be of high quality when it received a score of ≥ 7 while a study that received a score of < 7 was considered as a low quality study accord-

ing to quality assessment tool [12].

Data extraction and synthesis

Two reviewers' extracted data related to study population, study design, dropouts, prognostic factors, outcome measures, and data analysis and data presentation. Inter-reviewer reliability of quality assessment of the research studies was examined by calculating percent agreement and kappa co-efficient. The qualitative conclusion about the effective strategies for HEP adherence was based on levels of evidence (Table 2) [12]. The significance of strategies affecting adherence in VR was derived from multivariate analysis, analysis of covariance and non-parametric statistics.

Table 2. Levels of evidence

Strong	Consistent finding in at least 2 high quality cohorts/RCTs
Moderate	Finding from 1 high quality cohort/RCT and consistent findings from 1 or more low quality cohorts/RCTs
Limited	Findings from 1 high quality cohort/RCT or consistent findings from 1 or more low quality cohorts/RCTs
Conflicting	Inconsistent findings regardless of quality
No evidence	No studies found

RCTs: randomized controlled trials.

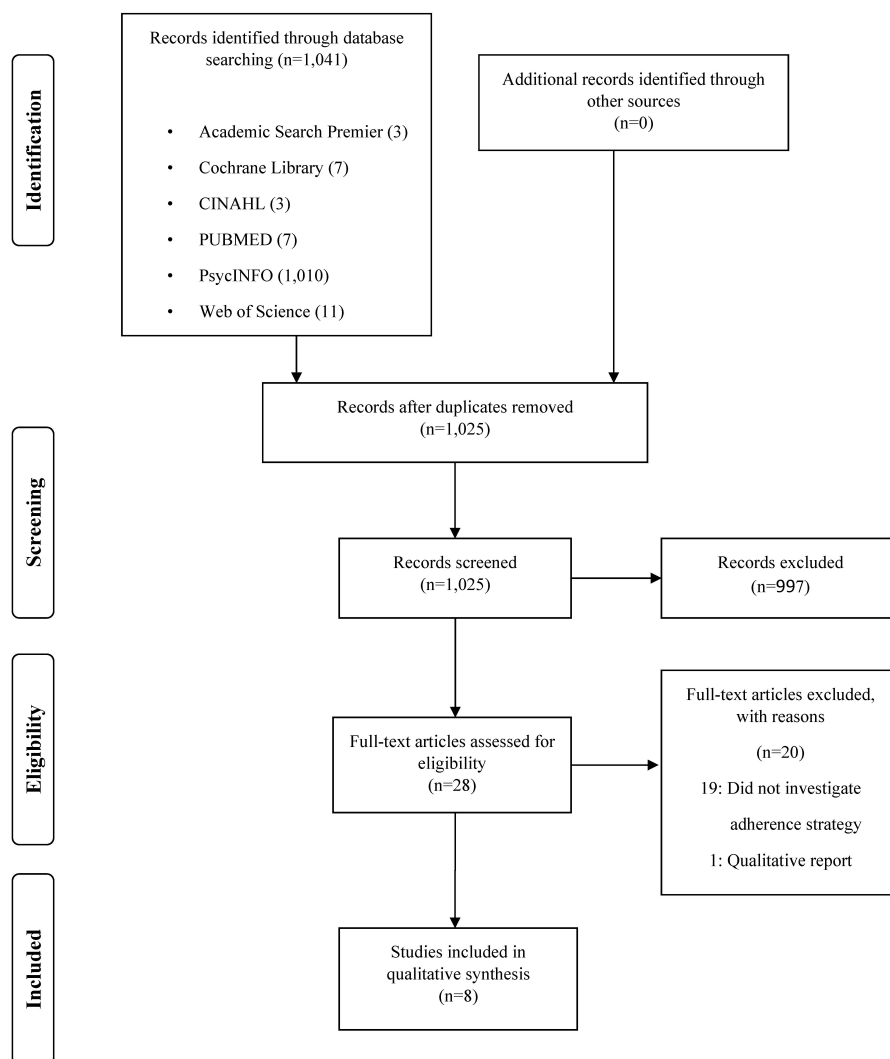


Figure 1. Preferred reporting items for systematic reviews (PRISMA) flow diagram showing flow of information through the review.

Results

The steps of study selection are shown in Figure 1. A total of 1,041 citations were identified from six databases. After the first screening 1,003 studies were excluded and 28 relevant studies were saved for secondary screening. A total of 28 studies were reviewed by two investigators SG and EJ. After achieving consensus between the opinions of these two investigators a total of eight studies were selected to be included in the review.

Methodological quality

Two reviewers TM and PS independently scored 104 items and disagreed on 5 items (95.2% agreement). The overall inter-rater agreement ($\kappa=0.73$) showed good agreement between the reviewers. The total score of quality assessment of the reviewed studies ranged from 9 to 13 (Table 3) [10,14-20]. This indicated that all of the studies included in the systematic review were high quality based on the quality assessment tool.

Study characteristics

A total of eight studies were included in this systematic review. There were six randomized controlled trials, one case series and one prospective intervention study (Table 4) [10,14-20]. Out of eight studies, one study recruited adults with Meniere's disease [14], four studies recruited adults with chronic dizziness [10,15-17], one study recruited older adults with chronic dizziness [18], and two studies recruited patients with unilateral vestibular dysfunction [19,20].

HEP adherence strategies

The HEP adherence strategies used in eight studies included in this systematic review were grouped into four main categories: 1) HEP with written summary of exercises,

2) HEP with computerized technology, 3) HEP with tele-rehabilitation, and 4) HEP with exercise maintenance log.

1) HEP with written summary of exercises: Six high quality studies investigated the use of written summary of exercises to improve patient's HEP adherence.

Yardley and Kirby [14] used two types of self-help symptom management booklets to manage vertigo and dizziness in patients with Meniere's disease, booklet-based education in VR versus symptom control (SC) self-management booklet versus control. As compared to the 15.8% patient improvement that was observed in control group, the VR and SC group showed 37.5% and 39.2% improvement respectively. Both booklet-based intervention groups reported greater ability to understand and cope with symptoms ($p<0.001$). Adherence was significantly different between the intervention groups with 50% of SC group reporting adherence to HEP as compared to 37.5% of the VR group. This study provided evidence that patients' HEP adherence can be improved with booklet-based self-management HEP.

Smaerup *et al.* [18] compared the effectiveness of VR in clinic along with computer program assisted HEP to VR in clinic with printed exercise instruction assisted HEP for older adults with chronic dizziness. There was no significant difference between the two groups post intervention. The compliance rate to computer program exercise was 57%. This study provided evidence that computer program assisted HEP was not more effective in improving outcome and treatment adherence than printed exercise instruction assisted HEP.

Yardley *et al.* [10] studied the effectiveness of booklet-based VR versus booklet-based VR with telephone support versus routine medical care. Adherence to exercise was 44% for the booklet self-management along with telephone support group, while it was 34% in the booklet self-management only group. This difference was not significant, but the

Table 3. Results of methodological assessment

Study	Year	A	B	C	D	E	F	G	H	I	J	K	L	M	Quality score
Meldrum <i>et al.</i> [19]	2015	1	1	1	0	1	1	0	1	1	1	1	1	1	11
Pavlou <i>et al.</i> [16]	2013	1	1	1	0	1	1	1	1	1	1	1	1	1	12
Smaerup <i>et al.</i> [18]	2015	1	1	1	0	1	1	1	1	1	1	1	1	1	12
Yardley <i>et al.</i> [17]	2004	1	1	1	0	1	1	1	1	1	0	1	1	1	11
Yardley and Kirby [14]	2006	1	1	1	1	1	1	1	1	1	1	1	1	1	13
Yardley <i>et al.</i> [10]	2012	1	1	1	1	1	1	1	1	1	1	1	1	1	13
Szturm <i>et al.</i> [15]	2015	1	1	1	0	1	1	1	1	1	1	1	1	1	12
Topuz <i>et al.</i> [20]	2004	1	1	1	0	1	1	0	1	1	0	1	1	0	9

Table 4. Study characteristics

No.	Population	Intervention duration (wk)	Intervention description	Adherence strategy	Results
Randomized controlled trials					
1)	Meldrum <i>et al.</i> , 2015 [19]	6	Conventional balance exercises during VR (36 participants) Virtual reality-based balance exercises during VR (36 participants)	Weekly exercise booklet, exercise diary and foam balance mat for home exercise Weekly exercise booklet, exercise diary and virtual reality gaming system for home exercise	Both groups reported a high level of adherence to HEP: 78.5% in the conventional group and 77.1% in the virtual reality group. There was no significant difference between the groups post intervention. Dropout rate was significantly higher 55% for unsupervised exercise group compared to 10% dropout rate for both supervised exercise groups. There was no significant difference between the groups post intervention.
2)	Pavlou <i>et al.</i> , 2013 [16]	8	Optokinetic training via a full-field visual environment rotator (20 participants) Optokinetic training supervised video (20 participants) No supervised physical therapy session (20 patients)	Customized exercises and video for HEP; diary record of symptoms was reviewed at each session Customized exercises and video for HEP; diary record of symptoms was reviewed at each session Customized exercises and video HEP; diary record of symptoms was reviewed at final session only	Dropout rate was significantly higher 55% for unsupervised exercise group compared to 10% dropout rate for both supervised exercise groups. There was no significant difference between the groups post intervention.
3)	Smaerup <i>et al.</i> , 2015 [18]	16	VR with computer assisted HEP (32 participants) VR with printed instructions assisted HEP (31 patients)	HEP was assisted with computer training program "Move It To Improve It" (Mitti) HEP was assisted with printed instructions	Overall compliance rate for computer program exercise was 57% and there was no significant difference between the groups post intervention.
4)	Yardley <i>et al.</i> , 2004 [17]	12	VR and treatment booklet (83 patients) Usual medical care (87 patients)	First 3 months: booklet and telephone call support was provided by nurses at 1 and 3 weeks after initial session Next 3 months: none First 3 months: none Next 3 months: booklet and telephone call support was provided by nurses at 1 and 3 weeks after initial session	Self-reported adherence was fair, as 71% of patients carried out the exercises most days of the weeks, 55% continued the exercises for at least 9 weeks or until symptoms subsided. Telephone counseling was given to 85% of patients 1 week after initial session and to 76% of patients 3 weeks after initial session. There was a significant difference between groups at 3 month follow up post intervention as VR group showed significant improvement on all primary outcome measures.
5)	Yardley and Kirby, 2006 [14]	12	Booklet-based education in VR (120 patients) SC self-management booklet (120 patients)	VR booklet for daily balance training exercises performed at home including instruction on how to tailor them to particular symptoms experienced SC booklet gave details concerning how to carry out daily relaxation and controlled breathing exercises and how to use distraction to reduce attention to symptoms	Adherence was significantly different between groups with 50% of SC group reporting adherence to exercises compared to 37.5% of the VR group. There was a significant interaction between level of adherence and change over time in secondary outcome measures post intervention.
			Waiting list control without booklet (120 patients)		

Table 4. Continued

No.	Population	Intervention duration (wk)	Intervention description	Adherence strategy	Results
6)	Yardley <i>et al.</i> , 2012 [10]	12	Booklet-based VR (113 patients)	Exercise booklet provided comprehensive advice on undertaking VR HEP daily for up to 12 weeks using cognitive behavioral techniques to promote positive beliefs and treatment adherence	Adherence to exercise was 44% for the booklet self management along with telephone support group, while it was 34% in the booklet self management only group. This difference was not significant between groups.
			Booklet-based VR with telephone support (112 patients)	Exercise booklet provided comprehensive advice on undertaking VR HEP daily for up to 12 weeks to promote treatment adherence; also, three brief sessions of telephone support was offered from a vestibular therapist	
			Routine medical care (112 patients)		
	Case series				
7)	Szturm <i>et al.</i> , 2015 [15]	12	Home-based computer game VR (9 patients)	Home-based computer game with head rotation input device provided a simple method of grading gaze exercises; weekly email or telephone call was given to monitor progress, answer questions and to progress exercises; weekly exercise log was maintained by patients	All patients performed HEP for 12 weeks. There was a significant difference in the outcome measures post intervention. Daily exercise log showed that average exercise time was 35.4 minutes per session which exceeded the instructed exercise time.
	Prospective intervention study				
8)	Topuz <i>et al.</i> , 2004 [20]	8	Clinic (112 patients) and home (93 patients)	Patients continued same exercises at home with support of a written HEP on a daily basis for 6 weeks; HEP adherence was monitored with a daily chart completed by patients	Post intervention 80% patients showed improvement on outcome measures. Faster recovery was noticed during supervised sessions in clinic while there was no significant improvement noticed at the end of stage 2 of intervention.

HEP: home exercise program, VR: vestibular rehabilitation, SC: symptom control.

group with telephone support carried out the exercises at a greater intensity than the booklet only group. This study provided evidence that both booklet interventions with or without telephone support were highly cost effective.

Yardley *et al.* [17] investigated effectiveness of exercise booklet and telephone call supported HEP to usual medical care in adults with chronic dizziness. Self-reported adherence was fair, 71% of participants carried out the exercises most of the days of the week, 55% continued the exercises for at least 9 weeks or until symptoms subsided. Telephone counseling was given to 85% of participants 1 week after initial session and to 76% of participants 3 weeks after initial session. At 3 months follow up post intervention, VR group showed significant improvement on all primary outcome measures as compared to usual medical care group. This study provided evidence that exercise booklet along with telephone call supported HEP provided a fair level of adherence to exercise program.

Topuz *et al.* [20] studied the post intervention results of clinical along with home VR that was supported with written exercise instructions for patients with unilateral chronic vestibular dysfunction. At the end of the first stage (clinic), 68.8% of patients were in the exercise program while at the end of second stage (home program), 65.6% of patients continued to be in the exercise program. Post intervention, 80% patients showed improvement on outcome measures. Faster recovery was noticed during supervised sessions in clinic while there was no significant improvement noticed at the end of stage 2 of intervention. This study provided evidence that written instruction helps to ensure patients' adherence to HEP.

Meldrum *et al.* [19] investigated HEP adherence with conventional balance exercise in VR versus virtual reality gaming system-based HEP in patients with unilateral peripheral vestibular loss. Patients in both groups were given an exercise booklet to refer for HEP and they also maintained an exercise diary. A high level of adherence to exercise was reported for groups, 78.5% in the conventional group and 77.1% in the virtual reality group. There was no significant difference between the groups post intervention. This study provided evidence that referring to an exercise booklet and maintenance of exercise diary for both virtual reality gaming system-based balance exercises and conventional balance exercises reported high level of adherence to HEP.

2) HEP with computerized technology: Four high quality studies investigated the effectiveness of computerized tech-

nology to improve patient's HEP adherence.

Meldrum *et al.* [19] investigated HEP adherence with conventional balance exercise in VR versus virtual reality gaming system-based HEP in patients with unilateral peripheral vestibular loss. Both groups reported a high level of adherence to exercise, 78.5% in the conventional group and 77.1% in the virtual reality group. There was no significant difference between the groups post intervention. This study provided evidence that virtual reality gaming system-based balance exercises are not more effective as compared to conventional balance exercises for improving patient's HEP adherence.

Pavlou *et al.* [16] studied effectiveness of supervised physical therapy session of optokinetic stimulus training via a full-field visual environment rotator (OKF) versus supervised physical therapy session of optokinetic training with digital versatile disk (video) versus unsupervised video for HEP. Each group received customized exercises video for HEP. The dropout rate was significantly high, 55% for optokinetic stimuli training unsupervised (OKU) compared to 10% dropout rate for both supervised exercise groups (OKF and optokinetic stimuli training supervised [OKS]). There was no significant difference in the outcome measures among the groups post intervention. This study provided evidence that instructing patients to follow video alone for HEP is not effective for decreasing the patients' dropout rate and hence doesn't help to improve their HEP adherence.

Smaerup *et al.* [18] compared the effectiveness of a computer assisted HEP versus conservative home training with printed exercise instructions in older adults with chronic dizziness. There was no significant difference between both programs with the reported compliance rate for computer program exercise being 57%. This study provided evidence that computer program assisted HEP was not more effective in improving outcome and treatment adherence than printed exercise instruction assisted HEP.

Szturm *et al.* [15] studied the post intervention effect of home computer game-based VR in adults with peripheral vestibular dysfunction. There were no dropouts, 100% adherence to exercise program, and all participants performed HEP for 12 weeks. There was a significant difference in the outcome measures post intervention. A limitation addressed by the authors was that the study was a pre post-case series with no comparisons that can be made to the existing VR. This study provided evidence that use of computer game-based VR can improve HEP adherence.

3) HEP with tele-rehabilitation: Three high quality stud-

ies investigated the effectiveness of tele-rehabilitation to improve HEP adherence.

Yardley *et al.* [10] studied the effectiveness of booklet-based VR versus booklet-based VR with telephone support versus routine medical care. Adherence to exercise was 44% for the booklet self-management along with telephone support group, while it was 34% in the booklet self-management only group. This difference was not significant but the group with telephone support reported carrying out the exercises at a greater intensity than the booklet only group. This study provided evidence that both booklet interventions with or without telephone support were highly cost effective.

Yardley *et al.* [17] investigated effectiveness of exercise booklet and telephone call supported HEP to usual medical care in adults with chronic dizziness. Self-reported adherence was fair, 71% of participants carried out the exercises most days of the weeks, and 55% continued the exercises for at least 9 weeks or until symptoms subsided. Telephone counseling was given to 85% of participants 1 week after initial session and to 76% of participants 3 weeks after initial session. At 3 months follow up post intervention, VR group showed significant improvement on all primary outcome measures as compared to usual medical care group. This study provided evidence that exercise booklet along with telephone call supported HEP gives a fair level of adherence to HEP.

Szturm *et al.* [15] studied the post intervention effect of home computer game-based VR in adults with peripheral vestibular dysfunction. Weekly email or telephone contact was made with patients to monitor progress, answer questions, and to progress exercises. Also, weekly exercise log was maintained by patients. Daily exercise log showed that average exercise time was 35.4 minutes per session, with 5 sessions per week, which exceeded the 20 minutes time per session that the patients were instructed to perform. There were no dropouts, 100% adherence to exercise program, and all patients performed HEP for 12 weeks. There was a significant difference in the outcome measures post intervention. A limitation addressed by the authors was that the study was a pre post-case series with no comparisons that can be made to the existing VR. This study provided evidence that use of computer game-based VR along with weekly email or telephone call can improve patient's HEP adherence.

4) HEP with exercise maintenance log: Four high quality studies investigated the effectiveness of maintenance of exercise log to improve patient's HEP adherence.

Meldrum *et al.* [19] investigated HEP adherence with conventional balance exercise in VR versus virtual reality gaming system-based HEP in patients with unilateral peripheral vestibular loss. Patients in both groups maintained an exercise diary. A high level of adherence to HEP was reported for groups, 78.5% in the conventional group, and 77.1% in the virtual reality group. There was no significant difference between the groups post intervention. This study provided evidence that maintenance of exercise diary for both virtual reality gaming system-based balance exercises and conventional balance exercises reported high level of adherence to HEP.

Pavlou *et al.* [16] studied effectiveness of supervised physical therapy session of OKF versus supervised physical therapy session of optokinetic training with digital versatile disk (video) versus unsupervised video for HEP. Each group received customized exercises video for HEP. Each group maintained a diary to record frequency, duration, and symptom level for each customized and video HEP. Diary was reviewed at each session for OKF and OKS group, while for OKU group the diary was reviewed at the final session only. The dropout rate was significantly high, 55% for unsupervised exercise group (OKU) compared to 10% dropout rate for both supervised exercise groups (OKF and OKS). There was no significant difference in the outcome measures among the groups post intervention. This study provided evidence that supervised exercise sessions along with video for HEP and maintenance of diary to record exercise symptoms helps to decrease the patients' dropout rate and hence, improve their HEP adherence.

Szturm *et al.* [15] studied the post intervention effect of home computer game-based VR in adults with peripheral vestibular dysfunction. Weekly email or telephone contact was made with patients to monitor progress, answer questions, and to progress exercises. Also, patients maintained a weekly exercise log. Daily exercise log showed that average exercise time was 35.4 minutes per session, patients performed 5 sessions per week, which exceeded the 20 minutes time per session that they were instructed to perform. There were no dropouts, 100% adherence to HEP and all patients performed HEP for 12 weeks. There was a significant difference in the outcome measures post intervention. A limitation that was addressed by the authors was that the study was a pre post-case series with no comparisons that can be made to the existing VR. This study provided evidence that use of computer game-based VR along with weekly email or telephone call and maintenance of daily exercise log can im-

prove HEP adherence.

Topuz *et al.* [20] studied the post intervention results of clinical along with home VR that was supported with written exercise instructions for patients with unilateral chronic vestibular dysfunction. Patients maintained a daily exercise chart. At the end of first stage (clinic), 68.8% of patients were in the exercise program, while at the end of second stage (home program) 65.6% of patients continued to be in the exercise program. Post intervention, 80% of the patients showed improvement on outcome measures. Faster recovery was noticed during supervised sessions in clinic while there was no significant improvement at the end of stage 2 of intervention. This study provided evidence that written exercise instructions and maintenance of a daily exercise chart by patients helps to ensure their adherence to HEP.

Discussion

This systematic review evaluated eight high quality studies. Strong evidence was identified for 3 categories of strategies used in VR HEP adherence research. These categories included providing patient with written summary of HEP, asking patient to maintain HEP record and symptoms, and providing tele-rehabilitation along with in person treatment sessions. Strong evidence was reported for computerized technology not been more effective for improving HEP adherence (e.g., home-based computer gaming program, unsupervised use of HEP video and home-based virtual reality program) than other strategies.

Non-adherence to HEP is influenced by multidimensional factors [21]. A combination of specific adherence strategies such as telephone follow-up, supportive care, information, reminders, and self-monitoring were identified as helpful in improving treatment adherence in varying populations [22-24]. In a systematic review conducted to investigate exercise adherence in patients with Parkinson's disease, it was reported that several trials identified maintenance of daily log of exercise helps to achieve high level of HEP adherence in patients [25].

In this systematic review, strong evidence was identified for providing patients with a written summary of the HEP in the form of HEP booklet and printed HEP (6 trials, 1,207 participants). Strong evidence was also identified for patients maintaining the record of exercise and symptoms influenced their adherence to HEP and the overall outcome of intervention (4 trials, 234 participants). Also, tele-rehabilitation in the form of email support or telephone support

along with in person treatment session showed strong evidence for improving HEP adherence and the outcome of the treatment program (3 trials, 516 participants). Strong evidence was reported for computerized technology not been more effective for improving HEP adherence in VR (4 trials, 204 participants) than other strategies.

Studies published in non-indexed journals, unpublished studies and those published in languages other than English may have been missed. Smaerup *et al.* [18] did not report the HEP adherence rate for the control group, which can affect the confidence in the finding of the studies included in this systematic review. Identification of just eight studies in this systematic review could thereby limit the conclusion that can be drawn. This emphasizes the necessity for further investigation of HEP adherence strategies in VR.

This systematic review included 8 relevant studies. Strong evidence was identified for 3 major categories of effective HEP adherence strategies including providing patients with written summary of HEP, asking patients to maintain a record of HEP and symptoms, and providing tele-rehabilitation in the form of email and/or telephone support along with in person treatment sessions. Finally, strong evidence indicated that computerized technology was not superior to other strategies for improving HEP adherence in VR. Identification of barriers to adherence may help to develop more strategies to enhance HEP adherence in VR.

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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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