Vestibular rehabilitation for unilateral peripheral vestibular dysfunction (Review)

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[Intervention Review]

Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

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ABSTRACT

Background

This is an update of a Cochrane Review first published in *The Cochrane Library* in Issue 4, 2007.

Unilateral peripheral vestibular dysfunction (UPVD) can occur as a result of disease, trauma or postoperatively. The dysfunction is characterised by complaints of dizziness, visual or gaze disturbances and balance impairment. Current management includes medication, physical manoeuvres and exercise regimes, the latter known collectively as vestibular rehabilitation (VR).

Objectives

To assess the effectiveness of vestibular rehabilitation in the adult, community-dwelling population of people with symptomatic unilateral peripheral vestibular dysfunction.

Search strategy

We searched the Cochrane Ear, Nose and Throat Disorders Group Trials Register; the Cochrane Central Register of Controlled Trials (CENTRAL); PubMed; EMBASE; CINAHL; Web of Science; BIOSIS Previews; Cambridge Scientific Abstracts; ISRCTN and additional sources for published and unpublished trials. The most recent search was 1 July 2010, following a previous search in March 2007.

Selection criteria

Randomised trials of adults living in the community, diagnosed with symptomatic unilateral peripheral vestibular dysfunction. We sought comparisons of VR versus control (placebo etc.), other treatment (non-VR, e.g. pharmacological) or another form of VR. We considered the outcome measures of frequency and severity of dizziness or visual disturbance; changes in balance impairment, function or quality of life; and measure/s of physiological status with known functional correlation.

Data collection and analysis

Both authors independently extracted data and assessed trials for risk of bias.

Main results

We included 27 trials, involving 1668 participants, in the review. Trials addressed the effectiveness of VR against control/sham interventions, medical interventions or other forms of VR. Individual and pooled data showed a statistically significant effect in favour of VR over control or no intervention. The exception to this was when movement-based VR was compared to physical manoeuvres for benign paroxysmal positional vertigo (BPPV), where the latter was shown to be superior in cure rate in the short term. There were no reported adverse effects.

Authors' conclusions

There is moderate to strong evidence that VR is a safe, effective management for unilateral peripheral vestibular dysfunction, based on a number of high quality randomised controlled trials. There is moderate evidence that VR provides a resolution of symptoms and improvement in functioning in the medium term. However, there is evidence that for the specific diagnostic group of BPPV, physical (repositioning) manoeuvres are more effective in the short term than exercise-based vestibular rehabilitation; although a combination of the two is effective for longer-term functional recovery. There is insufficient evidence to discriminate between differing forms of VR.

PLAIN LANGUAGE SUMMARY

Vestibular rehabilitation for unilateral peripheral vestibular dysfunction to improve dizziness, balance and mobility

People with vestibular problems often experience dizziness and trouble with vision, balance or mobility. The vestibular disorders that are called unilateral and peripheral (UPVD) are those that affect one side of the vestibular system (unilateral) and only the portion of the system that is outside of the brain (peripheral - part of the inner ear). Examples of these disorders include benign paroxysmal positional vertigo (BPPV), vestibular neuritis, labyrinthitis, one-sided Ménière's disease or vestibular problems following surgical procedures such as labyrinthectomy or removal of an acoustic neuroma. Vestibular rehabilitation for these disorders is becoming increasingly used and involves various movement-based regimes. Components of vestibular rehabilitation may involve learning to bring on the symptoms to 'desensitise' the vestibular system, learning to co-ordinate eye and head movements, improving balance and walking skills, learning about the condition and how to cope or become more active.

We found 27 randomised clinical trials that investigated the use of vestibular rehabilitation in this group of disorders. All studies used a form of vestibular rehabilitation and involved adults who lived in the community with symptomatic, confirmed UPVD. The studies were varied in that they compared vestibular rehabilitation with other forms of management (for example medication, usual care or passive manoeuvres), with control or placebo interventions or with other forms of vestibular rehabilitation. Another source of variation between studies was the use of different outcome measures (for example reports of dizziness, improvements in balance, vision or walking, or ability to participate in daily life). Due to the variation between studies, only limited pooling of data was possible. The results of four studies could be combined, which demonstrated that vestibular rehabilitation was more effective than control or sham interventions in improving subjective reports of dizziness, and in improving participation in life roles. Three studies gave a combined result in favour of vestibular rehabilitation for improving walking. Other single studies all found in favour of vestibular rehabilitation for improvements in areas such as balance, vision and activities of daily living. The exception to these findings was for the specific group of people with BPPV, where comparisons of vestibular rehabilitation with specific physical repositioning manoeuvres showed that these were more effective in dizziness symptom reduction, particularly in the short term. However, other studies demonstrated that combining the manoeuvres with vestibular rehabilitation was effective in improving functional recovery in the longer term. There were no reports of adverse effects following any vestibular rehabilitation, and in the studies with a follow-up assessment (3 to 12 months) positive effects were maintained. There was no evidence that one form of vestibular rehabilitation is superior to another.

There is a growing and consistent body of evidence to support the use of vestibular rehabilitation for people with dizziness and functional loss as a result of UPVD. The studies were generally of moderate to high quality and were varied in their methods.

BACKGROUND

This is an update of a Cochrane Review first published in *The Cochrane Library* in Issue 4, 2007.

People with dysfunction within the vestibular system (vestibulopathy) often complain of dizziness, visual or gaze disturbances and balance disorders. Dizziness alone accounts for nearly seven million doctor visits per annum in the US (Gans 2002). These impairments lead to significant activity and participation restrictions for the person affected (Perez 2001). The cause of the dysfunction can be a disease-related pathology or trauma and can be sited in the central (brain) or peripheral (inner ear) portions of the vestibular system. More specifically, because the vestibular system is replicated symmetrically in the periphery, many commonly presenting vestibulopathies involve unilateral (asymmetrical) peripheral vestibular dysfunction (UPVD). Examples of these disorders include benign paroxysmal positional vertigo (BPPV), vestibular neuritis, Ménière's disease (and endolymphatic hydrops) and perilymphatic fistula. Unilateral peripheral dysfunction can also occur after surgical interventions such as unilateral labyrinthectomy or neurectomy (acoustic or vestibular) (Curthoys 2000; Fetter 2000). This review will only address the management of these unilateral peripheral diagnoses.

Table 1 contrasts the incidence, aetiology, symptomatology, diagnosis and specific management of the most prevalent unilateral peripheral vestibulopathies. Whilst there are many aspects specific to each group, there are commonalities in terms of presentation of symptoms that have been reported to be amenable to interventions such as vestibular rehabilitation.

Table 1. Unilateral peripheral vestibulopathies

Vestibulopathy	Incidence	Aetiology	Symptoms	Diagnosis	Treatment
Benign paroxysmal positional vertigo (BPPV) (idiopathic) (Hilton 2004)	All age groups Peak 40 to 60 years 11 to 64 per 100,000 pa Females > males	Various: Canalithiasis (free-floating debris in semicircular canals) Cupulolithiasis (debris attached to cupula)	Episodic vertigo after rapid head motion, lasting seconds to 1 min; +/- nausea; some balance deficits; nystagmus (latency, fatigue, rotatory and beating)	Dix-Hallpike test (post) (Dix 1952) Lateral head-trunk tilt (Brandt 1999) etc Use of ENG to record nystagmus	1. Repositioning manoeuvre/s relative to semicircular canal (Epley 1992, Semont 1988) 2. VR 3. Vestibular suppressant medication for symptom relief 4. Vestibular Neurectomy or post-semicircular canal obliteration
Vestibular neuritis (Gans 2002)/ neuronitis and labyrinthitis (Strupp 1998)	Unknown	Unclear Viral, auto-immune or vascular mechanisms Viral or bacterial infection of labyrinthine fluids (labyrinthitis) or CN VIII (neuritis)	Acute onset Distressing tonal imbalance producing: rotatory vertigo; spontaneous nystagmus (horizontal); falls to the affected side; nausea	From history and presentation ENG and caloric irrigation show reduced or no response in horizontal semicircular canal; ocular tilt reaction	Symptomatic medication (vestibular suppressants) Bacterial/viral management VR
Ménière's disease (Scott 1994)	Unknown Equal males and females Greatest in 3rd and 4th decades	Unclear Endolymphatic hydrops	Acute: unpredictable and episodic Hearing loss, tinnitus and vertigo, +/- nausea, vomiting,	History and presentation Audiogram ENG with calorics	Acute: medication (antihistamines, suppressants) diet; low salt; diuretics Chronic: VR, psy-

Table 1. Unilateral peripheral vestibulopathies (*Continued*)

			visual disturbance, anxiety, motion sensitivity Chronic: UPVD or bilateral PVD		chological support, surgery (see next row)
Postoperative: Labyrinthectomy Neurectomy In- tra-tympanic injection of gentamycin	Unknown	For management of intractable UPVD, tumour removal, Ménière's	UPVD, i.e. spontaneous nystagmus, vertigo, disequilibrium, VOR gain, postural instability	-	VR Symptomatic medication (Dowdal-Osborn 2002)
Perilymphatic fistula (Baloh 2003)	Unknown	History of head trauma, barotraumas or sudden strain; may be associated with chronic oti- tis or cholesteatoma; perforation of tympanic membrane	Unilateral hearing loss, vertigo, nystagmus	Induce symptoms by pressure in external ear canal Positive head thrust ENG Audiography	Symptomatic medication Surgical packing

ENG = electronystagmography
pa = per year
UPVD = unilateral peripheral vestibular disorder
VOR = vestibular ocular reflex
VR = vestibular rehabilitation

General treatment and management options

It has been reported that in many cases of chronic vestibular dysfunction, pharmacological and surgical interventions offer limited improvement (Smith-Wheelock 1991). Medication is often directed at vestibular suppression and/or control of symptoms, such as nausea, or for specific disease processes, such as control of infection. Surgery has a limited role in the management of patients with vestibular dysfunction. It can be used as a 'last resort' in patients whose symptoms are attributable to episodic fluctuation in peripheral function. In such patients, a procedure may be undertaken to remove function from a peripheral vestibular structure (by for example labyrinthectomy) or to interrupt the central input of vestibular signals (by vestibular nerve section). Fluctuating vestibular function is thereby replaced with a fixed vestibular deficit. Surgery may also have a role in certain specific conditions, such as the repair of a perilymphatic fistula or removal of an acoustic neuroma.

There has been increasing interest in the use of vestibular rehabilitation for the treatment or management of patients with vestibular dysfunction (Chang 2008; Gans 2002; Giray 2009). Vestibular rehabilitation is an exercise-based group of approaches that began with the aim of maximising central nervous system compensation for vestibular pathology (Denham 1997). The original protocols by Cooksey and Cawthorne used group activities in a hierarchy of difficulty to challenge the central nervous system (Cooksey 1946). More recently, specific components have been further defined in the vestibular rehabilitation armamentarium (Herdman 2000), each having differing physiological or behavioural rationales as summarised below:

Compensatory responses (for positional or motion-provoked symptoms), based on the inherent plasticity of the central nervous system and using motion to habituate or reduce responsiveness to repetitive stimuli and to re-balance tonic activity within the vestibular nuclei (Gans 2002). Whilst this process is often termed habituation it is more likely to be a compensatory or neuroplastic

process rather than a physiological synaptic habituation response.
Adaptation for visual-vestibular interaction (gaze stabilisation) and possibly eye/hand co-ordination, using repetitive and provocative movements of the head and/or eyes to reduce error and restore vestibulo-ocular reflex (VOR) gain.
Substitution which promotes the use of individual or combinations of sensory inputs (such as visual or somatosensory) to bias use away from the dysfunctional vestibular input or conversely to strengthen use and drive compensation.
Postural control exercises, falls prevention, relaxation training, (re)conditioning activities and functional/occupational retraining which are based on motor learning principles to change movement behaviour and/or to promote movement fitness.
In addition there are specific *repositioning* manoeuvres that may be incorporated into the overall vestibular rehabilitation package for particular diagnostic groups of vestibular dysfunction (for example benign paroxysmal positional vertigo) (Bronstein 2003; Hilton 2004). These manoeuvres (e.g. canalith repositioning manoeuvres or Epley's, Semont and liberatory) are performed on the patient (rather than the patient performing exercises) and are based on a mechanical rationale to shift vestibular debris. Such techniques are not the focus of this review.
In summary, the symptoms and signs of vestibular dysfunction of varying aetiologies are frequent, and often chronic and disabling. Differential diagnosis between possible pathologies is often difficult with many patients receiving a label of "unilateral vestibulopathy of unknown cause" (Baloh 2003). Vestibular rehabilitation is a growing method used to reduce resultant impairments and is believed to be predominantly management-based (in that it is not 'curative'). Furthermore, vestibular rehabilitation tends to be delivered, and investigated, as a package and prescription is based on the presence of symptoms rather than a specific diagnosis. This review updates the previous Cochrane Review of 2007 for vestibular rehabilitation and a second general review also published in 2007 for a broader range of vestibular disorders conducted by Hansson (Hansson 2007).

OBJECTIVES

To assess the effectiveness of vestibular rehabilitation in the adult, community-dwelling population of people with symptomatic unilateral peripheral vestibular dysfunction.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials.

Types of participants

Community-dwelling adults with vestibular dysfunction of unilateral peripheral origin, experiencing a combination of symptoms that may include one or all of the following: dizziness, vertigo, balance deficits (dysequilibrium), visual or gaze disturbances.
Participants with a diagnosis of a symptomatic unilateral, peripheral vestibular dysfunction, named as: peripheral vestibular hypofunction, vestibular neuritis, acoustic neuroma/schwannoma, perilymphatic fistula, Ménière's disease, benign paroxysmal positional vertigo or a combination of these. In the case of a diagnosis of Ménière's disease the participants are in the late stage with a fixed (non-fluctuating) vestibular deficit.

Types of interventions

Interventions described as 'vestibular rehabilitation' that are predominantly exercise and movement-based, excluding specific (passive) repositioning manoeuvres.
Vestibular rehabilitation does not include medical, electrophysiological or pharmacological management.
Possible comparison interventions from the literature included:

- vestibular rehabilitation versus control (placebo, sham or usual care);
- vestibular rehabilitation versus other treatment (e.g. pharmacological or surgical); and
- vestibular rehabilitation of one type versus another form of vestibular rehabilitation.

Types of outcome measures

Primary outcomes

Measure(s) of change in the specified symptomatology (for example proportion with dizziness resolved) and/or changes in function or quality of life. Symptomatic ratings must be reported and recorded pre- and post-trial.

Secondary outcomes

Measure(s) of physiological status where reproducibility has been confirmed and shown to be relevant or related to health status (for example posturography).

Search methods for identification of studies

We conducted systematic searches for randomised controlled trials. There were no language, publication year or publication status restrictions. The date of the last search was 1 July 2010, following a previous search in March 2007.

Electronic searches

We searched the following databases from their inception for published, unpublished and ongoing trials: the Cochrane Ear, Nose and Throat Disorders Group Trials Register; the Cochrane Central Register of Controlled Trials (CENTRAL Issue 2, *The Cochrane Library* 2010); PubMed; EMBASE; AMED; CINAHL; LILACS; KoreaMed; IndMed; PakMediNet; CAB Abstracts; Web of Science; BIOSIS Previews; CNKI; ISRCTN; ClinicalTrials.gov; ICTRP (International Clinical Trials Registry Platform) and Google. We modelled subject strategies for databases on the search strategy designed for CENTRAL. Where appropriate, we combined subject strategies with adaptations of the highly sensitive search strategy designed by the Cochrane Collaboration for identifying randomised controlled trials and controlled clinical trials (as described in *The Cochrane Handbook for Systematic Reviews of Interventions* Version 5.0.2, Box 6.4.b. (Handbook 2009)). Search strategies for major databases including CENTRAL are provided in Appendix 1.

Searching other resources

We scanned the reference lists of identified publications for additional trials and contacted trial authors where necessary. In addition, we searched PubMed, TRIPdatabase, NHS Evidence - ENT & Audiology and Google to retrieve existing systematic reviews relevant to this systematic review, so that we could scan their reference lists for additional trials.

Data collection and analysis

Selection of studies

One of the authors retrieved papers from the identified lists on the basis of title and abstract. The two authors then reviewed these in full against the established criteria and confirmed them as eligible for consideration. Where there was disagreement between the authors about the inclusion/exclusion criteria, a third expert was consulted and a consensus decision reached.

Data extraction and management

The two authors extracted data from the included studies independently using standardised data forms.

Assessment of risk of bias in included studies

We independently assessed the quality of included studies. We assessed risk of bias using the criteria recommended in Section 8 of *The Cochrane Handbook for Systematic Reviews of Interventions* Version 5.0.1 (Handbook 2009). The six domains are sequence generation, allocation concealment, blinding of participants, personnel and outcome assessors, incomplete outcome data, selective reporting and 'other' (sample size). The latter judgement was based on reported power calculations. We gave an overall judgement for each of the domains for each study using three levels - low, unclear or high risk of bias. Risk of bias was also reported as part of the analysis of findings.

Data synthesis

We extracted and analysed data to calculate odds ratios (fixed-effect), 95% confidence intervals and individual and total effect sizes. This required the identification of the number of participants in each group in each trial and total number (for dichotomous data) and number of participants plus mean and standard deviations for each group (for continuous outcome data).

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies; Characteristics of ongoing studies.

From the 2010 update searches a total of 802 references were retrieved: 652 of these were removed in first-level screening (i.e. removal of duplicates and clearly irrelevant references), leaving 150 references for further consideration. Of the 15 retrieved from this list, we ultimately included six studies and added these to the original 21 studies. We excluded a further 10 because they did not meet the review inclusion criteria (see Characteristics of excluded studies). A further four citations reported trial protocols however the authors did not respond to our request for clarification of completion. The current review therefore includes a total of 27 studies (1668 participants) and a total of 21 studies are excluded. In searches from 2007, a total of 232 papers were retrieved and reviewed against the inclusion criteria with 32 being accepted for initial inclusion and quality assessment. After quality appraisal and full consideration we excluded a further 11 for reasons such as subject inclusion of mixed aetiology (e.g. unilateral and bilateral vestibular dysfunction, inclusion of vestibulopathy of central origin or of unknown aetiology), lack of clear intervention or lack of randomisation (see Characteristics of excluded studies table). We included several studies investigating patients with dizziness from a variety of aetiologies (unilateral and bilateral vestibular dysfunction) because they differentiated between the two groups in the analyses (Krebs 2003; Pavlou 2004; Scott 1994; Szturm 1994). This enabled the UPVD patients to be analysed separately. Yardley 1998 and Yardley 2004 also included subjects with dizziness of vestibular origin with mixed aetiology but stipulated that central

pathology was excluded. We also decided that because these authors confirmed dizziness as the primary symptom that this would effectively confirm an asymmetrical pathology.
We also noted that several papers reported the same trial but with differing outcome measures in each of the papers, notably Cohen 2003 and McGibbon 2004, although the two reports of the latter study were later excluded due to mixed aetiology.

Design

Whilst all studies reported randomisation, the majority were unclear in their description of the method of allocation or generation.
The comparisons varied, with 14 investigating vestibular rehabilitation versus placebo or sham interventions. Seven studies compared vestibular rehabilitation with a non-vestibular rehabilitation intervention. Twelve studies compared a form of vestibular rehabilitation with one or more other forms of vestibular rehabilitation.

Sample sizes

A total of 1668 subjects participated in the 27 studies, with a mean sample size of 64.6 and a range of 14 to 360. Sample size calculations were rarely reported and this omission (with probable poor statistical power) in the smaller studies was a frequent methodological flaw.

Setting

Four studies investigated vestibular rehabilitation in an acute hospital setting, with the remainder being conducted in community or outpatient environments. Some studies required the vestibular rehabilitation intervention to be performed in the outpatient clinic, others established programmes to be performed in the home or more frequently a combination of the two was administered.

Participants

Participants were all adults, living in the community under normal circumstances. The four studies investigating vestibular rehabilitation in the hospital setting recruited participants who were community dwellers pre- and post-operatively. Whilst the acute hospital inpatients were ultimately community dwellers, we separated these out in the final discussion. Age range varied, with most studies reporting a higher recruitment of people in the 65 plus range, reflecting the increasing incidence of dizziness with increasing age.
Six studies investigated benign paroxysmal positional vertigo, five investigated acute unilateral vestibular loss, four investigated post-operative patients (either acoustic neuroma resection or ablative vestibular surgery), two specifically investigated Ménière's (non-acute phase) and the rest reported their sample variously as having chronic unilateral vestibular weakness, hypofunction, dysfunction or dizziness of vestibular origin (including labyrinthitis, neuronitis and other mixed or idiopathic unilateral peripheral vestibular dysfunction pathologies).

Interventions

As expected most studies included a mixture of the various components of vestibular rehabilitation, the most common combination being habituation (movement-provoking) with gaze stabilising (adaptation), balance and gait/activity training (17). Other additions to this type of package included education (three), booklet-based (two), sensory substitution (three) and relaxation (two).
Five studies described single component vestibular rehabilitation: these included Varela 2001 investigating Brandt Daroff exercises (a form of habituation), Cohen 2003 investigating rapid versus slow head movements (habituation) and Scott 1994 investigating relaxation. Two studies compared individualised vestibular rehabilitation with a generic vestibular rehabilitation programme (Szturm 1994; Zimbelman 1999).
Control or placebo interventions involved either usual care or some form of sham exercise that did not target compensatory or adaptation processes (e.g. sham manoeuvres, range of motion, general conditioning, general instructions or strength training).
Studies that compared vestibular rehabilitation with non-vestibular rehabilitation interventions were also varied. Chang 2008, Cohen 2005, Toledo 2000 and Varela 2001 compared exercise-based vestibular rehabilitation with repositioning manoeuvres; Kulcu 2008 and Horak 1992 compared vestibular rehabilitation with medication; Scott 1994 compared vestibular rehabilitation (relaxation) with electrical stimulation and Barozzi 2006 compared oculomotor exercises (adaptation VR) with electrical stimulation.

Outcomes

There was considerable variation in the outcome measures used. We considered those that related to symptomatology (dizziness, dysequilibrium or visual disturbance) or functional status (gait, activities of daily living - ADL). Secondary outcome measures that have previously been shown to relate to function such as visual acuity or posturography (also described as computerised dynamic posturography or Equi-test) were also considered. Other reported physiological measures - such as electronystagmography (ENG) and tests for vestibular ocular reflex (VOR) and ocular torsion, subjective visual vertical or biomechanical tests of kinematic and kinetic parameters - were not considered because they have not been directly related to health or functional status.
The outcome measures included in the analyses were as follows.

Primary outcomes

Subjective measures of change in symptoms (impairments):

- Dizziness cure rate - 'cure' defined as the disappearance of the sensation of dizziness (Varela 2001): dichotomous data of proportion cured.
- Subjective improvement in dizziness - subjects asked to nominate improvement (better) or no change/worsening in subjective experience of dizziness (dichotomous) (Horak 1992; Yardley 1998; Yardley 2004; Yardley 2006; Zimbelman 1999).
- Vertigo symptom scale (VSS) - shortened version (14-item), measuring frequency of dizziness/vertigo, imbalance and related autonomic symptoms during the past month, higher score indicates greater symptoms (score range 0 to 60) (Pavlou 2004; Yardley 1998; Yardley 2004; Yardley 2006). Component related to vertigo reported (VSS-V), second component related to autonomic/somatic anxiety (VSS-A).
- Vertigo visual analogue scale (VAS) - subjective rating of vertigo on a closed VAS ranging from 0 mm (no symptoms) to 100 mm (worst possible symptoms) (Kammerlind 2005).
- Vertigo intensity (VI) - subjective rating of intensity of vertigo on a five point qualitative scale from 1 (no vertigo) to 5 (severe) (Cohen 2002; Cohen 2003).
- Vertigo frequency (VF) - subjective rating of frequency of vertigo experiences on a four point scale from 0 (no episodes per day) to 3 (> 10 episodes per day or constantly) (Cohen 2002; Cohen 2003).

Secondary outcomes

Objective measures of change in impairment, activity or participation:

- Repetitive head movement task - measure of standard head movements and resultant provocation (or not) of symptoms, scored as time to perform and intensity of elicited vertigo. Reduction in time and intensity scores indicates improvement (intensity scores not analysed) (Cohen 2003).
- Dynamic visual acuity - tests for visual acuity during head movements either under predictable conditions (patient moved own head) or unpredictable (head moved by tester), related to oscillopsia and scored as number of errors during tests (Herdman 2003).
- Romberg test - a measure of standing balance, as dichotomous data, scored as number of pass or fail scores (Herdman 1995). Also (sharpened) Romberg test (scores) - static standing balance tests, timed in seconds where the higher score indicates better (longer) balance (Kammerlind 2005; Yardley 1998).
- Sway path - measure of standing balance, recording the length of the path of the centre of force (in two planes) during a given time and potentially under differing stance conditions, giving a total sway path measured in metres per minute where the smaller path indicates greater balance proficiency (Strupp 1998). Also posturography - (computerised dynamic posturography) a battery of standing balance tests under prescribed variable conditions (sensory organisation test), which can be scored as composite scores and sensory ratios (compared to normative data, other variables available) (Cohen 2002; Cohen 2003; Pavlou 2004).
- Dynamic gait Index (DGI) - scores eight mobility tasks (ranging from straight walking through to stair ascent/descent) to give a total score of 24 points (Chang 2008; Teggi 2009; Vereeck 2008).
- Gait ataxia - dichotomous data, scored as the presence or absence of abnormal co-ordination during walking (Herdman 1995) or as continuous data from deviations along a lined walking task (Cohen 2003).
- Tandem walk - test of dynamic balance and gait proficiency where subject walks 15 steps forward then backward along a line, scored as number of correct steps (performed heel to toe and on line) with a higher score indicating greater proficiency (Kammerlind 2005).
- Vestibular dysfunction in activities of daily living (VD-ADL) - questionnaire to rate impact of dizziness or vestibular dysfunction on primary activities of daily life, higher score indicates greater functional loss (Cohen 2003; Yardley 1998).
- Vertigo handicap questionnaire (VHQ) - shortened version (14-item) which measures restriction of activity caused by dizziness and the social effects of this activity restriction (score range 0 to 56) (Cohen 2003; Yardley 1998).
- Dizziness handicap inventory (DHI) - measures patient perception of handicap related to dizziness (an indication of effect of the symptom on participation or quality of life), where a higher score indicates greater dysfunction (Barozzi 2006; Giray 2009; Teggi 2009; Yardley 2004; Yardley 2006; Zimbelman 1999).

Follow-up assessment was variable from no follow up (12 studies) to between two, three, six and 12 months for the remaining studies.

Risk of bias in included studies

The risk of bias for each of the six domains is reported for each trial in the individual 'Risk of bias' tables (see Characteristics of included studies). A summary is also illustrated in Figure 1 and Figure 2. These figures most significantly demonstrate a marked deficiency in the reporting of the methods used to generate and conceal the randomisation process across the majority of studies. The other domains were more clearly reported and generally were evaluated at a low risk of bias.

Figure 1. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

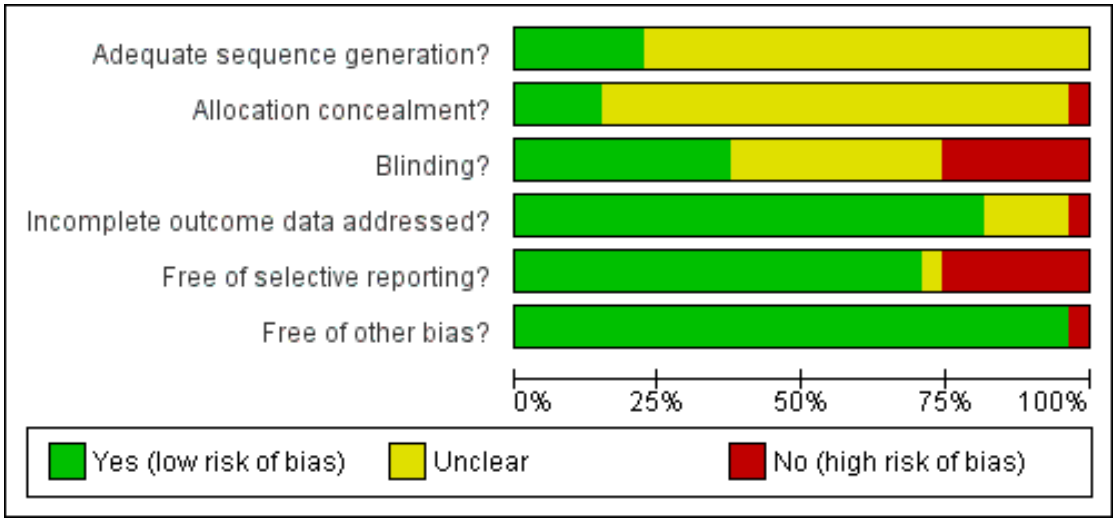
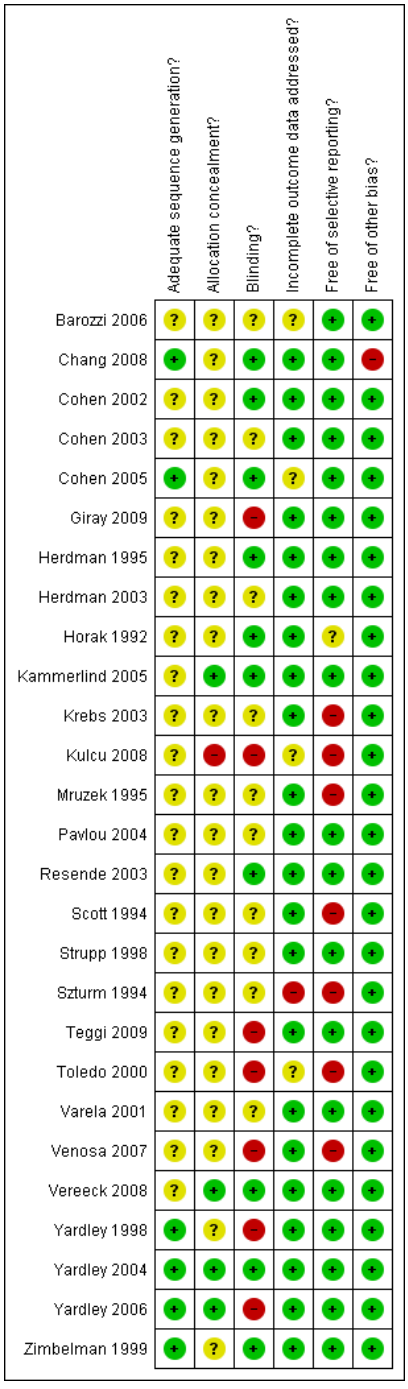


Figure 2. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Effects of interventions

The majority of studies measured more than one aspect (symptomatology and/or function), therefore some participants appear in more than one section. Seven studies did not provide the necessary data to enable further analyses and therefore appear in the included studies but not in the meta-analyses. The majority of all analyses contain data from only one study each, due to the heterogeneity of outcome measures within each comparison. Three studies potentially appear in more than one comparison as they had three-way (or more) group comparisons (Cohen 2005; Horak 1992; Yardley 2006). Vereeck 2008 data appear twice in one analysis but this is reporting separate subgroups based on age (< 50 and > 50 years old).

Comparison 1: Vestibular rehabilitation versus control (placebo, sham, usual care or no intervention)

There were 13 trials analysed in this comparison (Cohen 2002; Cohen 2005; Giray 2009; Herdman 1995; Herdman 2003; Horak 1992; Resende 2003; Strupp 1998; Teggi 2009; Vereeck 2008; Yardley 1998; Yardley 2004; Yardley 2006). Two other studies performed this comparison (Krebs 2003; Venosa 2007), however they could not supply data to enable meta-analysis.
Statistically significant differences between vestibular rehabilitation and control/placebo interventions in favour of vestibular rehabilitation were found for the following.

Primary outcome

- Subjective improvement in dizziness (OR fixed 2.67, 95% CI 1.85 to 3.86, P < 0.0001) (Analysis 1.3) (Horak 1992; Yardley 1998; Yardley 2004; Yardley 2006).
- Vertigo symptom scale (VSS) (SMD fixed -0.68, 95% CI -0.87 to -0.49, P < 0.00001) (Analysis 1.7) (Yardley 1998; Yardley 2004; Yardley 2006).

Secondary outcomes

- Gait ataxia (OR fixed 0.04, 95% CI 0.00 to 0.77, P = 0.03) (Analysis 1.2) (Herdman 1995).
- Vestibular disorders activities of daily living (VD-ADL) (SMD fixed -2.71, 95% CI -4.17 to -1.25, P = 0.0003) (Analysis 1.4) (Resende 2003).
- Sway path (posturography data) (SMD fixed -2.94, 95% CI -3.87 to -2.01, P < 0.00001) (Analysis 1.5) (Strupp 1998).
- Dynamic visual acuity (OR fixed 84.00, 95% CI 4.51 to 1564.26, P = 0.003) (Analysis 1.6) (Herdman 2003).
- Vertigo handicap questionnaire (VHQ) (SMD fixed -0.33, 95% CI -0.66 to 0.00, P = 0.05) (Analysis 1.8) (Yardley 1998).
- Sharpened Romberg scores (balance) (SMD fixed 0.35, 95% CI 0.02 to 0.68, P = 0.04) (Analysis 1.9) (Yardley 1998).
- Dizziness handicap inventory (DHI) (SMD fixed -0.80, 95% CI -1.00 to -0.60, P < 0.00001) (Analysis 1.13) (Giray 2009; Teggi 2009; Yardley 2004; Yardley 2006).
- Dynamic gait index (DGI) (SMD fixed -0.92, 95% CI -1.38 to -0.46, P < 0.0001) (Analysis 1.14) (Teggi 2009; Vereeck 2008, < 50 and > 50 years old).

Differences were non-significant for the other four measures: Romberg test, vertigo intensity (two separate comparisons) and posturography.
The two studies which could not be included in the meta-analysis, due to inadequate reporting of data (Krebs 2003; Venosa 2007) supported the positive findings of vestibular rehabilitation improving gait and reducing duration of dizziness symptoms compared to a control group. Details of these studies' results are in the table Characteristics of included studies.

Comparison 2: Vestibular rehabilitation versus other treatment (non-vestibular rehabilitation)

There were six studies in this comparison (Barozzi 2006; Chang 2008; Cohen 2002; Cohen 2005; Horak 1992; Varela 2001) with a further three studies with inadequate data (Kulcu 2008; Scott 1994; Toledo 2000).

Primary outcome

Statistically significant differences between vestibular rehabilitation and other interventions (manoeuvres) in favour of 'other' (where 'other' were physical manoeuvres for BPPV) were found for the following.

- Dizziness cure rate (OR fixed 0.13, 95% CI 0.03 to 0.51, P = 0.004) (Analysis 2.2) (Varela 2001).

Secondary outcome

Statistically significant differences between vestibular rehabilitation plus CRM (physical manoeuvres for BPPV) and CRM only, in favour of vestibular rehabilitation plus CRM were found for the following.

- Dynamic gait index (SMD fixed -0.87, 95% CI -1.69 to -0.06, P = 0.03) (Analysis 2.6) (Chang 2008).

Differences were non-significant for all other measures (four): subjective improvement in dizziness, vertigo intensity (two) and dizziness handicap inventory.
One study not included in the meta-analysis (Kulcu 2008) compared a home-based exercise programme with betahistine medication and found that the exercise programme improved dizziness symptoms and health-related quality of life to a greater extent.

The second study (Scott 1994) compared relaxation with electrical stimulation and found no significant differences. The third study not included in the meta-analysis (Toledo 2000) compared only the Semont manoeuvre with combined manoeuvre and vestibular rehabilitation for people with BPPV. The manoeuvre was found to be superior in cure rate in the short term (15 days) but the combination approach was superior in the longer term (three months). Details of these studies' results are in the table Characteristics of included studies.

Comparison 3: Vestibular rehabilitation versus other form of vestibular rehabilitation

Five studies were included in these analyses (Cohen 2003; Kammerlind 2005; Pavlou 2004; Yardley 2006; Zimbelman 1999). Another two studies also performed this comparison but did not provide appropriate data (Mruzek 1995; Szturm 1994). Statistically significant differences between one form of vestibular rehabilitation and another form of vestibular rehabilitation in favour of the inclusion of simulator activities were found for the following.

Primary outcome

- Vertigo symptom scale (VSS-V) (SMD fixed 1.12, 95% CI 0.45, 1.80, P = 0.001) (Analysis 3.6) (Pavlou 2004).

Differences were non-significant for all other measures (16) in these comparisons between different forms of vestibular rehabilitation: repetitive head movement task, vertigo VAS, tandem walk, posturography (two), VSS (two), DHI (two), subjective improvement in dizziness, VI, VF, VHQ, ataxia, VD-ADL and subjective health.

Of the two studies not included in the meta-analysis, one reported similar results whether vestibular rehabilitation was performed with or without social support (Mruzek 1995) and the other reported that a formal vestibular rehabilitation programme was more effective in improving balance/reducing falls than a home-based Cooksey Cawthorne programme (Szturm 1994). Details of these studies' results are in the table Characteristics of included studies.

DISCUSSION

If consideration is directed solely at the clinical question, 'Is vestibular rehabilitation effective in improving the symptoms of unilateral peripheral vestibular dysfunction?', then the evidence from the review is sufficient to answer yes, given the number of moderate to high quality studies reporting outcomes in favour of the vestibular rehabilitation intervention. The 2010 update has served to strengthen the original 2007 findings. The heterogeneity of the 27 studies still acts as a qualifier to this strong conclusion. The study variability lies in three domains: the varied comparators and the nature of the vestibular rehabilitation intervention, the sample characteristics (for example sub-categories of unilateral peripheral vestibular dysfunction, or acute versus chronic) and the outcome measures. In the following section we discuss the studies by grouping them in these three domains in turn, to answer subsidiary questions of, 'Is vestibular rehabilitation better than no or other interventions' and 'What form of vestibular rehabilitation is most effective, do different categories of unilateral peripheral vestibular dysfunction respond differently and what signs/symptoms are affected?' Unless otherwise indicated, we will only discuss the studies where data could be extracted.

Comparisons

Taken at the strictest level of evidence provided by meta-analysis, the low risk of bias studies of Giray 2009, Horak 1992, Teggi 2009, Vereeck 2008, Yardley 1998, Yardley 2004 and Yardley 2004 offer support for the use of vestibular rehabilitation to improve subjective measures of dizziness (including the vestibular symptom scale), level of participation (DHI) and gait performance (DGI) in people with chronic peripheral vestibulopathy, as compared to sham exercises or no vestibular rehabilitation/usual care. Individually the studies of Herdman 1995, Herdman 2003, Resende 2003 and Strupp 1998 also offer evidence of effectiveness for improvement in measures of balance, activities of daily living and vision compared to no or sham interventions. These studies, as a body of evidence, therefore offer strong support for the effectiveness of vestibular rehabilitation across a broad range of outcomes in unilateral peripheral vestibular dysfunction as compared to placebo, sham or no intervention. it should be noted that a large degree of heterogeneity was found for the comparisons using the VSS and the DHI. We examined the studies that contributed to this finding (Yardley 2004 and Yardley 2006) and found that the only clinical source of heterogeneity was in the population, where one was general UPVD and the other Ménière's disease. However, these populations are both versions of chronic UPVD.

Studies which compared vestibular rehabilitation to other forms of unilateral peripheral vestibular dysfunction management (non-vestibular rehabilitation) include Barozzi 2006 (electrical stimulation), Horak 1992 and Kulcu 2008 (medication), Chang 2008 (physical manoeuvres for BPPV (CRM) plus vestibular rehabilitation versus CRM alone), Toledo 2000 (Semont manoeuvre) and Varela 2001 (Semont and Epley manoeuvres). Horak 1992 and Kulcu 2008 found that vestibular rehabilitation was superior to medication in improving subjective reports of dizziness in people with unilateral peripheral vestibular dysfunction, however Toledo 2000 and Varela 2001 found in favour of manoeuvres. The difference in findings can be explained by considering the different subject groups - Horak recruited a pool of people with general PVD whereas Varela investigated confirmed BPPV diagnoses only. This specific issue of BPPV will be discussed later. The studies by

Cohen 2002 and Cohen 2005 failed to reach a sufficient effect size despite statistical significance in the original 2005 paper. Barozzi 2006 reported no difference in effect size between the VR and electrical stimulation groups.

Considering the relative effectiveness of different forms of vestibular rehabilitation, only one study reached statistical significance in our review. Pavlou 2004 compared customised home-based vestibular rehabilitation exercises with the same programme plus simulator-based visual and self-motion stimulation, finding in favour of the supplemented programme. Therefore there is some evidence to support the addition of simulator-based activities in a vestibular rehabilitation approach. The lack of homogeneity means that it is not possible to draw strong conclusions about the other studies that compared different versions of vestibular rehabilitation. However if we broadly compare the types of vestibular rehabilitation approach across studies in the meta-analysis, the strongest evidence emerges from the Yardley studies that investigated a simplistic version of vestibular rehabilitation consisting of education, demonstration and follow up with an exercise booklet, versus just a booklet alone that provided basic vestibular rehabilitation exercises. Kammerlind 2005 also found no difference between groups receiving home-based vestibular rehabilitation plus extra physical therapy or home vestibular rehabilitation alone. This suggests that the intervention can be administered in quite a minimalist fashion and still be effective. Cohen 2003 also reported no difference between rapidly performed vestibular rehabilitation (with or without extra attention) compared to more slowly performed vestibular rehabilitation. Further studies with a larger sample size are needed to clarify questions of which exercises, in what environment, administered by whom and for how long or how intensively (dosage).

Sub-diagnoses of unilateral peripheral vestibular dysfunction

The majority of studies investigated chronic dizziness of broad unilateral peripheral vestibular dysfunction origin. However, four studies considered vestibular rehabilitation in the acute stage immediately **post-surgery** for acoustic neuroma resection. Vereeck 2008 reported that older subjects in particular (> 50 years old) regained postural control more quickly with vestibular rehabilitation compared to general instructions, and that the greater benefits for postural control were maintained 12 months postoperatively. Herdman 1995 found a variable picture comparing vestibular rehabilitation which targeted vestibular gain versus eye movements that did not influence gain, reporting that balance and gait tests were superior in the vestibular rehabilitation group at day six postoperatively. Cohen 2002 found no difference between vestibular rehabilitation and sham interventions at day six, whilst Mruzek 1995 (not possible to include in the meta-analysis) found that vestibular rehabilitation (with or without social reinforcement) had better effects than a sham exercise for several dizziness and sensitivity quotients in the longer term (seven weeks post-operation).

Kammerlind 2005 investigated **acute** unilateral vestibular loss, comparing two forms of vestibular rehabilitation, and finding them equally effective. Teggi 2009 (vestibular rehabilitation versus control) and Venosa 2007 (adaptation vestibular rehabilitation versus placebo) both reported greater benefits for people with acute vestibular presentations receiving vestibular rehabilitation, in terms of reduced symptom duration and medication use.

A third specific group investigated was subjects with confirmed **BPPV**. Resende 2003 investigated elderly patients with BPPV comparing either vestibular rehabilitation (Cooksey Cawthorne type exercises) with no intervention - both groups had received prior Ginkgo biloba. The vestibular rehabilitation group performed significantly better on measures of activities of daily living post-intervention. In contrast, the study of Varela 2001 also investigated subjects with confirmed BPPV and found that manoeuvres (either Epley or Semont) were more effective in producing resolution than habituation exercises (Brandt 1999). They concluded that a hierarchy of interventions should be offered to people with BPPV, starting with a canalith repositioning manoeuvre. This suggestion has found favour in current clinical practice and is supported by the similar study of Cohen 2005 (though not in the meta-analysis) who also found in favour of manoeuvres (canalith repositioning manoeuvre and modified Liberatory) compared to two versions of vestibular rehabilitation habituation exercise, noting that the exercises were also superior to a sham manoeuvre. Similarly Toledo 2000 found the Semont manoeuvre to be superior to vestibular rehabilitation alone at 15 days, however by three months a combination of Semont and vestibular rehabilitation was superior to either of the sole interventions. The Semont only group had a > 30% recurrence rate by this time leading these authors to suggest vestibular rehabilitation has a preventative role. This result was confirmed more recently by Chang 2008 who compared canalith repositioning manoeuvres with vestibular rehabilitation versus CRM alone. They reported the combination promoted greater mobility skills (improved DGI) than the CRM alone. This body of evidence suggests that for people with BPPV the primary intervention should include manoeuvres to actually treat the condition and that this should be supported by vestibular rehabilitation to aid in longer-term functional recovery. The evidence for the effectiveness of manoeuvres for BPPV is the subject of an earlier Cochrane Review (Hilton 2004).

Vestibular neuritis was investigated firstly by Strupp 1998 who found postural control measures improved more in a group of patients with vestibular neuritis who performed vestibular rehabilitation (physical therapy and home-based) compared to no specific intervention (other than encouragement to move). Teggi 2009 more recently also reported that vestibular rehabilitation significantly reduced anxiety in people with acute neuritis compared to the control group.

Scott 1994 investigated people with **Ménière's disease** but found

no difference between applied relaxation training versus transcutaneous nerve stimulation on dizziness scores (could not be included in meta-analysis). Yardley 2006 also investigated people in a non-acute phase of Ménière's disease using booklet based forms of vestibular rehabilitation or symptom management and reported significant effects for subjective improvement in dizziness compared to control.

Outcome measures

Sixteen different measures were included in the results of this review as summarised in the Results section. They covered impairments (dizziness and visual disturbances), activity restrictions (balance and gait parameters, activities of daily living) and participation restrictions (quality of life and social roles). As reported, the four common outcome measures available to pool were dizziness reduction scores and the vestibular symptom scale (measures of impairment), the dizziness handicap inventory (measure of participation) and the dynamic gait index (measure of activity). Future studies should consider evaluation at these three levels and should wherever possible use the vestibular-specific scales.

Further considerations

Follow up was performed in the majority of studies and confirmed that any positive effects gained lasted for the three, six or 12-month period. This lends further support to the conclusions in favour of the use of vestibular rehabilitation for unilateral peripheral vestibular dysfunction as does the lack of reported adverse events. Studies also reported nil, or low to moderate drop-out rates and loss to follow up, though there was some suggestion that compliance may be an issue in some groups. Yardley 2006 reported a strong correlation between adherence and positive outcomes using booklet-based vestibular rehabilitation. These issues warrant further investigation both within future randomised controlled trials and with qualitative methodology to establish the individual experiences regarding patient acceptability of vestibular rehabilitation interventions.

AUTHORS' CONCLUSIONS

Implications for practice

There is moderate to strong evidence that vestibular rehabilitation (movement, exercise-based) is a safe and effective approach for unilateral peripheral vestibular disorders. This is based on (at least) 12 moderate to high quality studies comparing vestibular rehabilitation to placebo, sham or non-vestibular rehabilitation interventions. Improvements are reported across a range of outcomes including symptom reduction (dizziness), gait, ADL, visual impairments, balance and quality of life domains, though the number of studies supporting these latter individual outcome measures is small.

There is also moderate evidence that there is maintenance of improvements over the following months post-intervention.

The evidence for the dosage (frequency, intensity, timing) and specifics of vestibular rehabilitation (e.g. compensatory, adaptation, substitution, task-specific) is not clear from the largely heterogeneous studies. However, it appears even a minimalist approach of education, demonstration and home exercises may be effective.

There is mixed evidence for the effectiveness of exercise-based vestibular rehabilitation compared to repositioning manoeuvres for the specific diagnosis of BPPV. On balance there is more evidence for the use of repositioning manoeuvres in the first instance, if BPPV is confirmed, with evidence that vestibular rehabilitation should be incorporated in the long term as a preventative measure or to promote functional recovery, or both.

There is moderate evidence that vestibular rehabilitation is effective in improving function in post-surgical patients (acoustic neuroma resection), patients with vestibular neuritis or with acute unilateral peripheral vestibular dysfunction.

There is some evidence for the use of vestibular rehabilitation in patients with Ménière's disease in reducing dizziness.

Implications for research

Further research in this field should consider:

1. Patient diagnosis - in general researchers follow clinical practice and group all unilateral peripheral vestibular dysfunction patients together. It may also be useful to consider sub-diagnoses, however it is very difficult to differentially diagnose for the majority of unilateral peripheral vestibular dysfunction presentations. Several studies were rejected because they included bilateral peripheral vestibular dysfunction.

2. Power - small patient numbers reduce the strength of evidence. This is an issue for vestibular research where patient numbers in specific diagnostic categories may be small. Strong recommendations are made for multi-centre trials to boost power and allow for stratification of sub-diagnoses.

3. Generally study methodology was strong (given the inability to blind subjects in these clinical trials) however poor reporting of randomisation methods introduced uncertainty about risk of bias and poor reporting of basic means and standard deviations prevented more comprehensive data pooling.

4. Consistent use of valid and reliable, vestibular-specific outcome measures that cover the levels of impairment (subjective and objective), activity and participation restrictions.

International consensus could confirm a more consistent adoption of such scales.

5. Further quantitative and qualitative examination of patient compliance and adverse events.

6. Comparisons of different vestibular rehabilitation components to clarify questions of process, dosage and delivery. Whilst these studies are being performed, they require more appropriate methodology as noted above to enable meta-analysis.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Barozzi 2006

Methods	Randomised controlled trial
Participants	n = 28 Acute unilateral peripheral vestibular deficit
Interventions	Group 1: Oculomotor rehabilitation (adaptation) Group 2: Vestibular electrical stimulation VR versus non-VR
Outcomes	DHI Posturography
Notes	No significant differences between groups

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	There is insufficient information regarding the blinding of participants and assessors
Incomplete outcome data addressed? All outcomes	Unclear risk	The total numbers of participants in each group at follow up was not reported
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Chang 2008

Methods	Randomised controlled trial
Participants	n = 26 Unilateral posterior canal BPPV First ever attack of BPPV, diagnosed by neurologists and after clinical examinations to exclude peripheral vestibular hypofunction and central vestibular lesions

Chang 2008 (*Continued*)

Interventions	Group 1: Canal repositioning technique (CRT) and vestibular exercises Group 2: CRT only VR versus other (CRT)
Outcomes	Posturography (Balance Master) DGI Vertigo intensity (VAS) Tandem walk
Notes	Group 1 demonstrated a significant improvement in single leg stance with eyes closed at the 2-week assessment, and static balance and DGI at the 4-week assessment

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Low risk	"Subjects were then randomly assigned to either group by an independent person who picked one of the sealed envelopes before the start of the intervention"
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Low risk	Blinding of participants was possible but was not described. Outcomes were assessed by the same evaluator who was blinded to group assignment
Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	High risk	Authors acknowledge that the intensity and duration of treatment were greater in the experimental group which received 6.6 hours of treatment compared with 0.3 hours in the control group (p. 345)

Cohen 2002

Methods	Randomised controlled trial
Participants	n = 31 Acoustic neuroma resection - postoperative (1 week - acute) Diagnosed by history, audiometry, MRI
Interventions	Group 1: VR (head exercises) Group 2: Control (attention only) VR versus control (nil)

Cohen 2002 (*Continued*)

Outcomes	VOR Posturography VI and VF WOL	
Notes	No significant difference between all groups	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Low risk	Outcome assessors and treating physiotherapists were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	29% of participants were lost to follow up but the authors attempted to correct for this in the statistical analysis
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Cohen 2003

Methods	Randomised controlled trial
Participants	n = 53 Chronic vestibulopathy (labyrinthitis or neuronitis of more than 2 months) Diagnosed by physician using posturography, calorics and oculomotor test battery
Interventions	Group 1: VR (slow head exercises - habituation) Group 2: VR (rapid head exercises) Group 3: VR (rapid plus attention) VR versus VR versus VR
Outcomes	VSS VDADL VHQ DHI VI VF

Cohen 2003 (*Continued*)

Notes	All groups significantly improved for VI, VF, DHI, VSS VHQ no change	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	Outcomes were questionnaires and not likely to be affected by bias
Incomplete outcome data addressed? All outcomes	Low risk	Reasons for drop-outs following initial assessment were reported although final numbers in each group was not
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Cohen 2005

Methods	Randomised controlled trial
Participants	n = 124 (24 drop-outs) Unilateral BPPV (post SC) Diagnosed by physician (D-H test)
Interventions	Group 1: CRP (24) Group 2: LM (25) Group 3: B-D exercises (25) Group 4: Habituation exercises (25) Group 5: Sham manoeuvre (25) VR versus other (CRPs) versus placebo
Outcomes	VI VF Posturography
Notes	Manoeuvres (CRP and LM) better results than exercises (B-D, habituation), both better than sham
Risk of bias	

Cohen 2005 (*Continued*)

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Low risk	Randomisation was computer-generated by the senior investigator
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Low risk	Outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Unclear risk	16% of participants dropped out of the study with reasons. Further drop-outs after the first post-test assessment were not adequately described (at 3 and 6 months)
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Giray 2009

Methods	Randomised controlled trial
Participants	n = 41 Participants were diagnosed by a neuro-otologist or neurologist with chronic decompensated unilateral peripheral vestibular deficit, secondary to peripheral vestibular dysfunction. Diagnosed by ENG, bithermal caloric test, ocular motor testing and positional testing
Interventions	Group 1: VR incorporating adaptation, substitution, visual desensitisation and balance exercises Group 2: Control, no input VR versus control (no input)
Outcomes	Unsteadiness (VAS) DHI BBS Posturography (Balance Master)
Notes	Significant improvements were seen in all parameters for the intervention group while there were no changes in the control group

Risk of bias

Bias	Authors' judgement	Support for judgement

Giray 2009 (*Continued*)

Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	High risk	Neither participants, investigators nor outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	One patient in the control group dropped out because of difficulty commuting to the hospital
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Herdman 1995

Methods	Randomised controlled trial
Participants	n = 19 Acoustic neuroma (postoperative) Diagnosed by MRI and surgically resected - study performed in acute post period
Interventions	Group 1: VR (adaptation to increase gain) plus ambulation exercises Group 2: Smooth pursuit exercises (no head movement) plus ambulation exercises VR versus control (placebo)
Outcomes	Romberg - normal and sharpened Fukuda Gait analysis Oculomotor tests Posturography Vertigo intensity (VAS) Dysequilibrium (VAS)
Notes	Group 1 significant improvements for dysequilibrium VAS, VOR to slow head movements, gait and posturography day 6 compared to control group

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation

Herdman 1995 (*Continued*)

Blinding? All outcomes	Low risk	Outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	Two participants were excluded from analysis and numbers are provided for each group
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Herdman 2003

Methods	Randomised controlled trial
Participants	n = 21 Unilateral vestibular hypofunction Diagnosed by caloric, rotary chair, +ve head thrust, abnormal DVA
Interventions	Group 1: VR (adaptation to enhance VOR) Group 2: Placebo (exercises) VR versus control (placebo)
Outcomes	DVA during head movements (predictable and unpredictable) Oscillopsia intensity (VAS)
Notes	12/13 improved DVA in Group 1 1/8 improved DVA in Group 2 Both improved VAS

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	It is not clear whether outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	Drop-outs were explained (9%)
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported

Herdman 2003 (*Continued*)

Free of other bias?	Low risk	The study appears to be free of other sources of bias

Horak 1992

Methods	Randomised controlled trial
Participants	n = 25 Peripheral vestibular dysfunction diagnosed by neuro-otologist for BPPV, inner ear concussion syndrome, reduced unilateral vestibular function
Interventions	Group 1: VR Group 2: General conditioning exercises Group 3: Medication VR versus control (sham) versus other non-VR (medication)
Outcomes	Posturography DI SOOL Questionnaire Positional vertigo - number of positions, DI and duration
Notes	VR - superior reduction in sway and increased SOOL DI decreased for both VR and medication 92% improvement rate in VR (75% with Group 2, 75% with medication) Graphed means, no SD

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Low risk	Participants, physicians and outcome assessors were all blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	All participants were available for follow-up assessments
Free of selective reporting?	Unclear risk	Some outcome data not reported for meta-analysis
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Kammerlind 2005

Methods	Randomised controlled trial
Participants	n = 54 Acute unilateral vestibular loss Diagnosis - confirmed by ENG with calorics
Interventions	Group 1: VR (home exercises plus extra PT (habituation, adaptation, balance and gait) (extra PT included individualised instruction and further exercises) Group 2: VR (home exercises only) VR versus VR
Outcomes	ENG Balance tests (clinical) Vertigo (VAS) Balance (VAS)
Notes	No significant difference between groups - intensity not supported

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Low risk	Sealed envelopes were used to inform participants of group allocation
Blinding? All outcomes	Low risk	Outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	Drop-outs and missed sessions were reported
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Krebs 2003

Methods	Randomised controlled trial
Participants	n = 33 (UPVD), n = 51 (bilateral VD) Mixed - unilateral and bilateral peripheral vestibular dysfunction Diagnosed by VOR gain, calorics etc Excluded BPPV, Ménière's, unstable vestibulopathy

Krebs 2003 (*Continued*)

Interventions	Group 1: VR (adaptation, balance) Group 2: control (strength exercises) VR versus control (sham)
Outcomes	Locomotor stability Gait speed Base of support
Notes	VR group significantly improved for gait speed and base of support measures UPVD and BVD groups improved equally though BVD were less functional at baseline Means and SD not reported

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	It is not clear whether outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	Reasons for missing data explained for both groups and analysis done only on participants who completed the study
Free of selective reporting?	High risk	Data not reported adequately to enable meta-analysis
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Kulcu 2008

Methods	Randomised controlled trial
Participants	n = 38 Diagnosed with BPPV and has undergone repositioning techniques by their otorhinolaryngologists but were still complaining of vertigo and dysequilibrium. Participants were included in the study if they had no intervention for at least the last 3 months
Interventions	Group 1: VR (Cawthorne-Cooksey exercises) Group 2: Medication (betahistine) VR versus medication
Outcomes	Vertigo, Dizziness, Imbalance Questionnaire (VDI) incorporating the symptom subscale and health-related quality of life subscale Vertigo Symptom Scale (VSS)

Kulcu 2008 (*Continued*)

Notes	The intervention group demonstrated significant improvements in the VSS and VDI at the end of the study (8 weeks)	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	"Randomization was done using a sequence of random numbers before the baseline assessments were recorded"
Allocation concealment?	High risk	Randomisation was performed using an open random allocation schedule
Blinding? All outcomes	High risk	Neither participants, investigators nor outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Unclear risk	One patient in the exercise group dropped out because of increased severity of symptoms
Free of selective reporting?	High risk	Appropriate data not reported for meta-analysis
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Mruzek 1995

Methods	Randomised controlled trial
Participants	n = 24 Post-ablative vestibular surgery Diagnosis: physician for acoustic neuroma or Ménière's, referred for ablative surgery
Interventions	Group 1: VR plus social reinforcement Group 2: VR no SR Group 3: General exercises plus SR VR versus other VR
Outcomes	CDP MSQ DHI
Notes	All same at 4 weeks Group 1 and 2 significant improvement for MSQ at 7 weeks Group 1 significant improvement for DHI at 8 weeks CDP no difference between groups
Risk of bias	

Mruzek 1995 (*Continued*)

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	It is not clear whether outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data were reported
Free of selective reporting?	High risk	Data not reported adequately to enable meta-analysis
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Pavlou 2004

Methods	Randomised controlled trial Did not justify sample size
Participants	n = 40 Peripheral vestibular disorder diagnosed by full vestibular examination Included 1-2 bilateral patients who were examined for effects on final results - did not make a difference
Interventions	Group 1: VR (customised exercises, including gaze control and stability, balance training) (20) Group 2: Simulator (optokinetic disc to produce visual-vestibular conflict plus above) (20) VR vs VR
Outcomes	Posturography VSS-V VSS-A HADS BBS SCQ, STAI, CMSSQ
Notes	Both groups improved significantly on posturography - Group 2 > Group 1 Subjective symptom reports reduced for both ? any difference Visual-vertigo symptoms improved for Group 2 not Group 1 Depression reduced significantly for both groups - Group 2 > Group 1 Anxiety reduced for both BBS not sensitive
Risk of bias	

Pavlou 2004 (*Continued*)

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	It is not clear whether outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data were reported
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Resende 2003

Methods	Randomised controlled trial
Participants	n = 16 BPPV diagnosed by ENT using history, ENT Ex, vENG Elderly
Interventions	Group 1: VR (compensation, adaptation, sensory substitution, balance: C-C) Group 2: Control VR versus control (nil) Both groups had Ginkgo biloba prior to exercises
Outcomes	VADL
Notes	Group 1 significant improved Group 2 no change

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation

Resende 2003 (*Continued*)

Blinding? All outcomes	Low risk	It is not clear whether outcome assessors were blinded to group allocation; questionnaire results unlikely to be affected by bias
Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data were reported
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Scott 1994

Methods	Randomised controlled trial (cross-over - analysed first phase as experimental phase)
Participants	n = 20 Ménière's disease diagnosed by medical and audiological examination (5 were bilateral but had one "worse" ear)
Interventions	Group 1: Transcutaneous nerve stimulation Group 2: Applied relaxation VR (relaxation) versus other non-VR (TNS)
Outcomes	Psychoacoustic measures (not relevant) Hearing ability (not relevant) Tinnitus discomfort (not relevant) Dizziness ENG Interview/questionnaire
Notes	No change in either group for relevant measures (dizziness etc.) Group 1 improved on hearing ability > Group 2 Group 2 improved on psychoacoustic tests > Group 1

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	It is not clear whether outcome assessors were blinded to group allocation

Scott 1994 (*Continued*)

Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data were reported
Free of selective reporting?	High risk	Data not reported adequately to enable meta-analysis
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Strupp 1998

Methods	Randomised controlled trial Did not justify sample size; did not report validity and reliability of measures
Participants	n = 39 (43 spontaneous resolution subjects were removed from study) Vestibular neuritis (acute/sub-acute) Diagnosed by history, examination - nystagmus, postural imbalance, ENG, calorics, ocular tilt reaction
Interventions	Group 1: VR (home exercises, based on Cooksey-Cawthorne, Norre - habituation, gaze exercises, sensory substitution, functional retraining) Group 2: control VR versus control (nil exercise but encouragement to move)
Outcomes	Ocular tilt (vestibular-ocular system) Subjective visual vertical (perception) Sway path values (vestibulo-spinal system)
Notes	For OT and SVV tests, Group 1=control For SP VR improved significantly compared with Group 2, i.e. balance improved

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	It is not clear whether outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data were reported

Strupp 1998 (*Continued*)

Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Szturm 1994

Methods	Randomised controlled trial
Participants	n = 23 Chronic peripheral vestibular dysfunction Diagnosed by calorics, dizziness; 3 bilateral vestibulopathy subjects within 23
Interventions	Group 1: VR Group 2: VR (home, C-C) VR versus VR
Outcomes	CDP VOR OKN (step chair rotations)
Notes	Group 1 had reduced falls, improved CDP values and reduced VOR asymmetry compared with Group 2

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	It is not clear whether outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	High risk	It appears that data are missing from Group B participants but this is not adequately explained in the results
Free of selective reporting?	High risk	Data not reported adequately to enable meta-analysis
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Teggi 2009

Methods	Randomised controlled trial
Participants	n = 40 All participants were recently hospitalised for an acute episode of rotational vertigo which lasted several days and were diagnosed with vestibular neuritis
Interventions	Group 1: VR Group 2: control ("perform usual daily activities") VR versus control (nil)
Outcomes	Posturography DGI DHI Anxiety (VAS)
Notes	Significant improvement in DHI between groups and reduction in anxiety. For both groups, there was a significant correlation between change in anxiety and change in DHI/ DGI

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	High risk	Neither participants, investigators nor outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Toledo 2000

Methods	Randomised controlled trial
Participants	n = 40 BPPV
Interventions	Group 1: Semont manoeuvre Group 2: VR (PC, head-eye and habituation) Group 3: Semont + VR

Toledo 2000 (*Continued*)

	Other vs VR vs VR + other	
Outcomes	Dix-Hallpike	
Notes	Group 1 80% cure rate day 15 versus Group 2 45% Group 1 66% cure rate 3 months versus Group 3 100%	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	High risk	There was no blinding of assessors or participants
Incomplete outcome data addressed? All outcomes	Unclear risk	It is not clear from the results or the figures whether the data from all participants are included
Free of selective reporting?	High risk	Numbers of participants in each group not provided in figures of results; data not reported adequately to enable meta-analysis
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Varela 2001

Methods	Randomised controlled trial Sample size not justified, reliability and validity of measures not reported, only basic statistics
Participants	n = 106 BPPV Diagnosed by history and D-H test (nystagmus)
Interventions	Group 1: VR (B-D habituation exercises) Group 2: Semont manoeuvre Group 3: Epley manoeuvre VR versus others (CRM/CDM)
Outcomes	Dix-Hallpike Number of sessions required for resolution (Group 2 and 3) Relapse frequency Subjective rating of outcome

Varela 2001 (*Continued*)

Notes	Group 2 and 3 similar cure rate at one week, by 3 months Group 3 were superior but Group 2 more stable CRM/CDM superior to habituation (BD) for BPPV

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Unclear risk	It is not clear whether outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data were reported
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Venosa 2007

Methods	Randomised controlled trial
Participants	n = 87 Acute episode of rotational vertigo within the last 5 days. BPPV, central nervous system disorders and perilymphatic fistula were excluded
Interventions	Group 1: VOR adaptation exercises (X1 and X2 viewing exercises) Group 2: Placebo exercises (sham visual fixation task) VR versus control (sham)
Outcomes	Dizziness intensity (VAS) Use of medication (dimenhydrinate) Spontaneous nystagmus incidence Romberg test Fukuda test Post head-shaking nystagmus (PHSN)
Notes	Intervention group recovered more quickly in all parameters measured and required significantly less medication by the end of the follow-up period (21 days)

Venosa 2007 (*Continued*)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	High risk	Outcomes were assessed by the principal investigator who was not blinded to group allocation; participants were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	The drop-outs were similar between the study (13%) and control (16%) groups
Free of selective reporting?	High risk	Data not reported adequately to enable meta-analysis
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Vereeck 2008

Methods	Randomised controlled trial
Participants	n = 53 All were consecutive patients post removal of an acoustic neuroma
Interventions	Group 1: Customised VR (exercises for balance, head motion, mobility, gaze and treadmill walking) Group 2: General instructions VR versus control (nil)
Outcomes	ENG (pre-op only) DHI Balance assessment (Standing Balance Sum of 7 timed tests) Timed Up and Go (TUG) Tandem Gait DGI
Notes	Participants were stratified according to age (above and below 50 years). Older participants performed significantly better than the control group for balance, TUG and Tandem Gait compared to the control group. There was no group effect for the younger participants

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

Vereeck 2008 (*Continued*)

Adequate sequence generation?	Unclear risk	Insufficient information about the sequence generation process
Allocation concealment?	Low risk	Closed envelopes were used to conceal allocation
Blinding? All outcomes	Low risk	Assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	Although no participants withdrew from the study there were multiple occasions of missing data but the authors attempted to deal with this in the analysis
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Yardley 1998

Methods	Randomised controlled trial
Participants	n = 143 Dizziness of vestibular origin Mixed aetiology - diagnosed where possible by medical records (1/3) Possibility of central pathology
Interventions	Group 1: VR (education, head and body movements, relaxation, breathing, encouragement to function) Group 2: control VR versus control (usual medical care) Possibly included all VR components. Delivered by primary care nurse
Outcomes	VSS VHQ HADS Sharpened Romberg Provocative movements
Notes	Group 1 improved significantly on all measures > Group 2 except VHQ (no difference) Overall Group 1 4x more likely to report subjective improvement than Group 2

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Low risk	Random number tables were used in the sequence generation process

Yardley 1998 (*Continued*)

Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	High risk	Neither the therapists, outcome assessors nor participants were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	Data were missing for various measures across many time points but this is adequately explained
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Yardley 2004

Methods	Randomised controlled trial
Participants	n = 170 Chronic dizziness Dizziness of vestibular origin by case history and MPD
Interventions	Group 1: VR (primary care: demonstration, booklet and follow up) Group 2: usual medical care VR versus control
Outcomes	CDP DHI VSS (short form) MPD
Notes	All measures improved significantly in VR compared with control group Clinical improvement 67% VR; 38% control

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Low risk	Stratified block randomisation was performed by an independent researcher
Allocation concealment?	Low risk	Allocation was concealed in sealed, opaque envelopes
Blinding? All outcomes	Low risk	Outcome assessors were blinded to group allocation
Incomplete outcome data addressed? All outcomes	Low risk	Data were missing at several time points but this was accounted for in the intention-to-treat analysis

Yardley 2004 (*Continued*)

Free of selective reporting?	Low risk	Study protocol is available and all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Yardley 2006

Methods	Randomised controlled trial
Participants	n = 360 Ménière's disease (non-acute phase)
Interventions	Group 1: VR (booklet of exercises) Group 2: SC (booklet for self-management) Group 3: Waiting list control VR versus other VR versus control
Outcomes	Questionnaire (better versus same/worse) VSS DHI HADS DBS PEI Adherence
Notes	At 3 months Group 1 had greater improvement on 5 measures compared with Group 2 (2 measures) compared with Group 3 (0 measures) At 6 months Group 1 and 2 both reported significant improvement > Group 3 Correlation between adherence and outcome

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Low risk	"An independent research administrator allocated participants to the intervention arms using a computer randomization program"
Allocation concealment?	Low risk	Participants were sent a letter directly by the independent research administrator informing them of group allocation
Blinding? All outcomes	High risk	Neither participants nor assessors were blinded to group allocation. Outcomes were assessed by the use of questionnaires
Incomplete outcome data addressed? All outcomes	Low risk	The drop-out rate was reported to be 5%

Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

Zimbelman 1999

Methods	Randomised controlled trial
Participants	n = 14 Peripheral vestibular dysfunction Diagnosed by neuro-otological tests - excluded central, included unilateral weakness, BPPV, Ménière's disease, neuronitis, labyrinthitis
Interventions	Group 1: VR (individual with adaptation and postural control) Group 2: VR (general C-C) VR versus VR
Outcomes	DHI BBS
Notes	Group 1 improved dizziness over time, Group 2 did not No change for either for BBS (insensitive) No between group differences - but 100% Group 1 reported improvement compared with 62.5% Group 2 Group 1 had more Ménière's disease

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Adequate sequence generation?	Low risk	Drawing random numbers was used to generate the random sequence
Allocation concealment?	Unclear risk	Insufficient information about the method of allocation
Blinding? All outcomes	Low risk	Outcome assessors for balance tests were blinded to group allocation (not for DHI)
Incomplete outcome data addressed? All outcomes	Low risk	No missing outcome data were reported
Free of selective reporting?	Low risk	Study protocol not available but all data appear to be reported
Free of other bias?	Low risk	The study appears to be free of other sources of bias

BBS = Berg balance scale
B-D = Brandt-Daroff
BPPV = benign paroxysmal positional vertigo
C-C = Cooksey-Cawthorne
CDP = computerised dynamic posturography
CMSSQ = childhood motion sickness short form questionnaire
CRM = canalith repositioning manoeuvre
DBS = dizziness belief scale
D-H = Dix-Hallpike test
DHI = dizziness handicap inventory
DI = dizziness intensity
DVA = dynamic visual acuity
ENG = electronystagmography
HADS = hospital anxiety and depression scale
LM = liberatory manoeuvre
MPD = motion-provoked dizziness
MRI = magnetic resonance imaging
MSQ = motion sensitivity quotient
OKN = optokinetic reflex
OT = ocular tilt
PC = postural control
PEI = patient enablement instrument
PT = physical therapy
SC = symptom control e.g. stress reduction techniques aspects of CBT approach
SCQ = situational characteristics questionnaire
SOLEC = stand on one leg, eyes closed
SOOL = standing on one leg
SP = sway path
SR = social reinforcement
STAI = Spielberger state trait anxiety inventory
SVV = subjective visual vertical
TNS = transcutaneous nerve stimulation
TUG = timed up and go test
UPVD = unilateral peripheral vestibular disorder
VAS = visual analogue scale
VD-ADL = vestibular disorders activities of daily living scale
VDI = vertigo dizziness imbalance questionnaire
VF = vertigo frequency
VHQ = vestibular handicap questionnaire
VI = Vertigo Intensity
VOR = vestibular ocular reflex
VSS = vestibular symptom scale
VSS-A = anxiety component
VSS-V = vestibular component
WOL = walk on line

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Andersson 2006	PARTICIPANTS Mixed aetiology, no separate analyses
Angeli 2003	ALLOCATION Study 2 (with VR intervention) not randomised
Ellialtioglu 2003	ALLOCATION Randomised but unclear INTERVENTION Comparison predominantly one for manoeuvres
Enticott 2008	PARTICIPANTS Mixed aetiology of dizziness (included bilateral)
Hall 2010	PARTICIPANTS Dizziness was not due to a vestibular disorder
Hansson 2004	PARTICIPANTS Dizziness of central or age-related origin
Hansson 2006	PARTICIPANTS Dizziness due to whiplash-associated disorders
Jauregui-Renaud 2007	PARTICIPANTS Mixed aetiology of dizziness (included bilateral)
Johansson 2001	PARTICIPANTS Mixed aetiology of dizziness
Lauenroth 2008	INTERVENTION Not routine vestibular rehabilitation
Lillet-Leclercq 1989	ALLOCATION Not adequately randomised (year of birth)
Loader 2007	INTERVENTION Computerised optokinetic therapy not routine vestibular rehabilitation
McGibbon 2004	PARTICIPANTS Mixed unilateral and bilateral vestibular dysfunction - no separate analysis
Meli 2006	ALLOCATION Non-randomised

(*Continued*)

Oh 2009	INTERVENTION Comparison predominantly one for manoeuvres
Orendorz 2002	ALLOCATION Unclear randomisation PARTICIPANTS Unclear aetiology INTERVENTION Investigating use of adjunct pharmacology with VR
Prasansuk 2004	PARTICIPANTS Unclear aetiology; elderly people with a history of balance disorders
Rzewnicki 2008	ALLOCATION Unclear randomisation
Simoceli 2008	ALLOCATION Unclear randomisation PARTICIPANTS Elderly people with body balance disorder
Viirre 2002	ALLOCATION Control group selected not randomised
Yardley 2001	PARTICIPANTS Symptomatic dizziness INTERVENTIONS No intervention analysed

VR = vestibular rehabilitation

Characteristics of ongoing studies *[ordered by study ID]*

Mørkved 2011

Trial name or title	Effects of vestibular rehabilitation in the treatment of patients with acute vestibular loss - a randomised controlled trial
Methods	RCT
Participants	Patients aged 18 to 70 years with acute symptoms of dizziness (vestibular injury) diagnosed by videonystagmography; inclusion within one week after symptom onset Exclusion criteria: chronic dizziness; psychiatric diagnosis that might interfere with participation

Mørkved 2011 (*Continued*)

Interventions	Group 1: Vestibular rehabilitation (daily home training (4 to 6 specific exercises) 2 to 3 times per day; group training led by a physiotherapist twice per week during the first 10 weeks and once per week from 10 weeks to 12 months or until symptoms are cured) Group 2: No intervention
Outcomes	Primary outcome measure: vertigo symptom scale Secondary outcome measures: Dizziness Handicap Inventory; UCLA-DQ; HADS; VAS-scale on dizziness; registration of provoked dizziness; Accelerometer; sick leave; adverse effects
Starting date	January 2008
Contact information	Dr Siv Mørkved, Norwegian University of Science and Technology
Notes	-

Winoto 2010

Trial name or title	Does adding otolith specific exercises to a standard vestibular rehabilitation program improve outcomes for adults with inner ear dizziness?
Methods	RCT
Participants	48 with unilateral peripheral vestibular dysfunction
Interventions	Group 1 - VR (home exercise programme) plus otolith-specific exercises Group 2 - VR (home exercise programme)
Outcomes	Primary outcome: degree of perceived impairment associated with dizziness via the Dizziness Handicap Inventory Secondary outcomes: computerised dynamic posturography - composite score and condition eyes closed + sway reference
Starting date	April 2008
Contact information	Arimbi Winoto, 32 Gisborne Street East Melbourne Victoria 3002, Australia: awinotosuatmadji@students.latrobe.edu.au
Notes	-

RCT = randomised controlled trial
VR = vestibular rehabilitation

DATA AND ANALYSES

Comparison 1. Vestibular rehabilitation versus control/placebo

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Romberg test	1	19	Odds Ratio (M-H, Fixed, 95% CI)	2.7 [0.33, 21.98]
2 Gait ataxia	1	19	Odds Ratio (M-H, Fixed, 95% CI)	0.04 [0.00, 0.77]
3 Subjective improvement in dizziness	4	565	Odds Ratio (M-H, Fixed, 95% CI)	2.67 [1.85, 3.86]
4 VD-ADL (physical)	1	16	Std. Mean Difference (IV, Fixed, 95% CI)	-2.71 [-4.17, -1.25]
5 Sway path	1	39	Std. Mean Difference (IV, Fixed, 95% CI)	-2.94 [-3.87, -2.01]
6 Dynamic visual acuity	1	21	Odds Ratio (M-H, Fixed, 95% CI)	84.0 [4.51, 1564.26]
7 Vestibular symptom scale	3	553	Std. Mean Difference (IV, Fixed, 95% CI)	-0.68 [-0.87, -0.49]
8 Vestibular handicap questionnaire	1	143	Std. Mean Difference (IV, Fixed, 95% CI)	-0.33 [-0.66, 0.00]
9 Sharpened Romberg test (scores)	1	143	Std. Mean Difference (IV, Fixed, 95% CI)	0.35 [0.02, 0.68]
10 Vertigo intensity	1	31	Std. Mean Difference (IV, Fixed, 95% CI)	-0.06 [-0.76, 0.64]
11 Posturography	1	31	Std. Mean Difference (IV, Fixed, 95% CI)	0.09 [-0.61, 0.80]
12 Vertigo intensity (BD vs sham)	1	50	Std. Mean Difference (IV, Fixed, 95% CI)	-0.43 [-0.99, 0.13]
13 Dizziness Handicap Inventory	4	491	Std. Mean Difference (IV, Fixed, 95% CI)	-0.80 [-1.00, -0.60]
14 Dynamic Gait Index	2	93	Std. Mean Difference (IV, Fixed, 95% CI)	-0.92 [-1.38, -0.46]

Comparison 2. Vestibular rehabilitation versus other

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Subjective improvement in dizziness	1	21	Odds Ratio (M-H, Fixed, 95% CI)	4.0 [0.30, 53.47]
2 Dizziness cure rate	1	71	Odds Ratio (M-H, Fixed, 95% CI)	0.13 [0.03, 0.51]
3 Vertigo intensity (BD vs CRM)	1	49	Std. Mean Difference (IV, Fixed, 95% CI)	-0.10 [-0.66, 0.47]
4 Vertigo intensity (XS vs CRM)	2	75	Std. Mean Difference (IV, Fixed, 95% CI)	-0.16 [-0.61, 0.30]
5 Dizziness Handicap Inventory	1	28	Std. Mean Difference (IV, Fixed, 95% CI)	Not estimable
6 Dynamic Gait Index	1	26	Std. Mean Difference (IV, Fixed, 95% CI)	-0.87 [-1.69, -0.06]

Comparison 3. Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Repetitive head movement task	1	51	Std. Mean Difference (IV, Fixed, 95% CI)	0.45 [-0.19, 1.09]
2 Vertigo VAS	1	54	Std. Mean Difference (IV, Fixed, 95% CI)	0.22 [-0.32, 0.75]
3 Romberg test (eyes closed)	1	54	Std. Mean Difference (IV, Fixed, 95% CI)	-0.45 [-0.99, 0.09]
4 Tandem walk	1	54	Std. Mean Difference (IV, Fixed, 95% CI)	0.25 [-0.29, 0.79]
5 Posturography	1	40	Std. Mean Difference (IV, Fixed, 95% CI)	0.06 [-0.56, 0.68]
6 Vertigo symptom scale (vertigo component)	1	40	Std. Mean Difference (IV, Fixed, 95% CI)	1.12 [0.45, 1.80]
7 Dizziness Handicap Inventory	1	14	Std. Mean Difference (IV, Fixed, 95% CI)	-0.62 [-1.72, 0.47]
8 Subjective improvement in dizziness	1	14	Odds Ratio (M-H, Fixed, 95% CI)	8.27 [0.35, 197.61]
9 Vertigo intensity	1	35	Std. Mean Difference (IV, Fixed, 95% CI)	-0.34 [-1.03, 0.35]
10 Vertigo frequency	1	35	Std. Mean Difference (IV, Fixed, 95% CI)	-0.08 [-0.77, 0.61]
11 Vertigo handicap questionnaire	1	35	Std. Mean Difference (IV, Fixed, 95% CI)	0.40 [-0.29, 1.09]
12 Ataxia	1	35	Std. Mean Difference (IV, Fixed, 95% CI)	-0.38 [-1.07, 0.31]
13 Vestibular disorders - activities of daily living scale	1	35	Std. Mean Difference (IV, Fixed, 95% CI)	-0.22 [-0.90, 0.47]
14 Posturography (Equitest composite)	1	35	Std. Mean Difference (IV, Fixed, 95% CI)	0.07 [-0.61, 0.76]
15 Vertigo Symptom Scale (vertigo short form)	1	240	Std. Mean Difference (IV, Fixed, 95% CI)	0.04 [-0.21, 0.30]
16 Subjective health	1	230	Odds Ratio (M-H, Fixed, 95% CI)	1.0 [0.58, 1.71]
17 Dizziness Handicap Inventory	1	240	Std. Mean Difference (IV, Fixed, 95% CI)	0.08 [-0.18, 0.33]

Analysis 1.1. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 1 Romberg test.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 1 Romberg test

Study or subgroup	Treatment n/N	Control n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Herdman 1995	9/11	5/8		100.0 %	2.70 [0.33, 21.98]
Total (95% CI)	**11**	**8**		**100.0 %**	**2.70 [0.33, 21.98]**
Total events: 9 (Treatment), 5 (Control)					
Heterogeneity: not applicable					
Test for overall effect: Z = 0.93 (P = 0.35)					

Analysis 1.2. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 2 Gait ataxia.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 2 Gait ataxia

Study or subgroup	Treatment n/N	Control n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Herdman 1995	4/11	8/8		100.0 %	0.04 [0.00, 0.77]
Total (95% CI)	**11**	**8**		**100.0 %**	**0.04 [0.00, 0.77]**
Total events: 4 (Treatment), 8 (Control)					
Heterogeneity: not applicable					
Test for overall effect: Z = 2.13 (P = 0.033)					

Analysis 1.3. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 3 Subjective improvement in dizziness.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 3 Subjective improvement in dizziness

Study or subgroup	Treatment n/N	Control n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Horak 1992	12/13	3/4		1.0 %	4.00 [0.19, 84.20]
Yardley 1998	26/67	17/76		28.0 %	2.20 [1.06, 4.57]
Yardley 2004	56/83	33/87		30.1 %	3.39 [1.81, 6.38]
Yardley 2006	42/115	23/120		41.0 %	2.43 [1.34, 4.39]
Total (95% CI)	**278**	**287**		**100.0 %**	**2.67 [1.85, 3.86]**
Total events: 136 (Treatment), 76 (Control)					
Heterogeneity: Chi^2 = 0.99, df = 3 (P = 0.80); I^2 =0.0%					
Test for overall effect: Z = 5.22 (P < 0.00001)					

Analysis 1.4. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 4 VD-ADL (physical).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 4 VD-ADL (physical)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Resende 2003	8	11.8 (0.9)	8	22.3 (5.1)		100.0 %	-2.71 [-4.17, -1.25]
Total (95% CI)	**8**		**8**			**100.0 %**	**-2.71 [-4.17, -1.25]**

Heterogeneity: not applicable

Test for overall effect: Z = 3.64 (P = 0.00027)

Analysis 1.5. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 5 Sway path.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 5 Sway path

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Strupp 1998	19	3.2 (1.9)	20	16.9 (6.1)		100.0 %	-2.94 [-3.87, -2.01]
Total (95% CI)	**19**		**20**			**100.0 %**	**-2.94 [-3.87, -2.01]**

Heterogeneity: not applicable

Test for overall effect: Z = 6.18 (P < 0.00001)

Analysis 1.6. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 6 Dynamic visual acuity.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 6 Dynamic visual acuity

Study or subgroup	Treatment n/N	placebo n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Herdman 2003	12/13	1/8		100.0 %	84.00 [4.51, 1564.26]
Total (95% CI)	**13**	**8**		**100.0 %**	**84.00 [4.51, 1564.26]**
Total events: 12 (Treatment), 1 (placebo)					
Heterogeneity: not applicable					
Test for overall effect: Z = 2.97 (P = 0.0030)					

Analysis 1.7. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 7 Vestibular symptom scale.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 7 Vestibular symptom scale

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Yardley 1998	67	7.9 (6.4)	76	12.9 (11.8)		32.5 %	-0.52 [-0.85, -0.18]
Yardley 2004	83	9.88 (0.76)	87	13.3 (0.74)		11.0 %	-4.54 [-5.11, -3.97]
Yardley 2006	120	13.76 (10.56)	120	13.99 (11.06)		56.5 %	-0.02 [-0.27, 0.23]
Total (95% CI)	**270**		**283**			**100.0 %**	**-0.68 [-0.87, -0.49]**
Heterogeneity: Chi^2 = 201.05, df = 2 (P<0.00001); I^2 =99%							
Test for overall effect: Z = 6.99 (P < 0.00001)							

Analysis 1.8. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 8 Vestibular handicap questionnaire.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

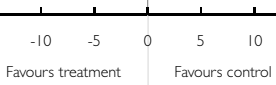
Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 8 Vestibular handicap questionnaire

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Yardley 1998	67	16 (9.9)	76	19.4 (10.6)		100.0 %	-0.33 [-0.66, 0.00]
Total (95% CI)	**67**		**76**			**100.0 %**	**-0.33 [-0.66, 0.00]**

Heterogeneity: not applicable

Test for overall effect: Z = 1.95 (P = 0.051)



Analysis 1.9. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 9 Sharpened Romberg test (scores).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

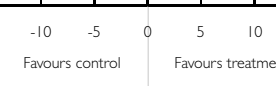
Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 9 Sharpened Romberg test (scores)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Yardley 1998	67	52 (26.8)	76	42.1 (28.7)		100.0 %	0.35 [0.02, 0.68]
Total (95% CI)	**67**		**76**			**100.0 %**	**0.35 [0.02, 0.68]**

Heterogeneity: not applicable

Test for overall effect: Z = 2.09 (P = 0.036)



Analysis 1.10. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 10 Vertigo intensity.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 10 Vertigo intensity

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2002	16	1.75 (0.6)	15	1.79 (0.7)		100.0 %	-0.06 [-0.76, 0.64]
Total (95% CI)	**16**		**15**			**100.0 %**	**-0.06 [-0.76, 0.64]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.17 (P = 0.87)

Analysis 1.11. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 11 Posturography.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

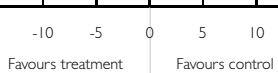
Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 11 Posturography

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2002	16	53.6 (8.9)	15	52.5 (13.7)		100.0 %	0.09 [-0.61, 0.80]
Total (95% CI)	**16**		**15**			**100.0 %**	**0.09 [-0.61, 0.80]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.26 (P = 0.80)



Analysis 1.12. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 12 Vertigo intensity (BD vs sham).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 12 Vertigo intensity (BD vs sham)

Study or subgroup	BD exercises N	Mean(SD)	sham N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2005	25	3.4 (2.3)	25	4.3 (1.8)		100.0 %	-0.43 [-0.99, 0.13]
Total (95% CI)	**25**		**25**			**100.0 %**	**-0.43 [-0.99, 0.13]**

Heterogeneity: not applicable

Test for overall effect: Z = 1.50 (P = 0.13)

Analysis 1.13. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 13 Dizziness Handicap Inventory.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 13 Dizziness Handicap Inventory

Study or subgroup	VR N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Giray 2009	20	31.6 (23.3)	21	52.9 (24.6)		9.6 %	-0.87 [-1.51, -0.23]
Teggi 2009	20	18.6 (11.7)	20	29.4 (12.8)		9.4 %	-0.86 [-1.51, -0.21]
Yardley 2004	83	31.09 (1.52)	87	35.88 (1.48)		19.1 %	-3.18 [-3.64, -2.72]
Yardley 2006	120	47.37 (22.95)	120	48.49 (22.67)		61.9 %	-0.05 [-0.30, 0.20]
Total (95% CI)	**243**		**248**			**100.0 %**	**-0.80 [-1.00, -0.60]**

Heterogeneity: Chi^2 = 138.82, df = 3 (P<0.00001); I^2 =98%

Test for overall effect: Z = 7.90 (P < 0.00001)

Analysis 1.14. Comparison 1 Vestibular rehabilitation versus control/placebo, Outcome 14 Dynamic Gait Index.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

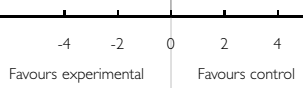
Comparison: 1 Vestibular rehabilitation versus control/placebo

Outcome: 14 Dynamic Gait Index

Study or subgroup	Control N	Mean(SD)	VR N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Teggi 2009	20	20.1 (1.1)	20	22.6 (1.1)		32.4 %	-2.23 [-3.03, -1.42]
Vereeck 2008	11	23 (0.8)	16	22.9 (0.8)		35.5 %	0.12 [-0.65, 0.89]
Vereeck 2008	11	21.6 (1.7)	15	22.6 (0.9)		32.1 %	-0.75 [-1.56, 0.06]
Total (95% CI)	**42**		**51**			**100.0 %**	**-0.92 [-1.38, -0.46]**

Heterogeneity: Chi^2 = 17.35, df = 2 (P = 0.00017); I^2 =88%

Test for overall effect: Z = 3.93 (P = 0.000086)



Analysis 2.1. Comparison 2 Vestibular rehabilitation versus other, Outcome 1 Subjective improvement in dizziness.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 2 Vestibular rehabilitation versus other

Outcome: 1 Subjective improvement in dizziness

Study or subgroup	Treatment n/N	Other (medication) n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Horak 1992	12/13	6/8		100.0 %	4.00 [0.30, 53.47]
Total (95% CI)	**13**	**8**		**100.0 %**	**4.00 [0.30, 53.47]**

Total events: 12 (Treatment), 6 (Other (medication))

Heterogeneity: not applicable

Test for overall effect: Z = 1.05 (P = 0.29)

Analysis 2.2. Comparison 2 Vestibular rehabilitation versus other, Outcome 2 Dizziness cure rate.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 2 Vestibular rehabilitation versus other

Outcome: 2 Dizziness cure rate

Study or subgroup	Treatment n/N	Other (CRM) n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Varela 2001	18/29	39/42		100.0 %	0.13 [0.03, 0.51]
Total (95% CI)	**29**	**42**		**100.0 %**	**0.13 [0.03, 0.51]**
Total events: 18 (Treatment), 39 (Other (CRM))					
Heterogeneity: not applicable					
Test for overall effect: Z = 2.92 (P = 0.0036)					

Analysis 2.3. Comparison 2 Vestibular rehabilitation versus other, Outcome 3 Vertigo intensity (BD vs CRM).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 2 Vestibular rehabilitation versus other

Outcome: 3 Vertigo intensity (BD vs CRM)

Study or subgroup	Brandt Daroff (VR) N	Mean(SD)	CRM N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2005	25	3.4 (2.3)	24	3.6 (1.8)		100.0 %	-0.10 [-0.66, 0.47]
Total (95% CI)	**25**		**24**			**100.0 %**	**-0.10 [-0.66, 0.47]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.33 (P = 0.74)							

Analysis 2.4. Comparison 2 Vestibular rehabilitation versus other, Outcome 4 Vertigo intensity (XS vs CRM).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

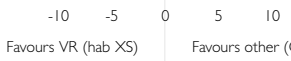
Comparison: 2 Vestibular rehabilitation versus other

Outcome: 4 Vertigo intensity (XS vs CRM)

Study or subgroup	Habituation exercise N	Mean(SD)	CRM N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Chang 2008	13	1.1 (1.2)	13	1 (1)		34.9 %	0.09 [-0.68, 0.86]
Cohen 2005	25	3.06 (1.9)	24	3.6 (1.8)		65.1 %	-0.29 [-0.85, 0.28]
Total (95% CI)	**38**		**37**			**100.0 %**	**-0.16 [-0.61, 0.30]**

Heterogeneity: $Chi^2 = 0.59$, df = 1 (P = 0.44); $I^2 = 0.0\%$

Test for overall effect: Z = 0.67 (P = 0.50)



Analysis 2.5. Comparison 2 Vestibular rehabilitation versus other, Outcome 5 Dizziness Handicap Inventory.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 2 Vestibular rehabilitation versus other

Outcome: 5 Dizziness Handicap Inventory

Study or subgroup	VR N	Mean(SD)	Other (electrical) N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Barozzi 2006	14	8.7 (2.6)	14	8.7 (2.4)		100.0 %	0.0 [-0.74, 0.74]
Total (95% CI)	**14**		**14**			**100.0 %**	**0.0 [-0.74, 0.74]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.0 (P = 1.0)

Analysis 2.6. Comparison 2 Vestibular rehabilitation versus other, Outcome 6 Dynamic Gait Index.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

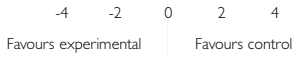
Comparison: 2 Vestibular rehabilitation versus other

Outcome: 6 Dynamic Gait Index

Study or subgroup	Control N	Mean(SD)	Experimental N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Chang 2008	13	22.5 (1.4)	13	23.5 (0.7)		100.0 %	-0.87 [-1.69, -0.06]
Total (95% CI)	**13**		**13**			**100.0 %**	**-0.87 [-1.69, -0.06]**

Heterogeneity: not applicable

Test for overall effect: Z = 2.11 (P = 0.034)



Analysis 3.1. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 1 Repetitive head movement task.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

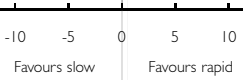
Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 1 Repetitive head movement task

Study or subgroup	Rapid VR N	Mean(SD)	Slow VR N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2003	38	49.7 (22.1)	13	40.6 (10.3)		100.0 %	0.45 [-0.19, 1.09]
Total (95% CI)	**38**		**13**			**100.0 %**	**0.45 [-0.19, 1.09]**

Heterogeneity: not applicable

Test for overall effect: Z = 1.39 (P = 0.16)

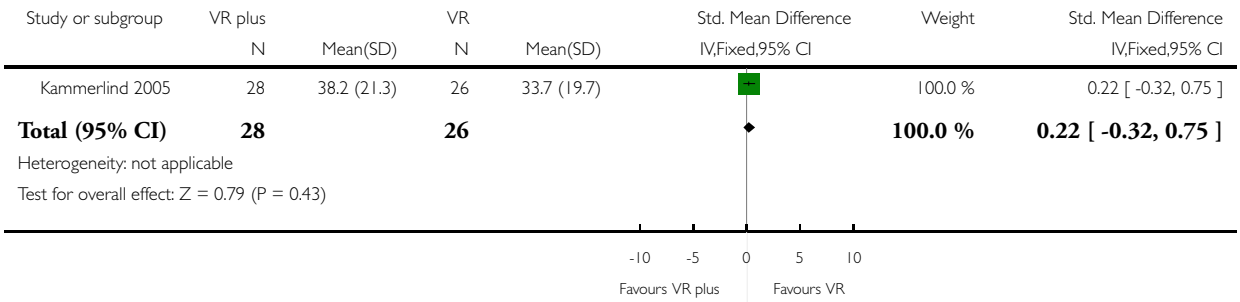


Analysis 3.2. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 2 Vertigo VAS.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 2 Vertigo VAS

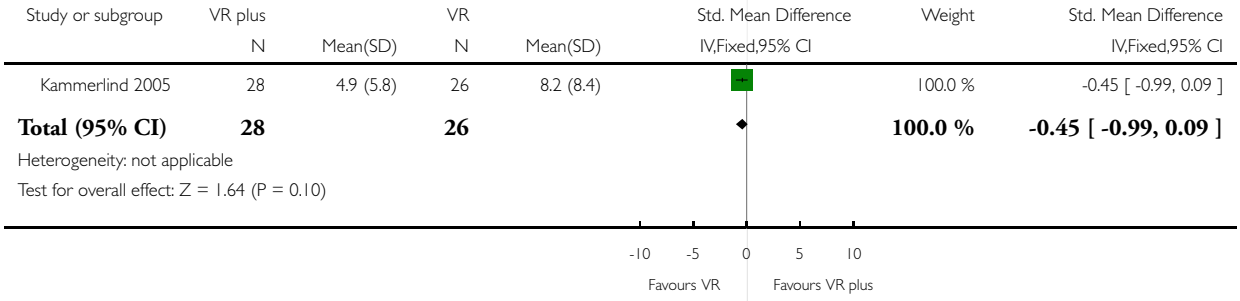


Analysis 3.3. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 3 Romberg test (eyes closed).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 3 Romberg test (eyes closed)

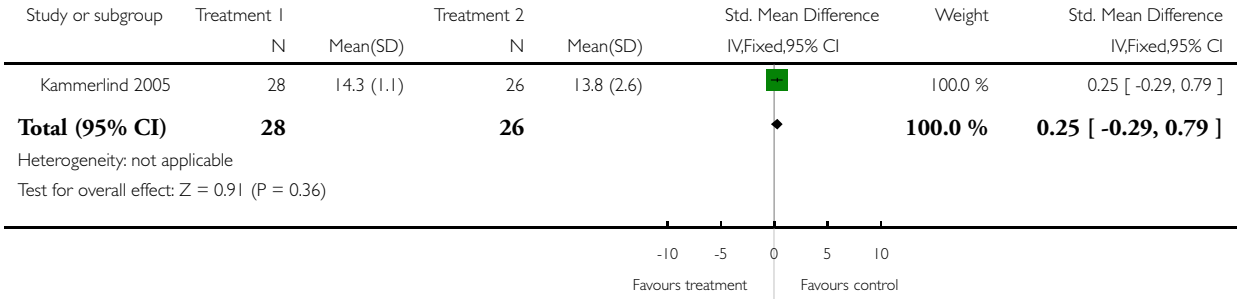


Analysis 3.4. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 4 Tandem walk.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 4 Tandem walk

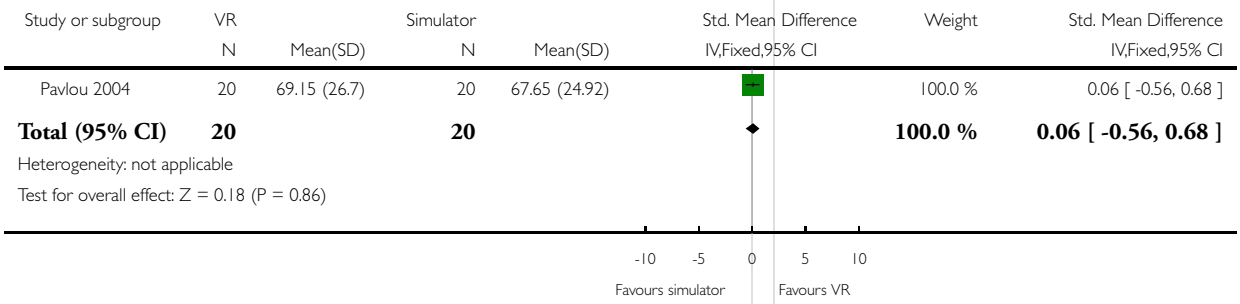


Analysis 3.5. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 5 Posturography.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 5 Posturography



Analysis 3.6. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 6 Vertigo symptom scale (vertigo component).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 6 Vertigo symptom scale (vertigo component)

Study or subgroup	VR N	Mean(SD)	Simulator N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Pavlou 2004	20	1.07 (0.18)	20	0.89 (0.13)		100.0 %	1.12 [0.45, 1.80]
Total (95% CI)	**20**		**20**			**100.0 %**	**1.12 [0.45, 1.80]**

Heterogeneity: not applicable

Test for overall effect: Z = 3.28 (P = 0.0010)

Analysis 3.7. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 7 Dizziness Handicap Inventory.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

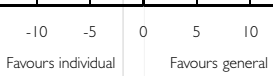
Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 7 Dizziness Handicap Inventory

Study or subgroup	VR individual N	Mean(SD)	VR general N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Zimbelman 1999	6	15 (13.9)	8	24.3 (14)		100.0 %	-0.62 [-1.72, 0.47]
Total (95% CI)	**6**		**8**			**100.0 %**	**-0.62 [-1.72, 0.47]**

Heterogeneity: not applicable

Test for overall effect: Z = 1.12 (P = 0.26)



Analysis 3.8. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 8 Subjective improvement in dizziness.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 8 Subjective improvement in dizziness

Study or subgroup	Individual n/N	General n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Zimbelman 1999	6/6	5/8		100.0 %	8.27 [0.35, 197.61]
Total (95% CI)	**6**	**8**		**100.0 %**	**8.27 [0.35, 197.61]**
Total events: 6 (Individual), 5 (General)					
Heterogeneity: not applicable					
Test for overall effect: Z = 1.31 (P = 0.19)					

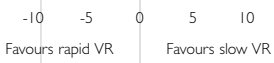
Analysis 3.9. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 9 Vertigo intensity.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 9 Vertigo intensity

Study or subgroup	Rapid VR N	Mean(SD)	Slow VR N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2003	22	3.9 (1.4)	13	4.5 (2.2)		100.0 %	-0.34 [-1.03, 0.35]
Total (95% CI)	**22**		**13**			**100.0 %**	**-0.34 [-1.03, 0.35]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.96 (P = 0.34)							



Analysis 3.10. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 10 Vertigo frequency.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

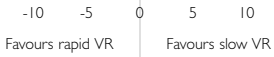
Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 10 Vertigo frequency

Study or subgroup	Rapid VR N	Mean(SD)	Slow VR N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2003	22	5 (2.1)	13	5.2 (3)		100.0 %	-0.08 [-0.77, 0.61]
Total (95% CI)	**22**		**13**			**100.0 %**	**-0.08 [-0.77, 0.61]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.23 (P = 0.82)



Analysis 3.11. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 11 Vertigo handicap questionnaire.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

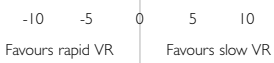
Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 11 Vertigo handicap questionnaire

Study or subgroup	Rapid VR N	Mean(SD)	Slow VR N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2003	22	66.95 (17.8)	13	59.6 (18)		100.0 %	0.40 [-0.29, 1.09]
Total (95% CI)	**22**		**13**			**100.0 %**	**0.40 [-0.29, 1.09]**

Heterogeneity: not applicable

Test for overall effect: Z = 1.14 (P = 0.26)



Analysis 3.12. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 12 Ataxia.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 12 Ataxia

Study or subgroup	Rapid VR N	Mean(SD)	Slow VR N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2003	22	1.33 (0.58)	13	1.56 (0.62)		100.0 %	-0.38 [-1.07, 0.31]
Total (95% CI)	**22**		**13**			**100.0 %**	**-0.38 [-1.07, 0.31]**

Heterogeneity: not applicable

Test for overall effect: Z = 1.07 (P = 0.28)

Analysis 3.13. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 13 Vestibular disorders - activities of daily living scale.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 13 Vestibular disorders - activities of daily living scale

Study or subgroup	Rapid VR N	Mean(SD)	Slow VR N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2003	22	1.89 (1.25)	13	2.19 (1.53)		100.0 %	-0.22 [-0.90, 0.47]
Total (95% CI)	**22**		**13**			**100.0 %**	**-0.22 [-0.90, 0.47]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.61 (P = 0.54)

Analysis 3.14. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 14 Posturography (Equitest composite).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 14 Posturography (Equitest composite)

Study or subgroup	Rapid VR N	Mean(SD)	Slow VR N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Cohen 2003	22	58.8 (22.77)	13	57.24 (18.17)		100.0 %	0.07 [-0.61, 0.76]
Total (95% CI)	**22**		**13**			**100.0 %**	**0.07 [-0.61, 0.76]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.21 (P = 0.84)

Analysis 3.15. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 15 Vertigo Symptom Scale (vertigo short form).

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 15 Vertigo Symptom Scale (vertigo short form)

Study or subgroup	VR booklet N	Mean(SD)	SC booklet N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Yardley 2006	120	13.76 (10.56)	120	13.31 (10.31)		100.0 %	0.04 [-0.21, 0.30]
Total (95% CI)	**120**		**120**			**100.0 %**	**0.04 [-0.21, 0.30]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.33 (P = 0.74)

Analysis 3.16. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 16 Subjective health.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 16 Subjective health

Study or subgroup	VR booklet n/N	SC booklet n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
Yardley 2006	42/115	42/115		100.0 %	1.00 [0.58, 1.71]
Total (95% CI)	**115**	**115**		**100.0 %**	**1.00 [0.58, 1.71]**
Total events: 42 (VR booklet), 42 (SC booklet)					
Heterogeneity: not applicable					
Test for overall effect: Z = 0.0 (P = 1.0)					

Analysis 3.17. Comparison 3 Vestibular rehabilitation versus other form of vestibular rehabilitation, Outcome 17 Dizziness Handicap Inventory.

Review: Vestibular rehabilitation for unilateral peripheral vestibular dysfunction

Comparison: 3 Vestibular rehabilitation versus other form of vestibular rehabilitation

Outcome: 17 Dizziness Handicap Inventory

Study or subgroup	VR booklet N	Mean(SD)	SC booklet N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Yardley 2006	120	47.37 (22.95)	120	45.67 (21.12)		100.0 %	0.08 [-0.18, 0.33]
Total (95% CI)	**120**		**120**			**100.0 %**	**0.08 [-0.18, 0.33]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.59 (P = 0.55)							

APPENDICES

Appendix 1. Search strategies

CENTRAL	PubMed	EMBASE (Ovid)	CINAHL (EBSCO)
#1 MeSH descriptor Vestibular Diseases explode all trees with qualifiers: NU,RH #2 MeSH descriptor Vertigo explode all trees with qualifiers: NU,RH #3 MeSH descriptor Dizziness explode all trees with qualifiers: NU,RH #4 MeSH descriptor Labyrinth Diseases explode all trees #5 MeSH descriptor Vestibulocochlear Nerve Diseases explode all trees # 6 (VERTIGO OR VESTIBULOPATH* OR DIZZINESS):ti #7 ((VESTIBULAR NEAR DISORDER*) OR (VESTIBULAR NEAR HYPOFUNCTION*) OR (VESTIBULAR NEAR DYSFUNCTION*) OR (VESTIBULAR NEAR IMPAIR*) OR (VESTIBULAR NEAR DISABILIT*) OR (VESTIBULAR NEAR PATHOLOG*) OR (VESTIBULAR NEAR DISTURBANCE*)):ti #8 ((BALANCE NEAR DISORDER*) OR (BALANCE NEAR HYPOFUNCTION*) OR (BALANCE NEAR DYSFUNCTION*) OR (BALANCE NEAR IMPAIR*) OR (BALANCE NEAR DISABILIT*) OR (BALANCE NEAR PATHOLOG*) OR (BALANCE NEAR DISTURBANCE*)):ti #9 (NEUROLABYRINTHI-	#1 "Vestibular Diseases/nursing"[Mesh] OR "Vestibular Diseases/rehabilitation"[Mesh] OR "Vertigo/nursing"[Mesh] OR "Vertigo /rehabilitation"[Mesh] OR "Dizziness / nursing"[Mesh] OR "Dizziness /rehabilitation"[Mesh] #2(VESTIBULAR [tiab] AND (REHABILITATION [tiab] OR ADAPTATION [tiab] OR HABITUATION [tiab])) # 3 "LABYRINTH DISEASES" [Mesh] OR "VESTIBULOCOCHLEAR NERVE DISEASES" OR ("PERILYMPH" [MeSH] AND "FISTULA" [Mesh]) #4 Vertigo [tiab] OR vestibulopath* [tiab] OR dizziness [tiab] OR ((vestibular [ti] OR balance* [ti]) AND (disorder [ti] OR hypofunction* [ti] OR dysfunction* [ti] OR impair* [ti] OR disability* [ti] OR pathology* [ti] OR disturbance* [ti])) #5 NEUROLABYRINTHITIDES [tiab] OR NEUROLABYRINTHITIS [tiab] OR (VESTIBULAR [tiab] AND (NEURITIS [tiab] OR NEURONITIS [tiab] OR NEURITIDES[tiab])) #6 "VESTIBULAR NERVE" [tiab] AND (INFLAMMATION [tiab] OR COMPRESSION [tiab])) #7 "ACOUSTIC NEUROMA" [tiab] OR "ACOUSTIC NEURINOMA" [tiab]	1 exp vestibular disorder/rh [Rehabilitation] 2 exp vertigo/rh [Rehabilitation] 3 dizziness/rh [Rehabilitation] 4 (VESTIBULAR and (REHABILITATION or ADAPTATION or HABITUATION)) .tw. 5 exp *inner ear disease/ 6 perilymph/ and fistula/ 7 (Vertigo or vestibulopath* or dizziness or ((vestibular or balance*) and (disorder or hypofunction* or dysfunction* or impair* or disability* or pathology* or disturbance*))).ti. 8 (NEUROLABYRINTHITIDES or NEUROLABYRINTHITIS or (VESTIBULAR and (NEURITIS or NEURONITIS or NEURITIDES))).ti. 9 ((ACOUSTIC adj NEUROMA) or (ACOUSTIC adj NEURINOMA) or (ACOUSTIC adj NEURILEMOMA) or (ACOUSTIC adj NEURILEMMOMA) or (VESTIBULAR adj SCHWANNOMA) or (ACOUSTIC adj SCHWANNOMA) or (MOTION adj SENSITIVITY) or (VESTIBULAR and PERIPHERAL) or (PERILYMPHATIC and FISTULA) or MENIERE* or (ENDOLYMPHATIC and HYDROPS) or (LABYRINTH* and HYDROPS) or (LABYRINTH* and SYNDROME) or BPV or	S1 (MH "Vestibular Diseases+/NU/RH") S2 (MH "Vertigo+/NU/RH") S3 (MH "Dizziness/NU/RH") S4 TX vestibular and TX (REHABILITATION or ADAPTATION or HABITUATION) S5 (MH "Labyrinth Diseases+") S6 (MH "VESTIBULOCOCHLEAR NERVE DISEASES+") S7 TX Vertigo or vestibulopath* or dizziness or ((vestibular or balance*) and (disorder or hypofunction* or dysfunction* or impair* or disability* or pathology* or disturbance*)) S8 TI NEUROLABYRINTHITIDES or NEUROLABYRINTHITIS or (VESTIBULAR and (NEURITIS or NEURONITIS or NEURITIDES)) S9 TX (ACOUSTIC adj NEUROMA) or (ACOUSTIC adj NEURINOMA) or (ACOUSTIC adj NEURILEMOMA) or (ACOUSTIC adj NEURILEMMOMA) or (VESTIBULAR adj SCHWANNOMA) or (ACOUSTIC adj SCHWANNOMA) or (MOTION adj SENSITIVITY) or (VESTIBULAR and PERIPHERAL) or (PERILYMPHATIC and FISTULA) or MENIERE* or (ENDOLYMPHATIC and HYDROPS)

(*Continued*)

TIDES
OR NEUROLABYRINTHITIS OR VESTIBULAR NEAR NEURITIS OR VESTIBULAR NEAR NEURONITIS OR VESTIBULAR NEAR NEURITIDES):ti
#10 (VESTIBULAR NERVE NEAR INFLAMMATION OR VESTIBULAR NERVE NEAR COMPRESSION):ti
#11 (ACOUSTIC NEUROMA* OR ACOUSTIC NEURINOMA* OR ACOUSTIC NEURILEMOMA* OR ACOUSTIC NEURILEMMOMA*):ti
#12 (VESTIBULAR SCHWANNOMA*
OR ACOUSTIC SCHWANNOMA*):ti
#13 (MOTION SENSITIVITY OR VESTIBULAR NEAR PERIPHERAL OR PERILYMPHATIC NEAR FISTULA*):ti
#14 (MENIERE* OR ENDOLYMPHATIC NEXT HYDROPS):ti
#15
((LABYRINTH* NEAR HYDROPS) OR (LABYRINTH* NEAR SYNDROME)):ti
#16 (#4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15)
#17 MeSH descriptor Occupational Therapy explode all trees
#18 MeSH descriptor Physical Therapy Modalities explode all trees
#19 MeSH descriptor Exercise Therapy explode all trees
#20 MeSH descriptor Exercise explode all trees
#21 MeSH descriptor Head Movements explode all trees

OR "ACOUSTIC NEURILEMOMA" [tiab] OR "ACOUSTIC NEURILEMMOMA" [tiab] OR "VESTIBULAR SCHWANNOMA" [tiab] OR "ACOUSTIC SCHWANNOMA" [tiab] OR "MOTION SENSITIVITY" [tiab] OR (VESTIBULAR [tiab] AND PERIPHERAL [tiab]) OR (PERILYMPHATIC [tiab] AND FISTULA [tiab]) OR MENIERE* [tiab] OR "ENDOLYMPHATIC HYDROPS" [tiab] OR (LABYRINTH* [tiab] AND HYDROPS [tiab]) OR (LABYRINTH* [tiab] AND SYNDROME [tiab]) OR BPV [tiab] OR BPPV [tiab] OR ANTBPPV [tiab]
#8 #3 OR #4 OR #5 OR #6 OR #7
#9 "OCCUPATIONAL THERAPY" [Mesh] OR "PHYSICAL THERAPY MODALITIES" [Mesh] OR "EXERCISE
THERAPY" [Mesh] OR "EXERCISE" [Mesh] OR "HEAD MOVEMENTS" [Mesh] OR "VESTIBULAR FUNCTION TESTS" [Mesh]
#10 REHABILITATION [tiab] OR PHYSIOTHERAP* [tiab] OR (PHYSICAL [tiab] AND THERAP* [tiab]) OR EXERCIS* [tiab] OR HABITUAT* [tiab] OR EPLEY [tiab] OR CANALITH [tiab] OR SEMONT [tiab] OR MANOEUVRE* [tiab] OR MANEUVER* [tiab] OR "RECONDITIONING ACTIVIT*" [tiab] OR POSTUROGRAPHY [tiab] OR "POSTURAL CONTROL" [tiab] OR PFPP [tiab] OR (SENBPPV or ANTBPPV).ti.
10 5 or 6 or 7 or 8 or 9
11 VOCATIONAL REHABILITATION/ or exp KINESIOTHERAPY/ or exp EXERCISE/ or exp HEAD MOVEMENT/
12 (REHABILITATION or PHYSIOTHERAP* or (PHYSICAL and THERAP*) or EXERCIS* or HABITUAT* or EPLEY or CANALITH or SEMONT or MANOEUVRE* or MANEUVER* or (RECONDITIONING adj ACTIVIT*) or POSTUROGRAPHY or (POSTURAL adj CONTROL) or PFPP or (SENSORY and RELEARN) or (SENSORY and RETRAIN*) or (POSTURAL and RELEARN*) or (POSTURAL and RETRAIN*)).tw.
13 ((POSITION* and PROCEDURE*) or (REPOSITION* and PROCEDURE*) or (REPOSITION* and PARTICLE*) or (VISUAL and VESTIBULAR) or (FUNCTIONAL and RETRAIN*) or (OCCUPATIONAL and RETRAIN*) or (OCCUPATIONAL and ADAPTATION) or (COOKSEY and CAWTHORNE)).tw.
14 11 or 12 or 13
15 10 and 14
16 1 or 2 or 3 or 4 or 15

or (LABYRINTH* and HYDROPS) or (LABYRINTH* and SYNDROME) or BPV or BPPV or ANTBPPV
S10 S5 or S6 or S7 or S8 or S9
S11 (MH "Occupational Therapy+")
S12 (MH "Physical Therapy+")
S13 (MH "Exercise+")
S14 (MH "Vestibular Function Tests+")
S15 TX REHABILITATION or PHYSIOTHERAP* or (PHYSICAL and THERAP*) or EXERCIS* or HABITUAT* or EPLEY or CANALITH or SEMONT or MANOEUVRE* or MANEUVER* or (RECONDITIONING adj ACTIVIT*) or POSTUROGRAPHY or (POSTURAL adj CONTROL) or PFPP or (SENSORY and RELEARN) or (SENSORY and RETRAIN*) or (POSTURAL and RELEARN*) or (POSTURAL and RETRAIN*)
S16 TX (POSITION* and PROCEDURE*) or (REPOSITION* and PROCEDURE*) or (REPOSITION* and PARTICLE*) or (VISUAL and VESTIBULAR) or (FUNCTIONAL and RETRAIN*) or (OCCUPATIONAL and RETRAIN*) or (OCCUPATIONAL and ADAPTATION) or (COOKSEY and CAWTHORNE)
S17 S11 or S12 or S13 or S14 or S15 or S16
S18 S10 and S17
S19 S1 or S2 or S3 or S4 or S18

(*Continued*)

#22 MeSH descriptor Vestibular Function Tests explode all trees #23 REHABILITAT* OR PHYSIOTHERAP* OR (PHYSICAL NEAR THERAP*) OR EXERCIS* OR HABITUAT* #24 EPLEY OR CANALITH OR SEMONT OR MANOEUVRE* OR MANEUVER* OR (RECONDITIONING ADJ ACTIVIT*) #25 POSTUROGRAPHY OR POSTURAL ADJ CONTROL OR PFPP #26 (SENSORY NEAR RELEARN*) OR (SENSORY NEAR RETRAIN*) OR (POSTURAL NEAR RELEARN*) OR (POSTURAL NEAR RETRAIN*) #27 (POSITION* NEAR PROCEDURE*) OR (REPOSITION* NEAR PROCEDURE*) OR (REPOSITION* NEAR PARTICLE*) #28 (VISUAL NEAR VESTIBULAR) OR (FUNCTIONAL NEAR RETRAIN*) OR (OCCUPATIONAL NEAR RETRAIN*) OR (OCCUPATIONAL ADJ ADAPTATION) #29 COOKSEY AND CAWTHORNE #30 (#17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29) #31 (#16 AND #30) #32 (#1 OR #2 OR #3 OR # 31)	SORY [tiab] AND RELEARN* [tiab]) OR (SENSORY [tiab] AND RETRAIN* [tiab]) OR (POSTURAL [tiab] AND RELEARN* [tiab]) OR (POSTURAL [tiab] AND RETRAIN* [tiab]) #11 (POSITION* [tiab] AND PROCEDURE* [tiab]) OR (REPOSITION* [tiab] AND PROCEDURE* [tiab]) OR (REPOSITION* [tiab] AND PARTICLE* [tiab]) OR (VISUAL [tiab] AND VESTIBULAR [tiab]) OR (FUNCTIONAL [tiab] AND RETRAIN* [tiab]) OR (OCCUPATIONAL [tiab] AND RETRAIN* [tiab]) OR (OCCUPATIONAL [tiab] AND ADAPTATION [tiab]) OR (COOKSEY [tiab] AND CAWTHORNE [tiab]) #12 #9 OR #10 OR #11 #13 #8 AND #12 #14 #1 OR #2 OR #13		
Web of Science	**BIOSIS Previews (Ovid)**	**CAB Abstracts (Ovid)**	**ISCTRN (mRCT)**

(*Continued*)

#1 TS=(VESTIBULAR and (REHABILITATION or ADAPTATION or HABITUATION)) #2 TI=(Vertigo or vestibulopath* or dizziness or ((vestibular or balance*) and (disorder or hypofunction* or dysfunction* or impair* or disability* or pathology* or disturbance*))) #3 TI=(NEUROLABYRINTHITIDES or NEUROLABYRINTHITIS or (VESTIBULAR and (NEURITIS or NEURONITIS or NEURITIDES))) #4 TI=((ACOUSTIC adj NEUROMA) or (ACOUSTIC adj NEURINOMA) or (ACOUSTIC adj NEURILEMOMA) or (ACOUSTIC adj NEURILEMOMA) or (VESTIBULAR adj SCHWANNOMA) or (ACOUSTIC adj SCHWANNOMA) or (MOTION adj SENSITIVITY) or (VESTIBULAR and PERIPHERAL) or (PERILYMPHATIC and FISTULA) or MENIERE* or (ENDOLYMPHATIC and HYDROPS) or (LABYRINTH* and HYDROPS) or (LABYRINTH* and SYNDROME) or BPV or BPPV or ANTBPPV) #5 #4 OR #3 OR #2 #6 TS=(REHABILITATION or PHYSIOTHERAP* or (PHYSICAL and THERAP*) or EXERCIS* or HABITUAT* or EPLEY or CANALITH or SEMONT or MANOEUVRE* or MANEUVER* or (RECONDITIONING adj ACTIVIT*) or POSTUROGRAPHY or (POSTU-	#1 TS=(VESTIBULAR and (REHABILITATION or ADAPTATION or HABITUATION)) #2 TI=(Vertigo or vestibulopath* or dizziness or ((vestibular or balance*) and (disorder or hypofunction* or dysfunction* or impair* or disability* or pathology* or disturbance*))) #3 TI=(NEUROLABYRINTHITIDES or NEUROLABYRINTHITIS or (VESTIBULAR and (NEURITIS or NEURONITIS or NEURITIDES))) #4 TI=((ACOUSTIC adj NEUROMA) or (ACOUSTIC adj NEURINOMA) or (ACOUSTIC adj NEURILEMOMA) or (ACOUSTIC adj NEURILEMOMA) or (VESTIBULAR adj SCHWANNOMA) or (ACOUSTIC adj SCHWANNOMA) or (MOTION adj SENSITIVITY) or (VESTIBULAR and PERIPHERAL) or (PERILYMPHATIC and FISTULA) or MENIERE* or (ENDOLYMPHATIC and HYDROPS) or (LABYRINTH* and HYDROPS) or (LABYRINTH* and SYNDROME) or BPV or BPPV or ANTBPPV) #5 #4 OR #3 OR #2 #6 TS=(REHABILITATION or PHYSIOTHERAP* or (PHYSICAL and THERAP*) or EXERCIS* or HABITUAT* or EPLEY or CANALITH or SEMONT or MANOEUVRE* or MANEUVER* or (RECONDITIONING adj ACTIVIT*) or POS-	1 (VESTIBULAR and (REHABILITATION or ADAPTATION or HABITUATION)).tw. 2 (Vertigo or vestibulopath* or dizziness or ((vestibular or balance*) and (disorder or hypofunction* or dysfunction* or impair* or disability* or pathology* or disturbance*))).ti. 3 (NEUROLABYRINTHITIDES or NEUROLABYRINTHITIS or (VESTIBULAR and (NEURITIS or NEURONITIS or NEURITIDES))).ti. 4 ((ACOUSTIC adj NEUROMA) or (ACOUSTIC adj NEURINOMA) or (ACOUSTIC adj NEURILEMOMA) or (ACOUSTIC adj NEURILEMOMA) or (VESTIBULAR adj SCHWANNOMA) or (ACOUSTIC adj SCHWANNOMA) or (MOTION adj SENSITIVITY) or (VESTIBULAR and PERIPHERAL) or (PERILYMPHATIC and FISTULA) or MENIERE* or (ENDOLYMPHATIC and HYDROPS) or (LABYRINTH* and HYDROPS) or (LABYRINTH* and SYNDROME) or BPV or BPPV or ANTBPPV).ti. 5 2 OR 3 OR 4 6 VOCATIONAL REHABILITATION/ or exp KINESIOTHERAPY/ or exp EXERCISE/ or exp HEAD MOVEMENT/ 7 (REHABILITATION or PHYSIOTHERAP* or (PHYSICAL and THERAP*) or EXERCIS* or HABITUAT* or EPLEY or	(vestibular OR vertigo OR dizziness) AND (rehab% OR adaptation OR habituation OR exercis%)

(*Continued*)

RAL adj CONTROL) or PFPP or (SENSORY and RELEARN) or (SENSORY and RETRAIN*) or (POSTURAL and RELEARN*) or (POSTURAL and RETRAIN*)) #7 TS=((POSITION* and PROCEDURE*) or (REPOSITION* and PROCEDURE*) or (REPOSITION* and PARTICLE*) or (VISUAL and VESTIBULAR) or (FUNCTIONAL and RETRAIN*) or (OCCUPATIONAL and RETRAIN*) or (OCCUPATIONAL and ADAPTATION) or (COOKSEY and CAWTHORNE)) #8 #7 OR #6 #9 #8 AND #5 #10 #9 OR #1	TUROGRAPHY or (POSTURAL adj CONTROL) or PFPP or (SENSORY and RELEARN) or (SENSORY and RETRAIN*) or (POSTURAL and RELEARN*) or (POSTURAL and RETRAIN*)) #7 TS=((POSITION* and PROCEDURE*) or (REPOSITION* and PROCEDURE*) or (REPOSITION* and PARTICLE*) or (VISUAL and VESTIBULAR) or (FUNCTIONAL and RETRAIN*) or (OCCUPATIONAL and RETRAIN*) or (OCCUPATIONAL and ADAPTATION) or (COOKSEY and CAWTHORNE)) #8 #7 OR #6 #9 #8 AND #5 #10 #9 OR #1	CANALITH or SEMONT or MANOEUVRE* or MANEUVER* or (RECONDITIONING adj ACTIVIT*) or POSTUROGRAPHY or (POSTURAL adj CONTROL) or PFPP or (SENSORY and RELEARN) or (SENSORY and RETRAIN*) or (POSTURAL and RELEARN*) or (POSTURAL and RETRAIN*)).tw. 8 ((POSITION* and PROCEDURE*) or (REPOSITION* and PROCEDURE*) or (REPOSITION* and PARTICLE*) or (VISUAL and VESTIBULAR) or (FUNCTIONAL and RETRAIN*) or (OCCUPATIONAL and RETRAIN*) or (OCCUPATIONAL and ADAPTATION) or (COOKSEY and CAWTHORNE)).tw. 9 6 OR 7 OR 8 10 5 AND 9 11 1 OR 10	

WHAT'S NEW

Last assessed as up-to-date: 30 June 2010.

Date	Event	Description
14 December 2010	New citation required but conclusions have not changed	The review authorship has changed.
1 July 2010	New search has been performed	We ran new searches on 1 July 2010. Six new studies were included in the review. The review conclusions have been strengthened.

HISTORY

Protocol first published: Issue 3, 2005

Review first published: Issue 4, 2007

Date	Event	Description
30 October 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

Susan Hillier: lead author, protocol development, design of search strategy, quality assessment, data extraction and analysis.

Michelle McDonnell: search and retrieval, quality assessment, data extraction and analysis.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- International Centre for Allied Health Evidence, Australia.

External sources

- No sources of support supplied

INDEX TERMS

Medical Subject Headings (MeSH)

*Vestibule, Labyrinth [physiopathology]; Dizziness [rehabilitation]; Exercise Movement Techniques; Postural Balance; Randomized Controlled Trials as Topic; Sensation Disorders [rehabilitation]; Vertigo [rehabilitation]; Vestibular Diseases [physiopathology; *rehabilitation]

MeSH check words

Humans