Vestibular rehabilitation following the removal of an acoustic neuroma: a systematic review of randomized trials

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Abstract

Introduction

An acoustic neuroma (also known as vestibular schwannoma) is an intracranial tumour of the vestibular nerve that is commonly treated by surgical resection. Following resection, patients may experience a range of symptoms that include deficits in gaze stability, mobility and balance. Vestibular rehabilitation may be useful in reducing the severity and minimizing the impact of these symptoms.

Objective

To systematically review the clinical trial evidence for the effectiveness of vestibular rehabilitation interventions following resection of an acoustic neuroma and provide a concise synthesis useful for informing clinical rehabilitation of this patient population.

Data sources

Electronic databases including Cochrane, PubMed, CINAHL, Embase and AUSThealth were searched with no time restriction. Search terms included combinations of MeSH terms ('acoustic neuroma', 'vestibular schwannoma', 'acoustic neurinoma', 'acoustic neurilemmoma', 'acoustic neurolleloma' or 'acoustic schwannoma') and ('rehabilitation', 'physiotherapy', 'physical therapy', 'adaptation', 'habituation', 'balance', 'exercise' or 'gaze stability').

Study selection

Randomized clinical trials of rehabilitation approaches following surgical resection of acoustic neuroma among adults were included. Studies with mixed populations that included bilateral vestibular loss or vestibular dysfunction of central or unknown aetiology were excluded. The 591 hits were screened by title, abstract and then full text by two independent researchers who reached a consensus on the eligibility of each study (a third researcher was available to arbitrate but was not required). Six clinical trials fulfilled the inclusion criteria.

Data extraction

The characteristics of each study including the trial design, sample, intervention, outcome measures and summary of results were extracted and tabulated.

Data synthesis

Methodological quality was independently assessed by two researchers using the Physiotherapy Evidence Database scale. The heterogeneity of both interventions and outcome measures did not allow a valid meta-analysis.

Conclusion

There is some evidence to support the use of adaptation exercises for this clinical group. Clinical trial evidence does not support the use of habituation exercises alone, although when combined with adaptation exercises and balance and gait training, habituation exercises may have some benefit. Further research is required to determine the optimal combination of vestibular rehabilitation interventions as well as the volume and timing of interventions.

Review

Background

An acoustic neuroma (also known as vestibular schwannoma) is an intracranial tumour of the vestibular nerve that is most commonly treated by surgical resection. Following resection, patients may experience a range of symptoms that include deficits in gaze stability, mobility and balance. The incidence and functional impact of these symptoms have varied across previous reports1–4. Although compensation through parallel systems and central processing usually occurs relatively quickly post-surgery, these impairments can be long lasting.5,6 Deficits in measures of balance and mobility have been found in patients at least three months post-resection of an acoustic neuroma who have not undergone vestibular rehabilitation.7 Similarly, deficits in gaze control have been found in patients at least three months post-resection of an acoustic neuroma. Vestibular rehabilitation may be useful in reducing the severity and minimizing the impact of these symptoms.

A broad Cochrane review of the evidence for vestibular rehabilitation in patients with symptomatic unilateral vestibular dysfunction found evidence supporting the use of vestibular rehabilitation for symptom resolution and improvement of function.7 This review included multiple diagnostic groups including benign paroxysmal positional vertigo, vestibular neuritis, Meniere’s disease including endolymphatic hydrops, perilymphatic fistula, unilateral labyrinthectomy or neurectomy (acoustic or vestibular). It compared vestibular rehabilitation to placebo or sham or...
usual care, vestibular rehabilitation to other kinds of management such as pharmacological and surgical interventions and one form of vestibular rehabilitation to another form of vestibular rehabilitation. The review considered vestibular rehabilitation to include a variety of interventions including adaptation exercises, habituation exercises, substitution exercises and balance and gait training activities. Although the review concluded that there is moderate evidence for vestibular rehabilitation following surgical removal of an acoustic neuroma, there was considerable variation in the outcomes of the reported studies, making it difficult to achieve clinical guidance for optimal rehabilitation protocols, including which elements of vestibular rehabilitation are the most effective for this diagnostic group.

The aim of this manuscript is to provide a systematic review of clinical trial evidence for vestibular rehabilitation interventions following resection of an acoustic neuroma and provide a concise summary useful for informing clinical rehabilitation of this patient population.

Search strategy
This review investigated an acoustic neuroma, also known as vestibular schwannoma, acoustic schwannoma, acoustic neurilemoma or acoustic neurinoma. Searches were performed in April 2011 in the following databases: Cochrane, PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Embase and AUShealth. Search syntaxes are presented in Appendix 1.

Study selection
A conventional four-stage approach for the identification of studies fulfilling the inclusion and exclusion criteria was adopted by two researchers (Figure 1). A third member of the research team was available to arbitrate any disagreement between the two researchers, but his intervention was not required. Studies were screened by title; non-relevant articles and duplicates were removed. Article abstracts were then screened and the articles that did not fulfil the inclusion criteria were excluded. Finally, the full texts of the remaining articles were examined and articles that fulfilled the inclusion criteria were included in the review.

Inclusion and exclusion
The population being investigated was adults following the resection of an acoustic neuroma. Studies with mixed populations that included bilateral vestibular loss or vestibular dysfunction of central or unknown aetiology were excluded. Studies were included if the sample comprised only post-resection of acoustic neuroma patients or a mixed diagnosis, which included patients post-resection of an acoustic neuroma and patients with unilateral vestibular loss with pathophysiological presentation and mechanism of recovery comparable with post-acoustic neuroma resection. Only studies using randomized-controlled trial methodologies were considered eligible for inclusion.

Interventions
The review considered vestibular rehabilitation interventions that could include walking or gait training, exercise, balance training, or specific vestibular rehabilitation treatments such as adaptation exercises, habituation exercises and substitution strategies. The authors found that this treatment is primarily delivered by physical therapists, although they may have also been delivered by other suitably qualified professionals. Adaptation exercises use the error signal created by retinal slip to induce adaptation of vestibulo-ocular reflex. The ×1 and ×2 viewing

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**Figure 1:** Literature search and number of articles excluded at each stage during study selection.

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Table 1: Quality scores (PEDro* scale) for included randomized trials

<table>
<thead>
<tr>
<th>PEDro scale items</th>
<th>Cakrt et al., 2010</th>
<th>Cohen et al., 2002</th>
<th>Herdman et al., 1995</th>
<th>Herdman et al., 2003</th>
<th>Mrzuk et al., 1995</th>
<th>Vereeck et al., 2008</th>
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<tr>
<td>1. Eligibility criteria specified</td>
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<td>3. Allocation concealed</td>
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<td>4. Groups similar at baseline</td>
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<td>5. Blinding of subjects</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>6. Blinding of therapists</td>
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<td>7. Blinding of assessors</td>
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<td>1</td>
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<td>8. Adequate follow-up</td>
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<td>9. Intention-to-treat analysis†</td>
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<td>10. Between groups statistical comparison</td>
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<td>1</td>
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<td>11. Point and variability measures</td>
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<td>5</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>6</td>
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</table>

*Range 0–10 points. †Eligibility criteria are related to external validity and not used in the cumulative total. ‡Intention-to-treat analysis may have been undertaken, but was not explicitly stated for all included studies. PED, Physiotherapy Evidence Database.

Data extraction and quality assessment

The characteristics of each study including the trial design, sample, intervention, outcome measures and summary of results were extracted and tabulated. The methodological quality of the included studies was independently assessed by two researchers, after which the results were compared and a consensus was reached. A third researcher was available to arbitrate any unresolved assessment disagreements. Each study was rated using the Physiotherapy Evidence Database (PEDro) scale. This scale consists of a checklist of 11 items designed to evaluate the methodological quality of clinical trials and has evidence to support its validity and reliability for this purpose. One item (eligibility criteria) relates to external validity and is not used in the calculation of the total PEDro score, which ranges between 0 and 10. The heterogeneity of both interventions and outcome measures used in the clinical trials did not allow a valid meta-analysis.

Heterogeneity

There was considerable diversity in methodological rigour between the six randomized-controlled trials. Quality scores using the PEDro scale ranged from 3–7 (Table 1). An inadequate description of whether an intention-to-treat analysis was conducted and failure to specify the eligibility criteria were common limitations of the included investigations. Assessments were blinded in four of the six trials.

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Vestibular rehabilitation following the removal of an acoustic neuroma, and all studies had small sample sizes (range, n = 15–65).

A variety of intervention types and duration were reported in the studies including adaptation exercises, habituation exercises, range of motion exercises, balance training, walking, general instruction and social reinforcement (Table 2). The intervention period in three studies was limited to the acute post-operative period (day 1–14). In one study, the interventions commenced in the acute post-operative period (day 3–5) and continued until 12 weeks post-surgery. Another study, the interventions were commenced the day after hospital discharge and continued until eight weeks post-surgery. Follow-up periods ranged from six days post-operatively to 12 months.

Monitoring of adherence to the intervention protocol varied across the studies. Observations of adherence were noted in five studies by the therapist treating each patient daily or through the use of a diary or a calendar. However, only one study described the level of adherence to the prescribed intervention and considered a patient to be compliant if he/she completed more than 50% of the prescribed exercises.

There was considerable variation in the outcome measures used across the studies (Table 2). Patients in all except one study underwent tests of vestibular function such as caloric, rotary chair testing and quantified dynamic visual acuity before the surgery or interventions. Only three studies used any vestibular functions test as an outcome measure. The investigators in one trial decided against the use of some clinical assessment items (Table 2) because of the acuity of their participants and the potential risk of adverse events with more vigorous testing early in the post-operative period. Posturography was measured in five studies, although with variation in utilization, for example some studies considered the six Sensory Organisation Test conditions, while others considered only one of the six conditions or used a composite score. Two studies considered clinical measures of balance and gait and one study did not include any measures of postural control or balance.

Effect of habituation exercises
Three studies included habituation exercises in the interventions. One study implemented habituation exercises as the only primary intervention. Findings from this study did not demonstrate a benefit from habituation exercises in the first week post-resection of an acoustic neuroma for balance, vestibulo-ocular reflex function or spatial orientation. The other two studies investigated habituation exercises in conjunction with balance training. One of these reported findings that were similar to the habituation-only investigation; however, the reduction in both motion sensitivity and self-perceived dizziness handicap was suggestive of more rapid improvement post-surgery. In contrast, the other reported early vestibular rehabilitation including habituation, balance and gaze stability exercises resulted in improved postural control for patients older than 50 years of age.

Effect of ambulation and balance retraining
Three studies included ambulation (walking or gait) and balance training as a component of vestibular rehabilitation. Of the remaining three studies, two included only ambulation training and one included only balance training. In four of the studies, ambulation or balance was included in both the control and intervention groups. This did not allow conclusions to be drawn about the effect of these interventions from those studies. One study implemented balance training as part of a multi-faceted vestibular rehabilitation intervention and although positive findings were reported, it was difficult to attribute improvement to any one facet of the intervention, such as ambulation and balance retraining exercises. Only one study specifically examined balance retraining in the acute post-operative period (day 5–14). This study found that patients who underwent balance retraining with visual biofeedback demonstrated better compensation and postural control than patients who performed balance rehabilitation without visual biofeedback cues.

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Table 2: Summary of study designs, samples, interventions, outcome measures and results of included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Study design and population</th>
<th>Intervention</th>
<th>Outcome measures</th>
<th>Summary of results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cakrt et al., 2010</td>
<td>• RCT</td>
<td>Control: Rehabilitation without visual biofeedback</td>
<td>Posturography – Centre of foot pressure parameters during the Clinical Test for Sensory Interaction of Balance conditions (1–4)</td>
<td>Firm surface with eyes closed: Control and intervention groups similar. Foam surface with eyes closed: Statistically significant improvement in intervention group in 5 out of 7 centre of foot pressure parameters (p values 0.008–0.027).</td>
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<tr>
<td></td>
<td>• Patients undergoing removal of vestibular schwannoma</td>
<td>Intervention: Rehabilitation using visual biofeedback</td>
<td></td>
<td>Summary: These findings indicate visual based rehabilitation treatment improved postural control better than rehabilitation without visual feedback.</td>
</tr>
<tr>
<td></td>
<td>• Control group (n = 8)</td>
<td>• Identical exercises to the intervention group</td>
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<td></td>
<td>• Intervention group (n = 9)</td>
<td>• Shifting centre of pressure on force platform with visual targets on monitor screen</td>
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<td></td>
<td>• Intervention: Day 5–14 post-surgery</td>
<td>Both groups: Vestibular adaptation exercises for vestibular-ocular reflex</td>
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<td></td>
<td>• Assessment: pre-operative, day 5 and day 14 post-surgery</td>
<td>• ×1 viewing ex with near and far target, horizontally and vertically</td>
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<td></td>
<td></td>
<td>Duration of treatments: Increased gradually from minutes day 5 post-surgery, up to 40 minutes on the day of discharge (day 14 or 15 post-surgery)</td>
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<tr>
<td>Cohen et al., 2002</td>
<td>• RCT</td>
<td>Control: Attention from laboratory assistant</td>
<td>Vertigo intensity and frequency: No significant difference between groups</td>
<td>No evidence for vestibular rehabilitation during acute post-operative week in terms of improved VOR function, balance and spatial orientation.</td>
</tr>
<tr>
<td></td>
<td>• Patients scheduled for resection of AN (n = 31)</td>
<td>Intervention: Received by therapist</td>
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<td></td>
<td>• Control group (n = 15)</td>
<td>Day 1: Passive range of motion of head and neck in yaw, pitch and roll while lying semi reclined in bed, yaw limited by dressing size to operated side</td>
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<td>• Intervention group (n = 16)</td>
<td>Day 2 and 3: Passive range of motion with head away from bed for full range of motion; active range of motion as fast as possible</td>
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<td>• Intervention: Day 1 post-surgery to discharge day 5–6 post-surgery</td>
<td>Day 3: Passive range of motion with head away from bed for full range of motion;</td>
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<td></td>
<td>• Assessment: pre-operative, discharge, approximately 3, 7 and 13 weeks post-surgery</td>
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<tr>
<th>Study</th>
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<th>Intervention</th>
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</thead>
<tbody>
<tr>
<td>Cohen et al., 2002</td>
<td>active range of motion as fast as possible • Performed sitting in chair • Commenced trunk movements in all planes, combined with upper limb reaching movements requiring patient to turn and look whilst reaching • Walking if tolerated Day 4 and 5: • Active range of motion head while sitting • Walking longer distances from 3 to 10 m as tolerated with augmented head movements in pitch and yaw Day 5 or 6: • Discharge at surgeon’s discretion based on medical status and safe mobility. Both groups: • Patients seen 2× daily • Duration gradually increased as tolerated from 5 minutes of treatment day 1 to 30 minutes day before discharge</td>
<td>VAS for vertigo and disequilibrium • Romberg • Qualitative gait analysis • Oculomotor test – Spontaneous nystagmus – Gaze evoked nystagmus – VOR to slow and horizontal head thrusts</td>
<td>Vertigo: No difference between groups Disequilibrium: At day 1–4 post-surgery there was no difference between groups At day 5 and 6 post-surgery the intervention group experienced less disequilibrium than control group (p &lt; 0.05) Romberg: At day 3, 25% of control and 64% of intervention group could perform with eyes closed At day 6, 57% of control and 80% of intervention group could perform with eyes closed</td>
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<tr>
<td>Herdman et al., 1995</td>
<td>RCT • Patients scheduled for resection of AN (n = 19) • Control group (n = 8) • Intervention group (n = 11) • Intervention: commenced day 3 post-surgery • Assessment: pre-operative, daily post-surgery</td>
<td>Control: Smooth pursuit exercises (without head movement) performed: in both vertical and horizontal directions in standing and sitting for 1 minute each, five times per day, for total of 20 minutes per day Intervention: Exercises to increase vestibular gain (×1 viewing paradigm (horizontal and vertical head movements maintaining visual fixation) performed: on near target (arms length) or far target (across the room) in standing and sitting</td>
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<tr>
<td>Ambulation</td>
<td>Posturography</td>
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<tr>
<td>• for 1 minute each, five times per day, for a total of 20 minutes a day <strong>Both groups:</strong>&lt;br&gt; Ambulation</td>
<td>• Peak to peak anterior–posterior sway&lt;br&gt; • Total sway path&lt;br&gt; • Frequency of sway</td>
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</table>

**Qualitative gait analysis:**<br> At day 3, all subjects had wide base of support, minimal–moderate ataxia and reduced head movement. Three of 8 in control group and 3 of 11 in the intervention group need assistance of one person for safe ambulation.<br> At day 6, all of the control group and 40% of intervention group were considered to have an abnormal gait. All of the control and 50% of intervention group had some ataxia or ataxia with head turns whilst walking.<br> No significant difference between gait on day 6 post-operatively and any pre-operative clinical assessment.<br> **Gaze evoked nystagmus (room light):**<br> At day 3, 88% of the control and 91% of the intervention group had gaze evoked nystagmus.<br> At day 6, 71% of the control and 73% of the intervention group had gaze evoked nystagmus.<br> **VOR (clinical) to slow head rotations:**<br> At day 3, 25% of the control and 55% of the intervention group had clinically normal VOR.<br> At day 6, 29% of the control and 73% of the intervention group had clinically normal VOR.<br> **Posturography:**<br> At day 3, there was no difference in peak to peak sway between pre- and post-surgery measures on tests 1–3 for control or intervention groups. There was a difference ($p < 0.05$) between pre- and post-surgery on tests 4–6 for both control and intervention groups.<br> At day 6, there was no difference between pre- and post-surgery on tests 1–3 for control or intervention groups. There was a significant difference ($p < 0.02$) between pre- and post-surgery on test 4–6 for the control group. There was a significant difference ($p < 0.04$) between pre- and post-surgery for test 5 and 6 but no difference on test 4 for intervention group.<br> **Summary:**<br> Vestibular adaptation exercises during the initial post-surgical period facilitates rate of recovery of postural...
### Table 2 (Continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Study design and population</th>
<th>Intervention</th>
<th>Outcome measures</th>
<th>Summary of results</th>
</tr>
</thead>
</table>
| Herdman et al., 2003 | • RCT  
• Patients with unilateral vestibular loss referred to laboratory for assessment  
• Control group (n = 8)  
• Intervention group (n = 13)  
• Intervention: 4–5 weeks  
• Assessment: pre-intervention, 2-week intervals after commencing intervention | Control:  
Vestibular neutral exercises  
• Saccadic eye movements with head stationary against a featureless surface  
Gait and balance exercises  
• Excluding exercised incorporating head movements  
Intervention:  
Adaptation exercises (×1 and ×2 viewing paradigms)  
Eye–head exercises to target Gait and balance exercises  
Both groups:  
Home programme  
• performed exercises 4–5× daily for a total of 20–30 minutes  
• plus 20 minutes balance and gait exercises | • Dynamic visual acuity  
− Predictable head movement (subject moves head)  
− Unpredictable head movement (assessor moves head)  
• VAS for visual blurring | Dynamic visual acuity change:  
There was no change in dynamic visual acuity predictable or unpredictable in the control group. There was significant improvement (p < 0.01) in dynamic visual acuity predictable in the intervention group with 12 of 13 subjects returning to normal for age. Intervention group also had significant improvement (p < 0.01) in dynamic visual acuity unpredictable  
Only exercise type contributed significantly (p = 0.009) to change in dynamic visual acuity predictable and for 50.5% of change in dynamic visual acuity unpredictable  
VAS for visual blurring:  
There was a significant reduction in visual blurring for control (p = 0.02) and intervention group (p = 0.03)  
Summary  
The recovery of gaze stability during predictable head movements and to a lesser extent unpredictable head movements, can be facilitated with vestibular rehabilitation exercises. Improvement occurs in <5 weeks |
| Mruzek et al., 1995 | • RCT  
• 24 patients scheduled for unilateral vestibular ablation  
• Control group, (n = 8)  
• Intervention group 1 (n = 8)  
• Intervention group 2 (n = 8)  
• Intervention: commenced day 1 post-hospital discharge | Control Group:  
Range of motion programme  
• Shoulder, elbow, hip, knee and ankle range of motion exercises performed in sitting position  
• No head and neck motions  
Social reinforcement  
• Encouragement and praise for participating in exercises  
3–5 minute phone calls, 1–2 times per week—reminded to do exercises, reinforced compliance and encouraged to continue programme  
10–15 minute meetings with physiotherapist during follow-up testing | • Dynamic posturography  
− Sensory Organisation Test  
− Motion Sensitivity Quotient  
− Dizziness Handicap Inventory  
− Rotary chair − Asymmetry index | Sensory organisation test:  
Intervention group 2 performed significantly better (p = 0.013) than the control group on sensory organisation test condition two at five weeks post-surgery. There were no other significant differences  
Motion sensitivity quotient:  
At 7 weeks post-surgery both intervention groups had significantly less (p = 0.03) motion sensitivity than the control group  
Dizziness handicap inventory:  
At 8 weeks post-surgery, intervention group 1 had significantly less (p = 0.05) physical disability than the control group |
**Assessment:** Within 1 month pre-operative, day 5 post-surgery, then 2, 5 and 7 weeks post-surgery

- Within 1 month pre-operative
- Day 5 post-surgery
- Then 2, 5 and 7 weeks post-surgery

**Sessions—progress discussed, questions answered, verbal encouragement offered**

Subjects were given no instruction about participating in any regular activity but may have received general instruction from the physician

**Intervention 1:**
- Vestibular rehabilitation
- Habituation exercises
- Balance exercises
- Daily walking programme
- Social reinforcement
- As per control group

**Intervention 2:**
- Vestibular rehabilitation
- As per intervention group 1

**All groups:**
Commenced as home programme on the day after hospital discharge

- Instructed to perform
  - 15-minute sessions, twice per day
  - Daily walk (groups 1 and 2 only)

**Standing balance**
- Romberg (floor)
- Romberg (foam)
- Sharpened Romberg
- Single limbs stance

**Timed up and go test**

**Tandem gait**

**Dynamic gait index**

**Asymmetry index:**
No significant difference between groups. Asymmetry at seven weeks post-surgery was close to pre-surgery levels

**Summary**
Patients can effectively compensate irrespective of the therapy programme they participate in. Reduction in motion sensitivity and self-perceived dizziness handicap for patients participating in vestibular rehabilitation suggests more rapid and perhaps more complete recovery in these patients

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**Vereeck et al., 2008**

- RCT
- 57 patients for resection of AN

- Control group <50 years (n = 11)
- Control group >50 years (n = 11)
- Intervention group <50 years (n = 16)
- Intervention group >50 years (n = 15)
- Intervention: commenced post-operatively and

**Control:**
- (general instructions)
- Pre-operatively
- Information

**Post-surgery**
Instructed to walk, eat at table, stairs, watch TV, read as soon as possible

**Post-discharge follow-up**
Informed of level of postural control
Discussed general level of activity and frightening movements and situations
Encouraged to increase activity levels including walking, cycling, driving, sport
No formal home programme given

**Patients >50 years:**
The intervention group performed significantly better (P < 0.05) than control group on all tests at all assessments with the exception of Dynamic Gait Index in the acute recovery period (1–6 weeks post-surgery) and standing balance and tandem gait in the follow-up period (6 and 12 months post-surgery)

At 6 weeks post-surgery, balance matched per surgery measures in the intervention group. At 12 weeks post-surgery, the intervention group performed better than pre-surgery.

At 1 year post-surgery, the intervention group still performed better than pre-surgery

(Contd.)
Table 2  (Continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Study design and population</th>
<th>Intervention</th>
<th>Outcome measures</th>
<th>Summary of results</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Intervention:</strong> (customized vestibular rehabilitation)</td>
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<td><strong>Pre-operatively</strong></td>
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<td>Information</td>
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<td><strong>Post-operatively</strong></td>
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<td></td>
<td>Same as control groups plus Basic exercises</td>
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<td></td>
<td></td>
<td>• Commenced day 3–5 post-surgery</td>
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<td></td>
<td></td>
<td>• Supervised walking with decreasing base of support, incorporate head movements, treadmill walking</td>
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<td><strong>Post-discharge follow-up</strong></td>
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<tr>
<td></td>
<td></td>
<td>customized home programme</td>
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<td></td>
<td></td>
<td>• 5 activities including gaze stability and motion sensitivity, balance and walking</td>
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<td></td>
<td></td>
<td>• Performed 3× daily, total 30 min/day</td>
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</table>

Patients <50 years: No significant effect of experimental group on tests

**Summary**
For patients >50 years early customized vestibular rehabilitation resulted in better postural control than general instructions only

For patients <50 years general instructions may be enough; however, some younger patients may benefit from a vestibular rehabilitation programme
Effect of social reinforcement and attention and instruction

The effect of social reinforcement on post-operative recovery was investigated in one study, which found no statistically significant difference in outcomes between treatment and control groups. However, a trend towards reduced emotional scores on the Dizziness Handicap Inventory our weeks post-operatively was evident. The small sample size (n = 24) for this three group trial (8 per group) indicated that a Type 2 error may have occurred.

Conclusion

Main findings

The six investigations included in this systematic review have provided some empirical evidence to support the use of vestibular rehabilitation following resection of an acoustic neuroma. The heterogeneous quality of clinical trial reporting, the interventions evaluated and the outcome measures used helped the authors to draw reserved conclusions on the effectiveness of the vestibular rehabilitation interventions that were evaluated. Overall, there appears to be evidence for the use of adaptation exercises, at least in the acute post-operative period.

Current clinical trial evidence does not support the use of habituation exercises in isolation following resection of an acoustic neuroma. Differences in the findings between the two studies of habituation exercises may be attributed to the outcome measures used. One study used the Motion Sensitivity Quotient, a measure of motion-induced dizziness, and the Dizziness Handicap Inventory, a measure of self-perceived disability due to vestibular dysfunction. The inclusion of the Motion Sensitivity Quotient in the other study may have yielded a different result. A salient finding from this study, though, is that habituation exercises did not produce a change in vestibulo-ocular reflex. Habituation exercises in combination with other vestibular rehabilitation interventions such as adaptation exercises, gait and balance training may promote more rapid recovery.

For patients older than 50 years of age, customized vestibular rehabilitation incorporating adaptation, habituation, balance and mobility improved outcomes. For most patients younger than 50 years of age, simple exercise programme may be sufficient, although it may be necessary to screen for patients likely to require more customized or intensive rehabilitation. The Romberg test with closed eyes performed on the third post-operative day was identified as a potential indicator of such patients. Interestingly, age was not a predictor of recovery following resection of an acoustic neuroma.

Findings from this review have provided a more focused analysis of the clinical trial evidence for vestibular rehabilitation following resection of an acoustic neuroma than that reported in the 2007 Cochrane review of vestibular rehabilitation. None of the studies of vestibular rehabilitation following resection of an acoustic neuroma included in the Cochrane review were included in a comparative analysis between forms of vestibular rehabilitation. It is possible that the variability in the findings of the Cochrane review is a result of considering vestibular rehabilitation interventions collectively rather than isolating techniques to determine which approach is the most effective. This is in contrast with this systematic review, which considered the different types of vestibular rehabilitation interventions or combinations of interventions. A more detailed analysis of the randomized-controlled trials investigating vestibular rehabilitation following the resection of an acoustic neuroma has provided greater insight into the efficacy of various components of vestibular rehabilitation interventions.

Study limitations

There were a number of limitations evident from this review of randomized-controlled trials. In addition to the presence of only a small number of randomized studies, all had small sample sizes. Most of the studies investigated vestibular rehabilitation interventions within the first two weeks post-operatively, with only two continuing interventions for eight and 12 weeks, respectively. Only one study included six- and 12-month follow-up assessments, making it difficult to speculate about the long-term effect of vestibular rehabilitation interventions on the patient group. The heterogeneity in interventions across studies and the outcome measures used did not allow valid meta-analyses. Greater consistency of outcome measures used and standardized time-frames for application of the measures in future studies will aid the interpretation of pooled results across clinical trials and allow stronger conclusions to be drawn.

Compliance with exercise protocols is another important consideration that was not adequately reported across the trials. Vestibular rehabilitation interventions include exercises that may induce symptoms of dizziness and related discomfort. Patients may not adhere to treatment protocols to avoid discomfort (or for other reasons). It is likely that some level of adherence to the vestibular rehabilitation intervention is a pre-requisite to its effectiveness. Non-compliance with exercises is likely to adversely affect the findings of a study and careful monitoring is warranted. This is perhaps easier among inpatients than community-based patients. It is possible for future studies to mandate a minimum level of compliance with the intervention protocol if the aim is to investigate the direct response to the vestibular rehabilitation intervention. However, if the aim of a trial is to investigate the feasibility and effectiveness...
of a vestibular rehabilitation protocol in clinical settings, compliance levels are likely to be relevant to clinical practice. Such a study could report the level of compliance and conduct analyses on an intention-to-treat basis, as well as reporting sub-group analyses for patients who did adhere to the protocol. This would be valuable for informing clinical practice and for the development of interventions to promote optimal adherence to vestibular rehabilitation protocols in clinical settings.

**Future research**

There are several key priorities for future research. Randomized-controlled trials with larger sample sizes and more rigorous methodologies are needed to investigate the effects of each element of vestibular rehabilitation, as well as when used in combination with comprehensive vestibular rehabilitation program with patients following resection of an acoustic neuroma. Conducting clinical trials with factorial designs offers a useful approach to make these comparisons. Elements of vestibular rehabilitation worthy of investigation on their own or in combination include adaptation exercises, habituation exercises, balance training and gait retraining.

Investigation of intervention parameters such as the timing and duration of interventions as well as the minimum and optimal ‘dosage’ requirement to achieve effectiveness should be considered. The effects of education and social reinforcement also require further investigation. Finally, the development of a clinical prediction rule(s) from empirical data would be useful to aid clinical staff in identifying those patients at risk of poor outcomes and where the greatest benefit can be achieved.

**Abbreviations list**

CINAHL, Cumulative Index to Nursing and Allied Health Literature; PEDro, Physiotherapy Evidence Database.

**Acknowledgement**

Steven M McPhail was supported by the National Health and Medical Research Council Early Career Award.

**References**

### Appendix 1: Search syntaxes

<table>
<thead>
<tr>
<th>Database</th>
<th>Search syntax</th>
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<tbody>
<tr>
<td>Cochrane</td>
<td>Acoustic neuroma or vestibular schwannoma or acoustic schwannoma or acoustic neurilemoma or acoustic neurinoma</td>
</tr>
</tbody>
</table>
| PubMed   | (acoustic neuroma OR vestibular schwannoma OR acoustic neurinoma OR acoustic neurilemoma OR acoustic neurinoma OR acoustic schwannoma) AND (physiotherapy OR physical therapy OR rehabilitation OR adaptation OR habituation OR balance OR exercise OR gaze stability)  
  Limits: Humans, All Adult: 19+ years |
| Embase   | (acoustic neuroma.mp. or exp acoustic neurinoma/) or (exp acoustic neurinoma/ or exp neurilemoma/ or exp vestibular schwannoma/ or exp neuroma/) and ([physiotherapy.mp. or PHYSIOTHERAPY/] or [physical therapy.mp.]) or ([rehabilitation or adaptation or habituation or gaze stability or balance or exercise].mp.  
  [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer,  
  drug manufacturer])  
  limit to (human and [adult <18 to 64 years> or aged <65+ years>]) |
| CINAHL   | [(MH Neuroma, Acoustic+] and [acoustic neuroma or acoustic schwannoma or acoustic neurinoma or acoustic neurilemoma or acoustic neurilemmoma or vestibular schwannoma]) and ([MH Physical Therapy+] or [physical therapy or physiotherapy or rehabilitation or adaptation or habituation or gaze stability or balance or exercise])  
  Limit: Human; Age Groups: All Adult |
| AUSThealth | (‘acoustic neuroma’ or ‘vestibular schwannoma’ or ‘acoustic neurinoma’ or ‘acoustic neurilemoma’ or  
  ‘acoustic neurilemomma’ or ‘acoustic schwannoma’) and (physiotherapy or ‘physical therapy’) or rehabilitation  
  or exercise or ‘gaze stability’ or adaptation or habitation or balance) |