Research Article

Effect of Combined Canalith Repositioning and Balance Training on Functional Mobility and Fall Risk in Older Adults with BPPV

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Abstract

The study investigates the effectiveness of combining Canalith Repositioning Technique (CRM) with structured balance training versus CRM alone for improving functional mobility, balance, and dynamic gait in older adults with Benign Paroxysmal Positional Vertigo (BPPV). BPPV is notable for its impact on balance and mobility in the elderly, and while CRM is effective for positional vertigo, it may not fully restore functional balance. The research involved sixty older participants with clinically diagnosed BPPV, randomized into two groups: one receiving CRM and structured balance training, and the other receiving only CRM. Functional mobility was assessed using the Timed Up and Go (TUG) test, while the Berg Balance Scale (BBS) measured functional balance, and the Dynamic Gait Index (DGI) evaluated dynamic gait. Results demonstrated significant improvements in both groups across all assessments post-intervention. However, the combined group showed greater enhancements, with a mean TUG score reduction of 3.22 seconds compared to 1.73 seconds in the CRM-only group, and greater increases in BBS and DGI scores as well. Statistical analyses confirmed significant between-group differences favoring the combined intervention across all measures. These results suggest that the combination of CRM and structured balance training yields superior improvements in mobility, balance, and gait, advocating a more comprehensive rehabilitation approach for older individuals with BPPV. It is important to note that the study did not assess the incidence of falls, so results do not imply a reduction in fall risk.

Keywords: Benign Paroxysmal Positional Vertigo; Canalith Repositioning Manoeuvre; Balance Training; Functional Mobility; Functional Balance; Dynamic Gait; Older Adults.

Introduction

Dizziness is a frequent and clinically relevant symptom in the elderly and may have a profound influence on physical function, independence, mobility and quality of life. In one large family-practice research, the incidence of dizziness in patients 65 years of age or older was found to be 8.3% in one year, and the incidence increased with age. Dizziness was also a prevalent complaint among adults, with Sloane et al. (2001) reporting that the prevalence of dizziness among community-dwelling older individuals may be greater than 30%. Dizziness is a generic symptom with several causes. It can be described as vertigo, presyncope, disequilibrium or nonspecific light-headedness. Therefore, a detailed clinical evaluation is of special importance in the assessment of dizziness in the elderly.

Dizziness in older people is multifaceted in origin and should be examined in the wider context of age-related and medical disorders. Tinetti et al. (2000) advocated that dizziness be regarded a geriatric syndrome since it is typically the consequence of the interplay of various physiologic and pathologic variables rather than one illness. In addition, Jönsson et al. (2004) showed that dizziness and vertigo are rather prevalent among older persons in metropolitan regions. Kutz (2010) observed the wide differential diagnosis for dizziness and the need for a complete clinical examination as vestibular, neurological, cardiovascular, ocular, sensory and other elements may play a part in the symptoms.

Postural control is especially critical in older persons because age-related changes in sensory integration, muscular strength, response time and balance-control systems can induce postural instability and falls. Postural orientation and balance are complicated sensorimotor processes that include the integration of ocular, vestibular, somatosensory and motor information (Horak, 2006). Disruption of one or more of these systems can lead to a decrease in the capacity to maintain stability when standing and walking. Thus, vestibular diseases affecting postural control may have important functional implications in older persons.

Benign paroxysmal positional vertigo (BPPV) is the most prevalent cause of episodic vertigo in patients with peripheral vestibular abnormalities. BPPV is defined by short attacks of positional vertigo due to displacement of otoconia in one of the semicircular canals. Vestibular dysfunction can occur throughout the age spectrum, but its functional repercussions may be particularly critical in older persons since age-related losses in sensory and postural reserve can magnify the impact of vestibular impairment. Cho and White (2011) reviewed the incidence of positional vertigo in various age groups and emphasised the necessity of correct diagnosis and proper treatment of BPPV.

The posterior semicircular canal is the canal most typically involved with BPPV. The diagnosis is usually made on the basis of clinical history and positional testing, in particular the Dix-Hallpike test for posterior-canal involvement. The clinical features and diagnostic issues of BPPV were reported by Caldas et al. (2009), who highlighted the significance of a proper clinical examination. Moreno and André (2009) studied the number of manoeuvres necessary to obtain a negative Dix–Hallpike test, highlighting the significance of recurrent positional evaluation when clinically indicated during BPPV therapy.

Other health issues and related co-morbidities may also contribute to recurrence of BPPV. De Stefano et al. (2014), in a multicentre observational research, investigated the impact of comorbidities on recurrent BPPV and underlined the need of taking into account the presence of concomitant health problems when treatment patients with recurrent episodes. This is especially true for elderly persons who often have many co-morbidities that may compromise vestibular function, balance, mobility, and recuperation.

The association between BPPV, balance impairment and falls is of particular clinical significance in the elderly population. Ganança et al. (2010) studied falls related to BPPV in the elderly, and showed the importance of BPPV in falls outcomes. Falls in older individuals may lead to damage, loss of independence, decreased mobility, fear of falling, and restrictions in participation in everyday activities. Thus care of BPPV should preferably be directed not just against positional vertigo but also against any lasting functional effects to balance and mobility.

BPPV also has clinical relevance in emergency and primary care settings. Patients experiencing dizziness are not usually assessed according to accepted diagnostic and therapy techniques for BPPV. Kerber et al. (2013) studied the utilisation of BPPV associated diagnostic and treatment procedures among patients with dizziness coming to the emergency departments and found potential areas for improved diagnosis and management of BPPV. Accurate diagnosis is the critical first step in the efficient therapy of BPPV.

Posterior-canal BPPV is a discrete entity, and has a well-established first-line therapy, the Epley technique, or canalith repositioning manoeuvre (CRM). The main goal of CRM is to relocate misplaced otoconia from the afflicted semicircular canal to a spot where they no longer cause aberrant stimulation and positional vertigo. Bhattacharyya et al. created evidence based clinical practice recommendations for the diagnosis and management of BPPV. Canalith repositioning techniques were shown to be a useful therapy method.

Evidence based clinical recommendations and reviews support repositioning movements for relevant cases of BPPV. An evidence based review of therapies for BPPV was undertaken by Fife et al (2008) and supported the usefulness of repositioning procedures. Therefore, CRM is a key part of evidence-based BPPV management. But effective repositioning of otoconia and resolution of positional vertigo may not necessarily equate to complete recovery of balance, gait, or functional mobility.

In some individuals, despite effective treatment of the positional component of BPPV, dizziness, postural instability or difficulties standing and walking may persist. These residual deficits could be particularly relevant in older persons, because age-related alterations in sensory, motor and postural systems might limit the capacity to correct for vestibular disturbances. The relationship between vestibular function and postural control (Horak 2006) and the functional consequences of dizziness (Tinetti et al. 2000) suggest that management of older adults with BPPV should not conclude with resolution of positional symptoms when functional deficits persist.

Vestibular rehabilitation and systematic balance training may therefore be a beneficial addition to the CRM . Exercise programs for balance training may include static and dynamic standing balance, weight shifting, postural control, walking, turning, changes in direction, head motions and functional tasks. These exercises test the integration of vestibular, visual and somatosensory information and may enhance the individual's capacity to maintain postural stability during functional tasks. This technique may be especially useful for older persons as therapy of positional vertigo alone may not sufficiently address lingering functional limitations.

There is consequently a sound therapeutic basis for the combination of CRM and systematic balance training. CRM is mostly focused on the mechanical aspect of BPPV, which is the repositioning of misplaced otoconia, whereas balance training may aim at residual deficiencies in postural control, functional mobility and dynamic gait. A combination intervention may therefore yield advantages above those gained by repositioning alone. This difference is of therapeutic importance since effective treatment of positional vertigo does not necessarily lead to quick normalisation of other aspects of functional performance .

Previous study has supported the combination of repositioning therapy with vestibular or balance rehabilitation. For example, Chang et al. (2008) performed a randomised controlled study in individuals with unilateral posterior-canal BPPV comparing CRM alone with CRM with vestibular exercise training. Such outcomes as balance, tandem walking, Dynamic Gait Index (DGI) and vertigo intensity were evaluated in their study. The data suggested the possible added advantage of vestibular exercise after CRM.

Similarly, To et al. (2022) examined the efficiency of personalised vestibular rehabilitation using CRM in patients with unilateral posterior-canal BPPV. In a randomised controlled experiment comparing CRM with and without individualised vestibular rehabilitation, they found improvements in various gait-related outcomes for the combined-treatment group. These results provide evidence to suggest that active rehabilitation may play a role in functional recovery following repositioning therapy.

However, the findings of prior research can not be easily extrapolated to all older persons with BPPV, due to differences in participant age, intervention techniques, treatment duration and outcome assessments. Some investigations, especially, have included comparatively younger adult populations. The functional effects of BPPV may be more evident in older persons due to age-related deficits in balancing reserve and sensory integration.

Functional mobility is an important result in older persons with vestibular diseases since the capacity to rise from a chair, move, turn, and seat securely are vital to independent daily functioning. Functional mobility can be evaluated using Timed Up and Go (TUG) test, in which the subject is requested to get up from a chair, walk a certain distance, turn, return to the chair and seat down. A shorter time taken to complete the test demonstrates an improvement in functional mobility.

Functional balance is another key element of rehabilitation evaluation. The Berg Balance Scale (BBS) is a measure of performance in a variety of functional balance activities including sitting, standing, transfers, reaching, turning, and static postural postures. Higher BBS scores indicated higher functional balance performance. The BBS is connected to functional status for falls, but does not provide a direct assessment of the actual number of falls.

Dynamic gait is especially clinically significant in older persons with BPPV as walking while changing speed, direction, head position, or environmental demands needs appropriate integration of vestibular, visual, and somatosensory information. Hence, the Dynamic Gait Index (DGI) is a pertinent outcome measure for evaluating dynamic gait and functional balance when walking activities.

The aim of the present study was to determine if adding structured balance training to CRM would lead to larger gains in functional mobility, functional balance, and dynamic gait compared to CRM alone in older persons with BPPV. The study contrasts CRM + organised balance training with CRM alone. Functional mobility was examined by TUG test, functional balance by BBS and dynamic gait by DGI.

The motivation for the present study is the difference between treating the mechanical aetiology of positional vertigo and managing lingering functional limitations. CRM is largely orientated on the realignment of misplaced otoconia, while organised training in balance may give repeated practice of postural control, weight shifting, standing, walking, turning and other functional tasks. Therefore, combining these techniques may offer a more complete rehabilitation plan for older persons with balance and mobility impairments associated with BPPV.

The purpose of the present study is to evaluate the effect of addition of structured balance training to the CRM on the functional mobility, functional balance and dynamic gait in older persons with BPPV. It also aims to investigate if the combined intervention leads to bigger gains in TUG, BBS, and DGI scores than CRM alone. Additional demonstration of a functional advantage might justify the introduction of systematic balance training into the rehabilitation care of older persons with BPPV who remain with balance and mobility problems following repositioning treatment.

Review Of Literature

Benign Paroxysmal Positional Vertigo in the Aged

Benign paroxysmal positional vertigo (BPPV) is one of the most frequent peripheral vestibular illnesses and is characterised by transient vertigo episodes induced by changes in head position. When displaced otoconia enter one of the semi-circular canals, they produce inappropriate stimulation during head movement and BPPV follows. The condition is of particular importance in the older people because age-related changes in the vestibular, visual, somatosensory and musculoskeletal systems might influence the ability to compensate vestibular disturbances .

In addition to positional vertigo, elderly patients with BPPV may have dizziness, postural instability, gait impairment, reduced mobility and increased risk of falls. Balatsouras et al. (2018) stressed the clinical significance of BPPV in the elderly and noted that this population can experience additional difficulties during the diagnostic and therapeutic procedures. The functional impact of BPPV may be further compounded by the presence of age-related balance decline.

Clinical practice guideline for diagnosis and therapy of BPPV Bhattacharyya et al. (2017) Emphasis on accurate diagnosis and appropriate management of canalith repositioning. "The guideline also pointed out the need for review in case of persistent symptoms after therapy. Therefore, the complete management of BPPV should include the treatment of positional vertigo and the identification of residual balance or functional abnormalities.

Canalith Repositioning Manoeuvre for BPPV

Canalith repositioning manoeuvres (CRM), notably the Epley operation for posterior-canal BPPV, are approved procedures that relocate displaced otoconia and alleviate positional vertigo. The Epley method involves a series of head and body movements to dislodge the otoconial material from the implicated semicircular canal to the vestibule.

The effectiveness of CRM in the treatment of posterior canal BPPV has been confirmed in clinical research and evidence-based recommendations. Hilton and Pinder demonstrated the Epley procedure to be effective for posterior-canal BPPV. Similarly, Bhattacharyya et al. (2017) advised canalith repositioning therapies for appropriate patients with posterior canal BPPV .

While CRM can be useful in alleviating the positional component of BPPV, effective repositioning does not always guarantee that normal balance and movement will be readily regained. Some experience residual dizziness, postural instability or difficulty with functioning duties following treatment. Such chronic deficiencies have led to the pursuit of rehabilitative therapies other than CRM.

BPPV, Balance Disorders and Risk of Falls

The association of BPPV with both balance impairment and falls has particular significance for elderly adults. Changes in vestibular function may affect the integration of sensory information essential for the maintenance of postural stability. These changes, in combination with age related reductions in strength, response speed, vision and proprioception, may lead to an overall higher risk of instability.

Ganança et al. (2010) evaluated falls among the elderly with BPPV that had fallen in the last year. Their results demonstrated a reduction in falls after particle repositioning therapy, highlighting the therapeutic value of a comprehensive treatment of BPPV for fall-related outcomes.

Balatsouras et al. (2018) also reported the association between BPPV, balance impairment and falls in the elderly. Older adults with BPPV may find it more challenging to maintain postural stability and to execute functional duties safely. Therefore, along diagnosing positional vertigo, it could also be essential to assess functional balance and mobility.

However, the association between falls and fall-related functional measures needs to be separated from fall incidence. The TUG and BBS are measures that inform on mobility and balance performance but do not directly assess if or not a person will fall or if an intervention has led to a reduction in the frequency of falls.

Vestibular Rehabilitation and Balance Training

Vestibular therapy is an exercise-based rehabilitation program that targets the restoration of postural stability, gaze stability, gait and functional performance in patients with vestibular disorders. Rehabilitation programs might incorporate balance exercises, head movements, walking, weight shifting, turning and more complex functional tasks.

Cohen and Kimball (2004) investigated vestibular rehabilitation in individuals with chronic symptoms related to peripheral vestibular disorders. Vestibular treatment resulted in improvements in balance and functional mobility including improvement in performance on the Timed Up and Go test. Although our research sample was not limited to BPPV patients, our findings support the use of vestibular treatment to improve functional postural control.

Balance training may be particularly essential following a successful CRM as the repositioning manoeuvre primarily addresses the mechanical aetiology of positional vertigo. The person may be able to learn to compensate for movement related issues and to improve the functional integration of vestibular, visual and somatosensory information by repeated practice of balance and mobility exercises.

Combined CRM and Vestibular Rehabiliation

Studies combining CRM with vestibular rehabilitation imply that rehabilitation may give extra functional advantages beyond repositioning therapy alone. Chang et al. (2008) performed a randomised controlled experiment with 26 subjects with unilateral posterior-canal BPPV. The experimental group was given CRM in combination with vestibular exercise training while the control group was given CRM alone. Outcome measurements included balance, tandem gait, Dynamic Gait Index, and vertigo intensity.

The results of Chang et al. (2008) lend credence to the hypothesis that extra advantages may accrue from vestibular training in conjunction with CRM. This is therapeutically significant as CRM mainly tackles the positional component of BPPV, whereas rehabilitation activities may target residual balance and gait deficits.
To et al. (2022) conducted a randomised controlled experiment in individuals with unilateral posterior-canal BPPV to evaluate personalised vestibular rehabilitation plus CRM. Twenty-eight individuals were randomly assigned to either a CRM-only control group or an experimental group receiving CRM with customised vestibular therapy. The combination intervention improved many dynamic gait outcomes including gait duration, stride velocity, turning time and number of steps during turning.
The results of To et al. (2022) add more evidence supporting the combination of repositioning therapy and rehabilitation. However, the participants in that research were adults, with an average age of about 50 to 54 years. Thus, the results are evidence from an adult BPPV group; nevertheless, are not regarded to be direct proof for older individuals.

Rehabilitation of older adults with BPPV Balance
Their capacity to correct for vestibular disturbances may be affected by age-related changes so that balance-oriented vestibular therapy may be especially important for older persons with BPPV. Ribeiro et al., performed a randomised controlled trial to explore the impact of vestibular rehabilitation on balance in older persons with BPPV. The rehabilitation treatment consisted of balancing exercises with CRM when clinically recommended.
The results indicated that vestibular therapy may enhance balance-related outcomes in older persons with BPPV. This finding is important for the present investigation because the target population is likewise older persons with BPPV and the intervention involves balance-focused therapy in addition to CRM.
Ribeiro et al. have provided information about the role of vestibular rehabilitation and repositioning techniques in older persons with BPPV. They conclude that therapy should target the vestibular aetiology of positional vertigo and the functional effects associated with balance impairment.
Evidence from research with older persons is particularly relevant as balance deficiencies in this population may be due to numerous interacting variables including age-related sensory deterioration, diminished muscular strength, increased response time and decreased postural reserve.

Functional Mobility After BPPV Treatment
Functional mobility is an essential result in older persons as mobility is directly connected to independence and engagement in daily activities. Improvement in the capacity to stand, walk, turn, and execute other functional motions safely should be associated with resolution of positional vertigo.
The Timed Up and Go (TUG) test is a frequently used clinical assessment of functional mobility. The test involves a person to get up from a chair, walk a distance, turn around, walk back to the chair and seat down. often, functional mobility is reflected in the time taken to complete the activity, with shorter timeframes to complete the task often indicating superior mobility performance.
Vestibular therapy improved functional mobility in those with persistent peripheral vestibular diseases (Cohen & Kimball, 2004). Their results support the use of functional mobility measures in vestibular rehabilitation studies.
To et al. (2022) also described improvements in gait and turning outcomes after individualised vestibular therapy with CRM. Results indicate rehabilitation may have an effect on functional movement performance beyond remission of positional vertigo.
Thus, the TUG test is a suitable outcome measure for measuring functional mobility in the present study.

Gait and Postural Control Dynamic
Dynamic gait needs ongoing integration of vestibular, visual and somatosensory information. As people walk, they must maintain postural stability as they change direction, pace, head position, and environmental demands. These needs may be especially difficult for elderly persons with vestibular impairment.
People with BPPV may have trouble doing anything dynamic like turning, altering the direction of walking or rotating their head while walking. Such problems may remain after effective repositioning of the dislocated otoconia.
Chang et al. (2008) used the Dynamic Gait Index (DGI) as an outcome measure in their randomised controlled trial of patients with BPPV. Findings revealed that vestibular exercise with CRM might enhance dynamic balance and gait function.

To et al. (2022) similarly found improvements in gait and turning performance after a tailored vestibular rehabilitation program combined with CRM. These results support the use of dynamic gait assessment in the evaluation of the functional consequences of combined BPPV therapy.
Thus, in the present investigation the DGI is a clinically relevant outcome measure for the assessment of dynamic gait and functional postural control.

Functional Balance and Berg Balance Scale
The Berg Balance Scale (BBS) is a frequently used clinical assessment of functional balance. It evaluates the capacity to do a variety of actions related to sitting, standing, transferring, reaching, turning, and sustaining postures.
Higher scores of BBS imply higher functional balance ability. The BBS can give valuable insight into functional balance condition of older persons since balance impairment is related to risk of falls. But the BBS is neither a direct measure of actual falls or a direct indication that an intervention has decreased the incidence of falls.
The results of Ribeiro et al. are relevant to the present study as they investigated vestibular rehabilitation and balance outcomes in older persons with BPPV. Their results suggest the potential importance of balance-focused rehabilitation in enhancing functional balance after treatment of BPPV.
Therefore, in the present investigation, the BBS was adopted as a supplemental outcome measure to TUG and DGI. These metrics together enable assessment of functional mobility, functional balance and dynamic gait from separate but connected viewpoints.

The Need for a Broad Approach to Rehabilitation
Current literature supports CRM as an evidence-based strategy for the positional component of BPPV. However, there is also evidence that some persons may have lingering dizziness, balance impairment or movement difficulties even after effective repositioning.
Vestibular therapy and systematic balancing exercises may treat these persistent functional deficits by regularly testing postural control, weight shifting, walking, turning, and other functional tasks. So the combination of CRM and rehabilitation may offer a more complete approach than simply moving therapy.
Chang et al. (2008), Ribeiro et al., and To et al. (2022) lend support to the possible extra advantages of rehabilitation following CRM. However, prior research have used different features of participants, different protocols of intervention, different periods of therapy and outcome measures.
Chang et al. (2008) studied a very small population of individuals with posterior-canal BPPV whereas Ribeiro et al. focused on elderly persons. To et al. (2022) studied gait measures in persons with BPPV following individualised vestibular rehabilitation.
These disparities point to the necessity for future research especially among older persons with BPPV utilising an organised and well-defined balance-training program.

Research Gaps
There is good evidence to support the use of CRM for the management of BPPV. The extra functional benefits of carefully designed balance training in addition to CRM are nonetheless less well documented, especially among older persons.
Previous research demonstrated favourable benefits of vestibular therapy on balance, gait and functional mobility . However, variations in participant age, intervention methods, duration of therapy, rehabilitation content and outcome measures make direct comparisons between studies challenging.
In particular, research comparing CRM paired with structured balance training to CRM alone in older persons with BPPV while simultaneously measuring functional mobility, functional balance, and dynamic gait is needed.
The present study addresses this gap by comparing a combined CRM and structured balance-training program to CRM alone in older persons with BPPV. Three clinically relevant outcome measures are utilised. The TUG test is used to assess functional mobility and the BBS to assess functional balance and the DGI to assess dynamic gait. These three outcome measures are employed to give a wider outlook of functional recovery since the intervention may impact various related but separate elements of physical performance.

Methodology

Research Design

The current study was conducted in a two-group, parallel-group randomised controlled pre-test–post-test experimental design to investigate the additive effect of structured balance training in conjunction with Canalith Repositioning Manoeuvre (CRM) in older adults with Benign Paroxysmal Positional Vertigo (BPPV).
Sixty suitable older people with clinically confirmed posterior-canal BPPV were recruited and randomly assigned into two groups of 30 participants each in a 1:1 ratio. Group A was given Canalith Repositioning Manoeuvre with organised balance training while Group B was given Canalith Repositioning Manoeuvre alone.
Functional results were evaluated by the Timed Up and Go (TUG) test, Berg Balance Scale (BBS) and Dynamic Gait Index (DGI) at baseline and immediately after the 4-week intervention. A follow-up evaluation was made at 4 weeks following the end of the intervention to study the preservation of the functional improvement.

Study population
The research cohort comprised older persons aged 65 years or older with clinically confirmed posterior-canal BPPV, recruited from a physiotherapy and vestibular rehabilitation clinical setting.
The diagnosis of BPPV was made on the basis of the clinical history and positional tests. Dix-Hallpike positional test revealed the posterior-canal involvement with classic positional vertigo and nystagmus compatible with the diagnosis.
Side of involvement was recorded prior to treatment. To provide a more clinically homogeneous group, those with bilateral posterior-canal involvement were omitted.

Sample Size
The study had a total of 60 eligible individuals. The participants were randomly assigned to 2 groups:
- Group A: CRM plus systematic balance training (n ¼ 30)
- Group B: CRM only (n=30)

The sample size chosen allowed for a fair comparison between the combined intervention and CRM-only intervention groups.

Randomisation
After eligibility screening, informed permission and baseline evaluation individuals were randomised to Group A or Group B in a 1:1 ratio.
A computer-generated randomisation sequence was used, with permuted blocks of four to ensure approximately equal group sizes during recruitment.
The randomisation sequence was produced by an investigator not engaged in the recruiting of participants, the delivery of the intervention or the assessment of the result. The group assignment was only conducted once the baseline evaluation was completed.

Concealment of allocation
Allocation concealment was achieved via sequentially numbered, sealed, opaque envelopes. Each envelope was marked with the group assignment based on the computerised randomisation process.
Upon completion of the baseline evaluation, the allocation investigator opened the next sequentially numbered packet. This process decreased the risk of selection bias in group allocation.

Criteria for inclusion
Participants were included if they satisfied all of the following criteria:
1. 65 years of age or older.
2. Posterior-canal BPPV clinical diagnosis.
3. Positive Dix-Hallpike positioning test compatible with posterior-canal BPPV.
4. Independent ambulation and standing or ambulation with the participant's normal assistive equipment.
5. Able to interpret and follow spoken directions.
6. Ability to safely conduct evaluations with TUG, BBS and DGI.
7. Interest in participating in the whole intervention program.
8. Written informed consent.

Exclusion Criteria
Participants were excluded from the study if they had:
1. Neurological disease with significant impairment of balance or gait.
2. Severe musculoskeletal diseases affecting standing or walking

3. Severe visual impairment which may interfere with outcome assessment.
4. Severe peripheral sensory impairment that would compromise balance testing.
5. Uncontrolled cardiovascular disease or other medical condition where exercising might be harmful.
6. Major surgery or acute musculoskeletal injury limiting movement during the last 6 months.
7. Diagnosis of another vestibular disease likely to affect study outcomes.
8. Significant cognitive impairment that would preclude dependable involvement.
9. Serious difficulty in communication such that instructions could not be understood.
10. Previous vestibular rehabilitation during the last three months

Ethical Considerations

The study was performed in conformity with the principles of the Declaration of Helsinki. Ethical consent was taken from the institutional ethics committee before the initiation of the participants' recruiting.

All participants were informed of the research goal, methods, potential advantages, possible discomforts, and that participation was optional. All participants gave informed written consent before to inclusion.

Participants were advised that they might withdraw from the trial at any time with no effect on their usual clinical treatment. The identity of the participants were kept anonymous and all the study data were coded and stored securely.

Benchmark Testing

Demographic data and clinical variables such as age, sex, body mass index (BMI), afflicted side, and important clinical aspects of BPPV were recorded before randomisation.

Baseline functional outcomes were examined by:

- -Timed Up and Go (TUG) test;
- Berg Balance Scale (BBS); and
- Dynamic Gait Index (DGI)

Baseline evaluations were performed before the first therapy session.

Outcome Measures

- **Timed Up and Go Test (TUG)**

Functional mobility was measured with the Timed Up and Go test. Participants were asked to stand up from a regular chair, walk three meters at a comfortable and safe speed, turn around, walk back to the chair and sit down.

The time taken to accomplish the assignment in seconds was noted. Shorter completion times indicated stronger functional mobility.

- **Berg Balance Scale**

Functional balance was assessed with the Berg Balance Scale. The scale measures performance in standardised activities including sitting, standing, transfers, reaching, turning and postural stability maintenance.

Better functional balance performance is indicated by higher scores on the BBS. The BBS was regarded in this study as a measure of functional balance, rather than a direct measurement of actual falls.

- **Dynamic Gait Index (DGI)**

The Dynamic Gait Index was designed to assess dynamic gait and functional postural control during gait. The examination challenges gait under multiple scenarios such as gait speed variations, horizontal and vertical head motions, turning, pivoting and walking over or around obstacles.

Higher DGI scores represent higher dynamic gait performance.

Intervention Procedure

The intervention period was of four weeks. Participants attended three supervised sessions per week for a total of 12 planned treatment sessions.

Supervised sessions were usually 40 minutes in length.

All procedures were performed by a professional physiotherapist with expertise in vestibular and balance therapy.

- **Group A: CRM in Combination with Structured Balance Training**

Group participants Received a crm and systematic balancing training.

For posterior-canal BPPV, the Epley canalith repositioning procedure was conducted utilising a standardised series of head and body postures. CRM was conducted at the start of each treatment session when clinically appropriate.

After the CRM, participants completed a rigorous balance-training program.
The balance training regimen included:

- static balance when standing;
- narrow-base pedestal;
- tandem, standing;
- activities to lose weight;
- actions undertaken;
- sit to stand exercises;
- stepping exercise;
- walk forth and backward;
- Laterally walking;
- modify and rotate exercises;
- walking with head movement;
- negotiating of obstacles; and
- activities in functional mobility.

Initially, balance exercises were conducted with external assistance if needed. The exercise was made progressively more challenging by diminishing hand support, decreasing the base of support, increasing the intricacy of the action, adding head motions and increasing the demands on walking and turning.
The balance-training component was around 25–30 minutes each session.
Participants were observed during training for dizziness, nausea, extreme tiredness, imbalance, or any other adverse effect.

- **Group B: CRM only**

The same standardised approach for Group A participants was used to perform the Canalith Repositioning Manoeuvre for Group B.
The Epley technique was applied for posterior-canal BPPV when clinically appropriate.
Group B did not get the organised balance-training program throughout the four-week intervention period. Participants resumed their regular daily activities, but were not given the formal balancing training that Group A received.
This group thus served as the active comparison group to see if organised balancing training produced further functional improvements beyond CRM alone.

Intervention Adherence
Attendance at all therapy sessions was recorded.
Intervention adherence was judged acceptable if participants attended at least 10 of the 12 sessions. Reasons for missing sessions were recorded.
Any departure from the protocol, treatment drop-out or adverse event was registered during the intervention period.

Loss of sight
Due to the physical nature of the therapies, participants and treating physiotherapists were unable to be blinded to group allocation.
However, outcome evaluations were conducted by a physiotherapist who was not engaged in therapy administration and was blinded to group allocation of the subject.
The assessor was unaware of the therapy received by the individual prior to and throughout outcome assessment.
The TUG, BBS and DGI evaluations were conducted by this assessor following standardised processes.

Assessment Schedule
Assessments were made at three time points:
T0 - Baseline: Prior to randomisation and the first intervention session.
T1 – Post-intervention: Immediately after the four week intervention.
T2 – Follow-up: Four weeks post-intervention completion.
The same methodologies (TUG, BBS, DGI) were applied at all sites of evaluation.
The main comparison was change from baseline to after intervention. A follow-up examination was utilised to evaluate the maintenance of improvements following the cessation of supervised therapy.

Safety Procedures

- Safety of the participants was checked during all treatment sessions.
- Subjects were monitored for dizziness, nausea, imbalance, weariness, instability, or other adverse reactions. Balance exercises were performed in standing, walking, turning and changing directions, under close observation.
- Balance exercises were done with adequate safeguards and environmental safety procedures.
- If extreme dizziness, major imbalance, or other clinically significant adverse responses were seen, the activity was changed or terminated until the person was stable.
- All the bad stuff was written down.

Procedure of Data Collection

Data collection followed a regular sequence:

1. Participants screening.
2. Confirmation of BPPV diagnosis.
3. Evaluation of inclusion and exclusion criteria.
4. Informed consent in writing.
5. Baseline Demographic and Clinical Assessment.
6. Baseline examination of TUG, BBS and DGI.
7. Randomisation.
8. Four week intervention.
9. Follow-up on adherence to therapy and adverse occurrences.
10. Post intervention immediate evaluation.
11. Four-week follow-up visit.
12. Coding and statistical analysis of the data obtained.

Statistics

Descriptive statistics were used to provide an overview of demographic and clinical characteristics. Continuous data were expressed as mean ± SD, while categorical variables were provided as frequencies and percentages. Baseline differences between groups were explored with independent-samples t tests for continuous variables and chi-square testing for categorical variables. Within-group paired-samples t-tests were used to assess change from baseline to post-intervention. Change scores were compared between groups using independent-samples t tests. ANCOVA was performed as the major between-group analysis for post-intervention TUG, BBS, and DGI scores, with the respective baseline score as a covariate. Before ANCOVA, the assumptions of normality, homogeneity of variance, linearity, and homogeneity of regression slopes were checked. The size of the group effect was measured with partial eta squared (ηp2) in ANCOVA. 95% confidence intervals are included when applicable. The level of significance was $p < 0.05$.

Primary and Secondary Outcome Measures

The principal results were:

1. Functional mobility, evaluated by the TUG test.
2. Functional balance, assessed by BBS.

The DGI was a secondary outcome measure for dynamic gait assessment and functional postural control.

Prospective recording of actual fall incidents as a consequence was not performed. Thus, the improvements in TUG, BBS or DGI were considered as improvements in functional mobility, balance and dynamic gait and not as direct evidence of decreased fall incidence.

Flow and Follow-up of Participants

Recruitment, randomisation, intervention completion, follow-up and analysis should be described using a CONSORT style participant flow diagram.

Of the 60 randomised individuals, 30 were in the combined CRM and balance-training group and 30 in CRM just.

Explicitly describe the numbers of participants who completed the intervention and who were available for post-intervention and follow-up evaluations.

Any participant who is lost to follow-up, removed from treatment, or omitted from analysis should be recorded, including with the reason.

Data Analysis Matrix

Study Objective	Outcome Measure	Assessment Time	Statistical Analysis
To assess functional mobility	TUG	Baseline and post-intervention	Paired t-test; ANCOVA
To assess functional balance	BBS	Baseline and post-intervention	Paired t-test; ANCOVA
To assess dynamic gait	DGI	Baseline and post-intervention	Paired t-test; ANCOVA
To compare the additional effect of balance training	TUG, BBS, DGI	Post-intervention adjusted for baseline	ANCOVA
To examine maintenance of treatment effects	TUG, BBS, DGI	Follow-up	Repeated-measures analysis or appropriate longitudinal analysis

Result

Table 1. Baseline Characteristics of Participants

Variable	Combined CRM + Balance Training (n=30)	CRM Alone (n=30)	p-value
Age (years), Mean ± SD	68.43 ± 4.52	69.07 ± 4.76	0.596
Male, n (%)	13 (43.3)	14 (46.7)	0.795
Female, n (%)	17 (56.7)	16 (53.3)	0.795
BMI (kg/m²), Mean ± SD	24.81 ± 2.91	25.14 ± 3.08	0.674
TUG (sec)	13.84 ± 1.92	13.67 ± 1.88	0.729
BBS	43.27 ± 3.54	43.63 ± 3.47	0.691
DGI	17.43 ± 2.16	17.57 ± 2.24	0.806

The trial comprised 60 older persons with BPPV, who were randomly assigned to either a combined CRM and balance-training group (n = 30) or a CRM-only group (n = 30). Baseline demographic and clinical characteristics of study participants are summarised in Table 1.
The mean age was 68.43 ± 4.52 years in combined CRM and balance-training group and 69.07 ± 4.76 years in CRM solo group. The age difference between the groups was not statistically significant (p = 0.596).
The mixed group had 13 men (43.3%) and 17 females (56.7%) whereas the CRM-only group comprised 14 males (46.7%) and 16 females (53.3%). There was no statistically significant difference in sex distribution across the groups (p=0.795).
The mean BMI was 24.81 ± 2.91 kg/m2 and 25.14 ± 3.08 kg/m2 in the combination and CRM only group, respectively, with no statistically significant difference (p = 0.674).
Functional results at baseline were likewise similar across the two groups. The mean TUG score was 13.84 ± 1.92 seconds for the combined group and 13.67 ± 1.88 seconds for the CRM-only group (p=0.729). The mean BBS score was 43.27 ± 3.54 and 43.63 ± 3.47, respectively (p = 0.691) and the mean DGI score was 17.43 ± 2.16 and 17.57 ± 2.24, respectively (p = 0.806) .
Therefore, no statistically significant differences were found between the two groups at baseline in terms of age, sex, BMI, TUG, BBS, and DGI (all p > 0.05). The groups were consequently similar at baseline in terms of the demographic and functional parameters measured

Table 2. Within-Group Comparison of Functional Mobility (TUG)

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	t-value	p-value
Combined CRM + Balance Training	13.84 ± 1.92	10.62 ± 1.51	3.22	8.14	<0.001
CRM Alone	13.67 ± 1.88	11.94 ± 1.67	1.73	5.21	<0.001

Table 2 shows the comparison of the Timed Up and Go (TUG) test outcomes in functional mobility groups.
The mean TUG score in the combined group of CRM and balancing training was 13.84 ± 1.92 seconds at baseline and 10.62 ± 1.51 seconds after intervention. On average, times were decreased by 3.22 seconds and this improvement was statistically significant (t = 8.14, p < 0.001).

In the CRM-only group, the mean TUG score increased from 13.67 ± 1.88 seconds to 11.94 ± 1.67 seconds (mean difference, 1.73 seconds). This increase was likewise statistically significant ($t = 5.21$, $p < .001$).
Lower TUG completion time means more functional mobility, so the decreased TUG scores imply enhanced functional mobility in both groups. However, the improvement was greater in the combined intervention group than in the CRM only group (3.22 seconds vs. 1.73 seconds).

Table 3. Within-Group Comparison of Fall Risk (BBS)

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	t-value	p-value
Combined CRM + Balance Training	43.27 ± 3.54	49.13 ± 2.84	5.86	9.37	<0.001
CRM Alone	43.63 ± 3.47	46.87 ± 3.12	3.24	5.86	<0.001

Functional balance measured by the Berg Balance Scale (BBS) is presented in Table 3.
The mean BBS score increased from 43.27 ± 3.54 to 49.13 ± 2.84 following the intervention in the combined CRM and balance-training group. Mean increase was 5.86 points. The improvement was statistically significant ($t = 9.37$, $p < 0.001$).
In the CRM-only group, the mean BBS score increased from 43.63 ± 3.47 to 46.87 ± 3.12; the mean increase was 3.24 points . This improvement was also statistically significant ($t = 5.86$, $p < .001$).
The larger rise in BBS score in the combination group implies improved functional balance performance compared with CRM alone.

Table 4. Within-Group Comparison of Dynamic Gait Index (DGI)

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	t-value	p-value
Combined CRM + Balance Training	17.43 ± 2.16	22.16 ± 1.87	4.73	—	<0.001
CRM Alone	17.57 ± 2.24	20.24 ± 2.03	2.67	—	<0.001

Table 4 demonstrates the intra-group changes in dynamic gait measured by the Dynamic Gait Index (DGI).
In the combined CRM and balance-training group, the mean DGI scores were 17.43 ± 2.16 pre-intervention and 22.16 ± 1.87 post-intervention. Mean improvement was 4.73 points and the difference was statistically significant ($p<0.001$).
In the CRM only group, the mean score of DGI at baseline was 17.57 ± 2.24 and at the conclusion of the trial was 20.24 ± 2.03. The mean increase of 2.67 points ($p < 0.001$) was statistically significant.
The change in DGI score was substantially greater in the combined intervention group than in the CRM-only group (4.73 vs. 2.67 points), demonstrating improvement in dynamic gait and functional postural control.

Table 5. Between-Group Comparison of Change Scores

	Combined Group Mean Change	CRM Group Mean Change	t-value	p-value
TUG (sec)	−3.22 ± 1.16	−1.73 ± 1.12	−5.08	<0.001
BBS	+5.86 ± 2.01	+3.24 ± 1.92	5.18	<0.001
DGI	+4.73 ± 1.84	+2.67 ± 1.76	4.49	<0.001

Table 5 Comparison of magnitude of change in TUG, BBS and DGI scores between two intervention groups. For TUG, the mean decrease in the combined group was 3.22 ± 1.16 seconds against 1.73 ± 1.12 seconds for the CRM-only group. $t = -5.08$, $p < 0.001$ = statistically significant. The outcome benefited the combination intervention, as lower TUG scores suggest higher functional mobility.
BBS: the combined group showed a mean rise of 5.86 ± 2.01 points over 3.24 ± 1.92 points in the CRM only group. The between-group difference was statistically significant ($t = 5.18$, $p < 0.001$) demonstrating better improvement in functional balance in the combination intervention group.
For DGI the mean gain was 4.73 ± 1.84 points in the combined group vs 2.67 ± 1.76 points in the CRM-only group. The between-group difference was statistically significant ($t = 4.49$, $p < 0.001$) in favour of the combination intervention.

The change-score analysis indicated that the combined CRM and balance-training intervention resulted in considerably higher gains in functional mobility, functional balance and dynamic gait than CRM alone.
Important phrasing revision, do not say these studies show “reduction in fall risk” or “reduction in falls.” They showed improvement in functional outcomes related to balance and movement

Table 6. ANCOVA Comparing Post-Test Outcomes Between the Combined Intervention and CRM-Only Groups

Outcome	Group	Adjusted Mean	SE	F-value	p-value	Partial η²
TUG (sec)	Combined CRM + Balance Training	10.68	0.28	18.64	<0.001	0.246
	CRM Alone	11.88	0.28			
BBS	Combined CRM + Balance Training	49.02	0.49	16.87	<0.001	0.226
	CRM Alone	46.98	0.49			
DGI	Combined CRM + Balance Training	22.05	0.32	14.92	<0.001	0.207
	CRM Alone	20.35	0.32			

Table 6. ANCOVA of post-intervention outcomes between combined intervention and CRM only groups. The post-intervention TUG, BBS and DGI scores were compared between the two groups using ANCOVA adjusted for baseline values.
The adjusted mean post-intervention TUG was 10.68 ± 0.28 sec for the combined group and 11.88 ± 0.28 sec for the CRM-only group. The between-groups difference was statistically significant (F=18.64, p<0.001, partial η2=0.246). The combined intervention was beneficial in the corrected data, since reduced TUG scores reflect increased functional mobility.
The post-intervention mean of BBS was 49.02 ± 0.49 for mixed group and 46.98 ± 0.49 for CRM only There was a large group difference (F = 16.87, p < .001, partial η2 = .226), with the combination intervention being better than the others.
The mean corrected post-intervention in DGI was 22.05 ± 0.32 for the combined group and 20.35 ± 0.32 for the CRM-only group. There were significant differences between the groups (F = 14.92, p < 0.001).
In conclusion, the results show that the interventions result in substantial improvements in functional mobility, functional balance and dynamic gait. However, falls were not specifically recorded or tracked and hence the results cannot be interpreted as evidence of a direct reduction in fall occurrence.

Discussion

Overall Results

The present study was meant to evaluate the effect of combining Canalith Repositioning Manoeuvre (CRM) with organised balance training on functional mobility, functional balance and dynamic gait in older adults with Benign Paroxysmal Positional Vertigo (BPPV). Statistically substantial improvements in TUG, BBS and DGI scores were seen in both groups (p < 0.001). But the combined group (CRM + balance training) demonstrated substantially more development than the CRM just group. The data suggest that CRM is efficacious in the management of the positional component of BPPV; however, the inclusion of structured balance training may provide additional functional benefits.

Effects of CRM on Functional Outcomes

The improvement in the CRM-only group is in line with the well-established effectiveness of canalith repositioning in the treatment of BPPV. Epley (1992) initially detailed the use of canalith repositioning for treating BPPV. Bhattacharyya et al. (2017) approved canalith repositioning methods as evidence-based therapy for eligible patients with BPPV. Thus, the improvement in TUG, BBS, and DGI in the CRM-only group in the present study is in line with the expected therapeutic effect of CRM.

Effect on Functional Mobility – TUG

In the present study, there was a significant reduction in TUG time in both groups. The combined group improved from 13.84 ± 1.92 s to 10.62 ± 1.51 s while the CRM-only group improved from 13.67 ± 1.88 s to 11.94 ± 1.67 s . As a consequence, the combined group exhibited a greater improvement.
The Timed Up and Go (TUG) test assesses functional mobility when the person gets up from a chair, walks, turns around and sits down. The Timed Up and Go (TUG) was created by Podsiadlo and Richardson (1991) as a basic functional mobility test in the elderly. The combined group showed more progress, which might be due to

regular practice of standing, walking, turning, weight shifting and other functional activities included in the balance training program.

Effect on Functional Balance – BBS

Both groups showed significant improvement in BBS scores. The combined group improved from 43.27 ± 3.54 to 49.13 ± 2.84 whereas the CRM-only group improved from 43.63 ± 3.47 to 46.87 ± 3.12. The large increase in the combined group suggests that formal balance training enhances functional balance.

These results are in accordance with the results of Chang et al. (2008) where they saw improvement in balance-related outcomes following vestibular exercises with CRM in BPPV patients. Ribeiro et al. have reported favourable effects of vestibular rehabilitation and balance-oriented therapy in elderly people with BPPV. These findings support the current concept that balance training may provide further benefits over and beyond those of CRM alone.

Gait Dynamics – DGI

The DGI scores in the present study also considerably improved in both groups. The combined group improved from 17.43 ± 2.16 to 22.16 ± 1.87, while the CRM-only group improved from 17.57 ± 2.24 to 20.24 ± 2.03. The higher improvement in the combined group indicates better dynamic gait and functional postural control.

Chang et al. (2008) measured functional gait and balance following vestibular intervention in people with BPPV using the Dynamic Gait Index and found improvements after rehabilitation. Similarly, vestibular treatment with CRM was reported to enhance gait-related results (Se To et al., 2022). These findings are consistent with existing results and indicate that further benefits for dynamic gait may be obtained with organised therapy beyond CRM alone.

Remaining Balance after CRM & Functional Impairment

The greater improvement in the combined group suggests that the resolution of positional vertigo alone is not sufficient to restore functional balance and mobility. As Horak (2006) noted, postural regulation is based on integration of vestibular, visual and somatosensory information. Changes in these systems with ageing may compound issues of balance and mobility in older adults.

In the elderly, persistent residual vertigo has been reported despite successful treatment of BPPV (Teggi et al., 2011). Other residual symptoms following successful canalith repositioning were also studied by Martellucci et al. (2016) and Vaduva et al. (2018). Therefore, systematic balance training may be useful to address persistent functional impairments after treatment of the positional component of BPPV.

BPPV, Balance Impairment and Geriatrics

The findings are particularly noteworthy in older adults, because BPPV may interact with age-related reduction in balance reserve. Balatsouras et al. (2018) pointed out the clinical importance of BPPV in the elderly and its relationship to balance impairment and falls. Ganança et al. (2010) also found an association between BPPV and falls in the elderly.

Thus treatment of elderly people with BPPV should not be restricted to the alleviation of positional vertigo. Assessment and treatment of functional balance, gait and mobility may be effective in improving overall physical functioning.

Comparison with other studies of combined interventions

Improvements were greater in the combined intervention group than in the other groups, consistent with previous research on CRM with vestibular or balance treatment. Other functional benefits of vestibular exercises combined with CRM have been reported by Chang et al. (2008). In accordance with this, Se To et al. (2022) saw improvements in gait and balance with personalised vestibular treatment added to CRM versus CRM alone.

The present work extends this knowledge to older adults and three clinically relevant outcomes, namely TUG for functional mobility, BBS for functional balance, and DGI for dynamic gait. The steady improvement in all three parameters supports the conclusion that structured balance training may have an additional functional benefit when added to CRM.

Reading the Results of ANCOVA

ANCOVA findings also reveal superiority of the combo intervention. After correcting for baseline scores, there were significant group differences for TUG ($F = 18.64$, $p < 0.001$), BBS ($F = 16.87$, $p < 0.001$), and DGI ($F = 14.92$, $p < 0.001$).

The adjusted means favoured the combined group, with lower TUG scores and higher BBS and DGI scores. Partial eta-squared values also showed large group effects. The groups had equal starting scores, indicating that differences at baseline did not explain the superior post-intervention performance of the combined group.

Effects of Risk of Falls

The improvements in BBS, TUG and DGI imply better functional balance, mobility and dynamic gait, all of which are significant for functional performance related to fall risk. Ganança et al. (2010) shown the clinical relationship of BPPV with falls in the elderly.

But the study didn't really track genuine falls, and that's important to bring out. Thus, these results should be interpreted with care and not as direct proof of a reduction in the risk of falls by combined CRM and balance training. Instead, the findings suggest a clinically significant increase in functional outcomes for balance and fall-risk assessment.

Clinical implications

The findings suggest a more comprehensive approach to rehabilitation of older adults with BPPV from a physiotherapy perspective. CRM primarily deals with the mechanical or positional component of BPPV by repositioning displaced otoconia. Organised balance training provides repeated practice of postural control, weight shifting, walking, turning and functional mobility.

The results suggest that balance training might be a valuable complement to CRM in older adults who still have functional balance or mobility issues after repositioning treatment.

General Interpretations

The findings of the current study suggest that the combination of CRM and structured balance training are more effective than CRM alone to improve functional mobility, functional balance and dynamic gait in older adults with BPPV. These results are in line with previous studies by Chang et al. (2008), Ganança et al. (2010), Ribeiro et al. and Se To et al. (2022).

Results support the concept that balancing training and CRM may address different areas of functional impairment associated with BPPV. CRM may focus on the vestibular positioning component, whereas balance training may focus on residual postural, gait, and mobility deficits.

Conclusion

The present study demonstrated that the combination of Canalith Repositioning Manoeuvre (CRM) with structured balance training was more effective than CRM alone in improving functional outcome in elderly subjects with Benign Paroxysmal Positional Vertigo (BPPV).

Both groups exhibited statistically significant improvement in Timed Up and Go (TUG), Berg Balance Scale (BBS) and Dynamic Gait Index (DGI) scores post-intervention. But the group who had both CRM and balance training saw substantially higher gains than the group that got simply the CRM.

The findings imply that CRM is useful in the treatment of the positional component of BPPV and that the addition of structured balance training may lead to additional improvements in functional mobility, functional balance and dynamic gait.

Improvements in BBS, TUG and DGI show better functional performance of balance and mobility. However, in this study real falls were not directly tracked and so these data cannot be considered as convincing confirmation of a reduction in fall occurrence.

One physiotherapist thought that a combination of CRM and structured balance training would provide a more comprehensive rehabilitation for elderly people with BPPV, especially those still presenting balance and mobility impairments following therapy with repositioning procedures.

Future studies should include larger sample sizes, longer follow-up times and direct evaluation of fall incidence to determine the extent to which the functional benefits associated with combined CRM and balancing training translate into sustained gains and decreased actual falls.

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