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Delayed Vestibular Physiotherapy in Chronic Post-Traumatic Vestibulopathy: A Clinical Case Analysis

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Abstract

Background. Head trauma may cause persistent dizziness and impair balance, mobility, daily activities, and quality of life. Although vestibular rehabilitation is usually recommended early after injury, some patients do not receive timely treatment. Therefore, evidence on delayed vestibular physiotherapy remains limited.

Aim. To examine the effects of delayed vestibular physiotherapy initiated approximately two years after head trauma.

Methods. A single-case interventional clinical analysis was conducted in a 53-year-old male with chronic post-traumatic vestibular complaints. A 13-week home-based vestibular rehabilitation programme was adjusted according to symptoms and clinical response. Assessment included the Dix–Hallpike Test, Motion Sensitivity Quotient, Berg Balance Scale, Tinetti Test, Timed Up and Go Test, tandem standing, and single-leg stance. Measurements were performed at baseline, during follow-up, at the end of the intervention, and again four weeks later. The intervention included Brandt–Daroff exercises, the Epley manoeuvre, gaze stabilisation, and balance training.

Results. Positional symptoms gradually decreased and were no longer provoked at the final assessment. Motion sensitivity decreased to 0 and remained unchanged at re-assessment. Balance and functional mobility also improved over time, and the participant reported no dizziness during positional changes, head movements, or daily activities by the end of follow-up.

Conclusions. Delayed vestibular physiotherapy was associated with reduced positional symptoms and improved balance, mobility, and daily functioning in this clinical case.

Keywords: Vestibular rehabilitation; post-traumatic dizziness; vestibulopathy; delayed intervention

1. INTRODUCTION

Persistent dizziness after head trauma remains a clinically important problem because it may affect balance, mobility, daily activities, and overall quality of life. Dizziness is among the most common symptoms after a concussion and is also associated with prolonged recovery. In addition, post-traumatic dizziness is not a uniform condition, as it may arise from peripheral vestibular, central vestibular, visual, cervical, or mixed mechanisms, which makes clinical assessment and management more complex (Gianoli, 2022).

Among peripheral causes, benign paroxysmal positional vertigo (BPPV) is particularly relevant after head injury. Recent evidence suggests that previous head trauma is significantly associated with

later BPPV, supporting the opinion that trauma should be considered an important risk factor when evaluating position-provoked dizziness. This is clinically relevant because traumatic BPPV may be more persistent and may require repeated repositioning procedures rather than a single treatment session (Yoo et al., 2025).

Vestibular rehabilitation is widely regarded as an evidence-based approach for patients with vestibular dysfunction. The updated clinical practice guideline for peripheral vestibular hypofunction recommends exercise-based interventions – including gaze stabilisation, habituation, balance, and gait training – to reduce symptoms and improve gaze stability, postural control, and functional performance (Hall et al., 2022). Moreover, studies have shown that specific head positions and exercises that include head repositioning contribute to a positive effect on vertigo and nystagmus (Helminski, 2024). These interventions are typically initiated in the acute or subacute phase to facilitate central compensation and optimise neuroplasticity (Hall et al., 2022). In the context of mild traumatic brain injury, vestibular rehabilitation has also demonstrated beneficial effects, particularly in reducing dizziness-related symptoms and improving functional outcomes; however, most studies included in recent systematic reviews applied interventions within weeks to a few months post-injury (Aljabri et al., 2024). Similarly, earlier research indicates that vestibular therapy initiated within the first 2–6 weeks after concussion is associated with faster symptom resolution (Alsalaheen et al., 2010; Schneider et al., 2014). Despite this evidence, the effectiveness of vestibular rehabilitation when initiated after a delayed period remains underexplored, highlighting an important gap in understanding its role in persistent post-traumatic vestibular symptoms.

Thus, an important clinically relevant question remains insufficiently addressed: whether vestibular physiotherapy can still be effective when initiated long after the trauma. In routine clinical practice, not all patients receive vestibular rehabilitation during the acute/subacute period, and some continue to experience persistent or only partially compensated vestibular symptoms for months or even years. These cases reflect real-world clinical situations and provide an opportunity to better understand the potential for delayed intervention to promote central compensation, reduce symptom burden, and improve functional outcomes (Aljabri et al., 2024; Gianoli, 2022).

Therefore, this study aimed to examine the effects of delayed vestibular physiotherapy on the symptoms of post-traumatic vestibulopathy with persistent vestibular complaints approximately two years after head trauma.

2. METHODS

2.1. Study design and participant

This study was designed as a single-case interventional clinical analysis with repeated assessments over time. The participant was a 53-year-old male patient with chronic post-traumatic vestibular complaints following a head injury sustained in February 2024 after a fall from a height of approximately 2.5 m. The trauma was associated with traumatic subdural haemorrhage, temporal bone and skull base fractures, clavicle fracture, dislocation of the little finger, and multiple contusions. Bleeding from the left ear was reported after the injury. In the acute post-traumatic period, the patient experienced marked nausea and vomited once. Computed tomography reportedly demonstrated small subdural haemorrhagic collections of approximately 2–3 mm. No vestibular rehabilitation had been applied after the injury. At study entry, the patient continued to report dizziness when lying down and turning the head to the left, as well as when extending and rotating the head upwards to the left while standing. After the trauma, elevated blood pressure (147/96) was noted despite a previously reported tendency towards hypotension, and the patient was receiving antihypertensive medication. The patient also reported reduced confidence

when climbing ladders, although he had gradually returned to this activity. Magnetic resonance imaging performed in February 2025 reportedly showed small ischaemic foci. The study was conducted in an individual outpatient rehabilitation setting.

2.2. Ethical approval and informed consent

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval for the study was granted by the Local Bioethics Committee (No. 4/25/26). Before participation, the participant provided written informed consent. Confidentiality and anonymity were ensured throughout data collection, analysis, and reporting.

2.3. Sampling and recruitment procedures

A purposive sampling strategy was used. The participant was selected because the case matched the clinical focus of the study: persistent vestibular symptoms following head trauma and no prior vestibular rehabilitation. Inclusion criteria were adult age, a history of head trauma with concussion, chronic post-traumatic vestibular symptoms lasting approximately two years, diagnosed chronic left-sided post-traumatic vestibulopathy with positional dizziness, and willingness to participate in repeated assessments and home-based physiotherapy. As this was a single-case clinical analysis, one eligible participant was included. The exercise programme was temporarily interrupted due to illness during follow-up, but was later resumed.

2.4. Study organisation

During the 13-week study period, a total of five assessments were conducted, including one baseline assessment and four follow-up evaluations. The intervention timeline included an initial phase, a progression phase, a temporary interruption, and a resumed intervention phase with further progression.

Following the baseline assessment, the participant completed the initial intervention phase for two weeks, after which the second assessment was performed. The programme was then continued for approximately one additional week before being interrupted for two weeks due to illness, during which no exercises were performed. After recovery, the intervention was resumed, and the third assessment was conducted following two weeks of renewed exercise participation. Subsequent follow-up assessments were carried out at three-week intervals. The final assessment was completed approximately 13 weeks after the baseline measurement. Overall, the participant actively engaged in the intervention for approximately 11 weeks. The detailed chronological progression of the intervention and assessment schedule is provided in Supplementary Table S1.

2.5. Outcome measures

The primary outcomes of the study were changes in positional nystagmus and dizziness provoked during the Dix–Hallpike Test and motion sensitivity. The secondary outcomes were changes in functional mobility and balance performance.

The Dix–Hallpike Test was used to assess positional vertigo and nystagmus. The duration of provoked nystagmus and subjective dizziness was recorded on both sides.

The Motion Sensitivity Quotient (MSQ) was used to assess motion-provoked dizziness during a standardised sequence of head and body movements and to monitor changes over time.

The Berg Balance Scale (BBS) was used to assess functional balance. It consists of 14 tasks scored from 0 to 4, with a maximum total score of 56, where higher scores indicate better balance.

The Tinetti Balance and Gait Test was used to assess balance, gait, and mobility-related fall risk.

Tandem standing and later single-leg stance tasks were used to assess static balance under progressively more challenging conditions.

A researcher-developed structured interview form was used to collect supplementary clinical information on symptom history, exercise adherence, exercise tolerance, and the participant's subjective perception of change.

2.6. Intervention

A detailed overview of the exercise progression and programme modifications is presented in Supplementary Table S1. The study involved an individual home-based vestibular physiotherapy programme that was progressively adjusted according to the participant's symptoms and response to treatment. During the initial phase, the intervention included Brandt–Daroff exercises performed twice daily (morning and evening; five repetitions per body side), gaze stabilisation exercises performed 3–5 times per day, and tandem balance exercises on a firm surface in the evening.

After two weeks, the programme was progressed by introducing the Epley manoeuvre for the left side, while gaze stabilisation exercises were maintained. Brandt–Daroff exercises were continued in the morning, and balance training was advanced to a soft surface. Following the interruption and subsequent resumption of the programme, the Epley manoeuvre replaced Brandt–Daroff exercises in the morning and was continued in the evening, while gaze stabilisation exercises were maintained. Balance exercises were further progressed by increasing task difficulty, including performance on a soft surface and with eyes closed.

In the later stage of the intervention, balance training was advanced to a single-leg stance on a firm surface with eyes open and closed, according to the participant's abilities. The overall programme progression reflected an individualised approach aimed at promoting vestibular compensation and functional improvement.

2.7. Data analysis

The data were analysed descriptively using repeated within-case comparisons across the intervention period. Continuous outcomes were presented as raw values at each assessment point, and changes over time were interpreted descriptively. The analysis focused on changes in positional dizziness, nystagmus duration, motion sensitivity, functional mobility, and balance performance. No statistical software was used. No adjustments for confounders, multiple comparisons, or sensitivity analyses were performed.

3. RESULTS

3.1. Changes in positional symptoms and motion sensitivity

At baseline, the left-sided Dix–Hallpike Test was positive, whereas the right side was negative. During follow-up, the duration of provoked nystagmus and subjective dizziness on the left side gradually decreased and no longer occurred at the final assessment. This change is presented in Figure 1. Motion sensitivity also decreased during the early stage of the intervention from 2.34% to 0% (Table 1).

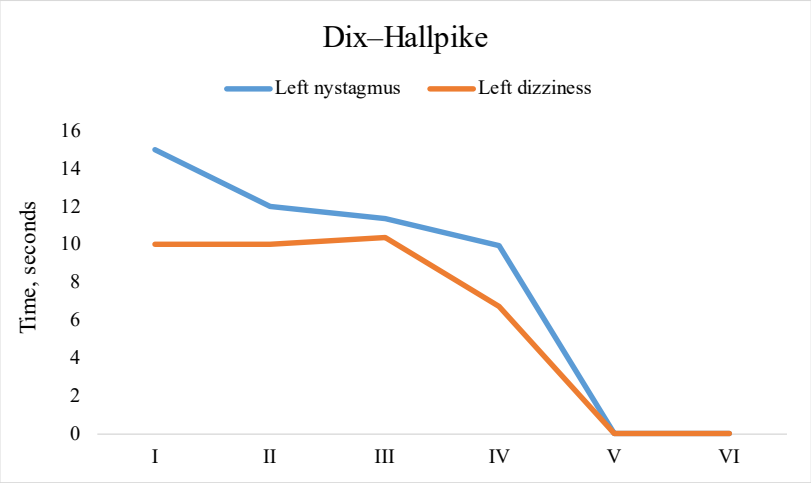

Figure 1. **Duration of left-sided nystagmus and dizziness during the Dix–Hallpike Test across five assessments**

3.2. Changes in balance and functional mobility

Over the intervention period, improvements were observed in both functional mobility and balance. Timed Up and Go (TUG) performance improved consistently across repeated assessments, suggesting better mobility over time. Static balance also showed progressive improvement, as reflected by longer tandem standing time and the participant's ability to perform more demanding single-leg stance tasks in the later phase of follow-up. Functional balance measures demonstrated the same general trend. However, although BBS and Tinetti scores also improved, both measures were already relatively high at baseline, suggesting limited room for change and a possible ceiling effect. Further details of balance and mobility outcomes are presented in Table 1.

Table 1. **Changes in clinical outcomes over the study period and at 4-week re-assessment**

Outcome	Baseline	2	3	4	Final Assessment	Re-assessment (4 Weeks After)
MSQ, %	2.34	1.76	1.35	0.59	0	0
Tandem standing, left (s)	2.9	3.97	30+	60+	60+	60+
Tandem standing, right (s)	3.2	18.2	30+	52	60+	60+
Single-leg stance EO, left (s)	–	–	–	26	30	40+
Single-leg stance EO, right (s)	–	–	–	30	30	40+
Single-leg stance EC, left (s)	–	–	–	6.56	16.35	21.08
Single-leg stance EC, right (s)	–	–	–	7.30	15.07	22.13
BBS	52	52	53	54	56	56
Tinetti total	27	27	27	28	28	28
TUG (s)	9.15	9.05	8.45	6.81	6.46	6.06

Note: EO, eyes open; EC, eyes closed; MSQ, Motion Sensitivity Quotient; BBS, Berg Balance Scale; TUG, Timed Up and Go.

3.3. Participant-reported changes

In addition to the objective improvement in positional symptoms and balance, the participant reported clinically meaningful subjective improvement over the intervention period. At the final assessment, dizziness was no longer provoked when turning in bed, lying on the left side, turning quickly, or maintaining the head in an extended and left-rotated position. The participant also reported that walking in a straight line with head movements to the sides or up and down no longer provoked dizziness. During the intervention period, an additional symptom-provoking position was noted, namely working with the head extended upwards and rotated to the left while the arms were elevated; however, by the final assessment, this position no longer caused discomfort. Overall, both the clinical findings and the participant's subjective reports indicated progressive improvement during the intervention period.

4. DISCUSSION

The present clinical case analysis showed that delayed vestibular physiotherapy was associated with progressive improvement in positional symptoms, balance, functional mobility, and participant-reported daily functioning in an adult with chronic post-traumatic vestibular complaints. Over the follow-up period, positional nystagmus and dizziness gradually decreased until they were no longer provoked at the final assessment, while mobility and balance performance also improved. The participant additionally reported that previously symptom-provoking daily situations no longer induced dizziness by the end of the intervention period.

One of the main findings of the present case was the gradual reduction and eventual disappearance of positional nystagmus and dizziness. This is clinically meaningful because post-concussive dizziness is often multifactorial and may persist beyond the acute stage of injury, with peripheral vestibular dysfunction representing one of the relevant mechanisms in at least a subgroup of patients (Gianoli, 2022). In the present case, repeated left-sided Dix–Hallpike positivity together with symptom provocation in specific head positions suggested positional vestibular involvement, and the subsequent improvement indicates that vestibular physiotherapy may still be clinically beneficial even when initiated long after the original trauma.

This interpretation is consistent with previous research supporting vestibular rehabilitation in patients with concussion-related dizziness and vestibular symptoms. A systematic review of randomised controlled trials concluded that vestibular rehabilitation appears useful for reducing symptoms after concussion, although the available studies were heterogeneous in intervention content, dosage, and outcomes (Galeno et al., 2022). Similarly, Aljabri et al. (2024), in a systematic review and meta-analysis, reported beneficial effects of vestibular rehabilitation therapy in patients with mild traumatic brain injury, particularly for dizziness-related complaints. Together with current clinical practice guidelines for peripheral vestibular hypofunction, these findings support the broader clinical relevance of vestibular rehabilitation in both vestibular and post-traumatic presentations (Aljabri et al., 2024; Galeno et al., 2022; Hall et al., 2022).

Another clinically relevant aspect of this case was that initial improvement was observed after approximately two weeks of intervention. Although the rate of recovery in vestibular rehabilitation may vary depending on chronicity, vestibular disorder characteristics, and treatment content, early change is clinically plausible. Vestibular rehabilitation may reduce symptoms through habituation, adaptation, and substitution processes, while repositioning manoeuvres may be particularly relevant in cases with positional symptom provocation. This interpretation is supported by recent real-world data showing

improvement in dizziness and imbalance after customised vestibular rehabilitation across vestibular disorders (Kim et al., 2024).

The traumatic context of the present case is also important. Head trauma has recently been identified as a significant risk factor for later benign paroxysmal positional vertigo (BPPV), which further supports consideration of trauma-related positional vestibular dysfunction in patients with prolonged dizziness after injury (Yoo et al., 2025). This is relevant because vestibular symptoms after trauma may remain clinically important well beyond the immediate post-injury period.

In addition to positional symptoms, improvements were also observed in balance and functional mobility. The participant showed better performance in timed mobility and balance tasks during follow-up, suggesting improved postural control and movement performance over time. This is clinically relevant because dizziness after concussion affects not only symptom perception, but also confidence, mobility, and everyday functioning (Gianoli, 2022). Moreover, recent evidence suggests that dizziness contributes directly to post-concussion symptom burden and is associated with poorer overall clinical status (Denby et al., 2024). However, although BBS and Tinetti scores also improved, both measures were already relatively high at baseline, suggesting limited room for change and a possible ceiling effect.

The participant also reported meaningful subjective improvement. By the end of follow-up, dizziness was no longer provoked when turning in bed, lying on the left side, turning quickly, or maintaining the head in an extended and left-rotated position. Head movements while walking also no longer provoked dizziness. These changes are important because they reflect not only improvement in clinical tests, but also better functioning in everyday situations. This practical relevance is particularly important in persistent post-traumatic dizziness, which often affects activity confidence and participation. In the present case, the participant had also reported reduced confidence in ladder climbing after the trauma, suggesting that the observed changes extended beyond test performance alone. This interpretation is in line with recent concussion management literature recommending individualised cervicovestibular or vestibular rehabilitation for patients with ongoing dizziness and related functional complaints after concussion (Schneider et al., 2023). An additional strength of this case is that the intervention period reflected real clinical conditions rather than an idealised treatment course. The exercise programme was temporarily interrupted because of illness, and the course of change was therefore not entirely linear. Nevertheless, further improvement was observed after programme resumption, suggesting that beneficial adaptation continued over time.

The clinical relevance of this case lies in the delayed initiation of vestibular physiotherapy, as referral for vestibular rehabilitation is more commonly discussed earlier after injury. However, in real clinical practice, some patients remain insufficiently recognised or inadequately treated for prolonged periods. This case therefore suggests that delayed vestibular physiotherapy may still be associated with meaningful improvement in chronic post-traumatic vestibular complaints. Recent reviews of persistent post-concussion symptoms likewise support the role of rehabilitation-based management for ongoing physical symptoms, including dizziness and balance-related difficulties (Jennings et al., 2023; Moser et al., 2024).

Nevertheless, the findings should be interpreted with caution. This was a single-case clinical analysis, and the results cannot be generalised. A possible learning effect due to repeated exposure to postural control and mobility tests cannot be excluded, particularly for tandem standing, single-leg stance, and TUG performance. Moreover, several balance and mobility outcomes were already within normal or near-normal ranges at baseline. The TUG Test was below 10 seconds at baseline, while BBS and Tinetti scores were also high, suggesting limited room for clinically meaningful improvement and a possible ceiling effect. Therefore, the main interpretation of this case was based primarily on the reduction of positional dizziness, nystagmus during the Dix–Hallpike Test, and motion-provoked symptoms rather than

on improvement in balance and mobility tests alone. Instrumental vestibular testing and a more detailed characterisation of nystagmus was not available, and not all outcomes were recorded at every assessment point. Symptom fluctuation, natural adaptation, or individual recovery factors may also have contributed to the observed changes. Therefore, this case should be interpreted as practice-based clinical evidence rather than proof of treatment efficacy.

Overall, the findings of this case suggest that delayed vestibular physiotherapy may be associated with reduced positional symptoms, improved balance and mobility, and better day-to-day functioning in a patient with chronic post-traumatic vestibular complaints. Further studies with larger samples are needed to clarify which patients may benefit most from delayed intervention and which programme components are most relevant in prolonged post-traumatic presentations.

5. CONCLUSIONS AND PERSPECTIVES

In this clinical case, delayed vestibular physiotherapy was associated with reduced positional symptoms, improved balance and mobility, and better daily functioning. By the final assessment, positional nystagmus and dizziness were no longer provoked, and the participant reported meaningful improvement in symptom-provoking daily activities.

These findings suggest that delayed vestibular physiotherapy may still be clinically relevant in chronic post-traumatic vestibular complaints. Further studies with larger samples are needed to evaluate the effectiveness of delayed intervention and to determine the most appropriate rehabilitation strategies for prolonged post-traumatic vestibular symptoms.

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Supplementary Table S1. **Chronological progression of the vestibular rehabilitation programme and assessment schedule**

Time Point	Intervention Components	Details / Progression
Baseline	Brandt–Daroff; gaze stabilisation; tandem balance (firm surface)	Brandt–Daroff: 2×/day (~07:00, ~19:00–20:00), 5 reps/side (~5 min total); gaze stabilisation: 3–5×/day; balance: evening, duration individualised
Follow-up 1 (Week 2)	Re-assessment + Epley manoeuvre (left side); continued previous exercises	Epley: 3 reps in evening (~1 min 30 s each); Brandt–Daroff continued (morning); balance progressed to soft surface
Weeks 3–4	**Interruption**	No exercises performed due to illness (2 weeks)
Resumption of intervention (Week 6)	Epley replaces Brandt–Daroff (morning); continued gaze stabilisation and balance	Epley: morning + evening (3 reps, left side); balance: soft surface, eyes closed
Follow-up 2 (Week 7)	Re-assessment Continued progression	Balance progressed based on ability
Follow-up 3 (Week 10)	Advanced balance training	Single-leg stance on firm surface, eyes closed
Final assessment (Week 13)	Re-assessment	End of intervention period; Single leg stance (eyes opened and closed), Timed Up and Go, Berg, Tinetti tests, and Dix-Hallpike Test repeated
Re-assessment (Week 17)	Re-assessment	One-month follow-up re-assessment after return to daily activities without continuation of the prescribed exercise programme. Single-leg stance, Timed Up and Go, Berg, Tinetti tests, and Dix–Hallpike Test were repeated