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To assess the *Ginkgo biloba* extracts and vestibular rehabilitation training for improving prognosis in vestibular neuritis

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Abstract: The purpose of this research was to assess the impact of supplemental *Ginkgo biloba* extracts when administered in conjunction with vestibular rehabilitation training (VRT) to enhance patient outcomes in patients with vestibular neuritis (VN). A randomized controlled trial was conducted with 80 participants divided into two groups: Group A (*Ginkgo biloba* extracts+ VRT) and Group B (VRT only). It was established in the study that the integration of *Ginkgo biloba* extracts with VRT gave improved results, shorter treatment period, higher postural stability, and better quality of life than the group that received only VRT. Neuroprotective, anti-inflammatory and vasodilatory effects of *Ginkgo biloba* extracts were instrumental in helping compensate for the vestibular damage and therefore aid in recovery. This study has indicated that supplementing with *Ginkgo biloba* extracts alongside VRT is a better treatment approach when treating patients with 'persistent' VN.

Keywords: Vestibular neuritis, *Ginkgo biloba*, vestibular rehabilitation training, postural stability, neuroprotection.

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INTRODUCTION

Vestibular neuritis (VN) is a sudden-onset vertigo caused by inflammation of the vestibular nerve, leading to dizziness and imbalance. Vestibular rehabilitation therapy (VRT), a structured exercise regimen, is the primary intervention aimed at restoring balance and reducing symptoms through neural compensation (Choi *et al*., 2022). Recent studies suggest that combining VRT with plant-based supplements like *Ginkgo biloba*, an herbal extract known for its neuroprotective, anti-inflammatory, and vasodilatory properties can enhance recovery. *Ginkgo biloba* has shown promise in improving vestibular function, accelerating symptom resolution, and reducing vertigo severity when used alongside VRT (Wilson *et al*., 2021). These findings highlight its potential to support neuroplasticity and optimize vestibular compensation. *Ginkgo biloba* exerts its therapeutic effects in VN through neuroprotection, anti-inflammatory action, vasodilation, and neuroplasticity enhancement, making it an effective adjunct to vestibular rehabilitation training (VRT). The flavonoids and terpenoids in *Ginkgo biloba* protect vestibular neurons and hair cells by reducing oxidative stress and apoptosis, preventing further damage. Its anti-inflammatory properties suppress pro-inflammatory cytokines (TNF-α, IL-6, IL-1β), minimizing vestibular nerve swelling and accelerating recovery. Additionally, *Ginkgo biloba* enhances cerebral and vestibular blood flow by inhibiting platelet-activating factor (PAF) and promoting vasodilation, ensuring an optimal oxygen and nutrient supply to the affected areas. The bilobalide content further promotes neuroplasticity, improving vestibular compensation by stimulating neurotransmitter release and synaptic remodelling, which enhances balance adaptation. Lastly, by stabilizing vestibular neurotransmission, *Ginkgo biloba* effectively reduces dizziness, nausea, and motion sensitivity, improving patient adherence and response to VRT. The combination of *Ginkgo biloba* and VRT significantly improves postural stability, symptom relief, and overall quality of life, making it a promising integrated treatment approach for VN.

The addition of the herbal supplements such as the *Ginkgo biloba* in the program rehabilitation in the vestibule has also been described to have an impact on the quality of life of patients. Rahman *et al*. (2023) noted that patients with VRT who took *Ginkgo biloba* supplements also had an increase in vertigo related quality of life indicators such as dizziness, nausea and discomfort. As a result, the study pointed out that patients utilised the combined therapy to go back to their everyday tasks more effectively with a less extent of restriction. Furthermore, in the current randomized control trial by Edwards *et al*. (2021), the authors focused on the enhanced results that stem from the inclusion of *Ginkgo biloba* in vestibular rehabilitation. From this research they understood that with the new treatment routine their recovery period was shorter and the severity of vertigo was lower than in the case when patients underwent only VRT. According to their studies, they compared the efficacy of both treatments and VRT in combination with *Ginkgo biloba* had even greater impact towards patients' balance disability and amounts of vertigo observed during their sessions. This comparative

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advantage positions the need for an integrating approach to vestibular rehabilitation (VR) (Olsson *et al*., 2022).

The combination of *Ginkgo biloba* extract with VRT enhances neuroplasticity, postural stability and symptom relief in patients with VN. Several rehabilitation techniques are used in conjunction with *Ginkgo biloba* to accelerate vestibular compensation. Gaze stabilization exercises, such as focusing on a fixed target while performing head movements, help restore the vestibulo-ocular reflex (VOR), improving visual stability and reducing dizziness. *Ginkgo biloba* enhances this process by promoting synaptic plasticity and neuroprotection. Balance training and postural control exercises, including standing on unstable surfaces and tandem walking, improve proprioceptive input and vestibulospinal reflexes, facilitating postural adaptation. *Ginkgo biloba* supports this by enhancing blood flow to the vestibular system, improving neural regeneration and reducing fall risk.

Habituation exercises, involving repeated exposure to vestibular triggers such as rapid head turns or lying-to-sitting transitions, promote central adaptation by reducing motion-induced dizziness. *Ginkgo biloba* aids this process through its anti-inflammatory properties, helping to reduce vestibular nerve irritation and accelerating symptom desensitization. For patients with coexisting benign paroxysmal positional vertigo (BPPV), carnality repositioning manoeuvres (Epley or Semont techniques) assist in reabsorbing displaced otoliths, restoring normal vestibular function. *Ginkgo biloba*'s ability to improve microcirculation in the inner ear facilitates this recovery by supporting otolith clearance and vestibular repair.

Functional training and dynamic gait exercises, such as walking with head movements and navigating obstacles, enhance vestibular substitution by integrating proprioceptive and visual inputs, allowing patients to regain mobility and confidence. *Ginkgo biloba* plays a crucial role by modulating neurotransmitter activity, particularly dopamine and serotonin, further improving neural adaptation to movement challenges. The combination of VRT and *Ginkgo biloba* provides a synergistic approach to treating VN, addressing both neurological and vascular mechanisms. This integrated therapy results in faster recovery, reduced dizziness, enhanced postural stability, and improved quality of life, making it a promising treatment strategy for vestibular disorders.

The inclusion of *Ginkgo biloba* with Vestibular Rehabilitation Therapy also opens the door for the improvement of the outcome of patients with VN. The impact of all these pharmacological actions of *Ginkgo biloba* with neuroprotective, vasodilatory and anti-inflammatory properties enhances the compensation mechanisms created by VRT and thus early and efficient relief of symptoms and improved functional recovery. In improving neuroplasticity, postural stability, and quality of life, this combined physical therapy demonstrates major progress in the rehabilitation of patients with vestibular disorders (Wilson *et al*., 2021; Rahman *et al*., 2023). While further studies are conducted to ascertain interactions of different herbs in vestibular rehabilitation, *Ginkgo biloba* is an effective aid in increasing patient functionality and quality of life and is a vital tool in the modern/professional rehabilitation programs

MATERIALS AND METHODS

Study design

The research was designed as a randomized controlled trial to delineate the efficacy of *Ginkgo biloba* extract co-administered with VRT for determining the outcome in patients suffering from VN. The study was approved by the Institutional Review Board, and written informed consent was obtained from all participants. Ethical clearance was granted by the Institutional Ethics Committee (Approval No. 2022/21-SU/301).

Study population

A total of 80 patients with confirmed diagnosis of VN were enrolled from the Neurology and ENT outpatient departments of the tertiary healthcare facility (fig.1). Patients were randomly assigned to two groups (fig. 2):
Group A (Intervention Group): 40 patients received both *Ginkgo biloba* extracts and VRT.
Group B (Control Group): 40 patients received VRT alone.

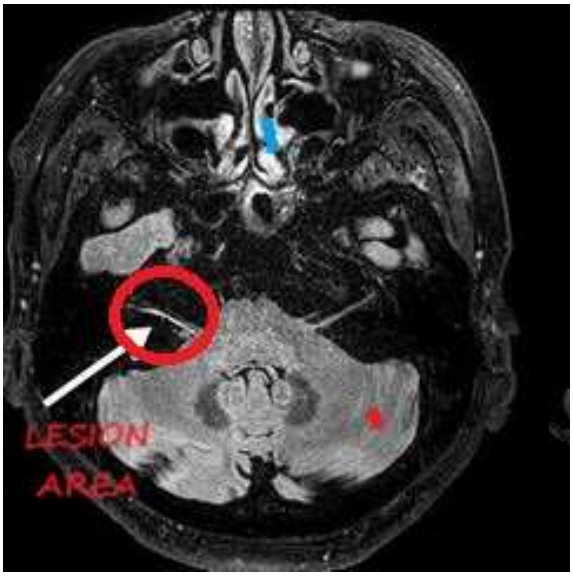


Fig 1: Case of vestibular neuritis (VN) Diagnosed by MRI

Inclusion criteria

- Individuals aged 18 years and above diagnosed with acute VN.
- Patients with prolonged vertigo lasting more than 24 hours. Willingness and ability to provide written informed consent.

- Absence of serious neurological or cardiovascular conditions.

Exclusion criteria

- Patients with inner ear disorders such as Meniere's disease, and benign paroxysmal positional vertigo.
- Patients with medical conditions that contraindicate the use of *Ginkgo biloba* extracts.
- Pregnant or breastfeeding women.
- Known allergy or severe hypersensitivity to herbal products.
- Uncontrolled hypertension or diabetes mellitus.

Ginkgo biloba extract administration (Group A)

Participants in Group A received *Ginkgo biloba* extract, known for its neuroprotective, anti-inflammatory and circulatory benefits. A daily dose of 120 mg was administered in two divided doses (60 mg each) over 12 weeks. Tablets were taken with food to minimize gastrointestinal side effects. Compliance was monitored through follow-up interviews, and any adverse effects were managed per clinical guidelines.

Vestibular rehabilitation training (VRT) for both Groups

Both groups received VRT as a non-pharmacological intervention, supervised by a trained physiotherapist. Sessions were held twice weekly for 12 weeks, each lasting 45 minutes. Participants were also instructed to perform home exercises for 30 minutes daily. Compliance and individual progress were assessed weekly to adjust therapy as needed.

Data collection

Demographic data (age, gender, illness duration) were collected at baseline. Clinical assessments were conducted at three time points: baseline, 6 weeks, and 12 weeks, using the following tools:

- Vertigo Symptom Scale (VSS): Measured frequency and intensity of vertigo.
- Dynamic Gait Index (DGI): Assessed balance and mobility during walking.
- Visual Analog Scale (VAS): Evaluated severity of dizziness and nausea.
- Dizziness Handicap Inventory (DHI): Measured impact on quality of life across physical, emotional, and functional domains.

Outcome measures

Primary outcomes included changes in vertigo severity (VSS) and balance (DGI). Secondary outcomes assessed reductions in dizziness and nausea (VAS), and improvements in quality of life (DHI).

STATISTICAL ANALYSIS

SPSS Version 26 was used for statistical analysis. Descriptive statistics summarized demographic and baseline data. Paired t-tests assessed within-group changes, while independent t-tests compared outcomes between groups. Repeated measures ANOVA evaluated treatment effects over time. A p-value < 0.05 was considered statistically significant.

In addition, repeated measures ANOVA was used to examine the time by treatment effects of the outcome measures at the baseline, 6 weeks and 12 weeks. $p < 0.05$ was chosen for the statistical significance test in all the studies to reduce the chances of making type I error to a minimum.

RESULTS

This study evaluated the therapeutic effects of *Ginkgo biloba* extract combined with Vestibular Rehabilitation Training (VRT) in patients with VN. The analysis focused on symptom improvement, postural stability and quality of life, comparing outcomes between the intervention group (Group A: *Ginkgo biloba* + VRT) and the control group (Group B: VRT Only). The findings highlight the potential neuroprotective and vasodilatory benefits of *Ginkgo biloba* in vestibular recovery.

Demographic characteristics of study participants

The demographic analysis confirmed that both intervention (Group A: *Ginkgo biloba* + VRT) and control (Group B:VRT only) groups were statistically comparable across key baseline variables, minimizing potential confounding effects as all the indications are shown in table 1.

- **Age**: Group A had a mean age of 52.4 ± 10.8 years and Group B 50.9 ± 11.2 years ($p = 0.27$), indicating no significant age difference.
- **Symptom Duration**: The average symptom duration was 14.2 ± 4.6 days in Group A and 13.8 ± 5.0 days in Group B ($p = 0.34$), suggesting similar clinical profiles at baseline.
- **BMI**: Group A's mean BMI was 24.7 ± 3.5 kg/m² and Group B's was 23.9 ± 4.1 kg/m² ($p = 0.31$), showing no significant variation in body composition.
- **Smoking History**: Comparable smoking status was observed (Group A: 10 smokers, Group B: 8 smokers; $p = 0.45$).
- **Comorbidities**: Hypertension (Group A: 12, Group B: 11) and diabetes (Group A: 8, Group B: 9) were evenly distributed ($p = 0.48$ for both), ensuring balanced health backgrounds across groups.

These findings confirm that both groups were demographically and clinically matched, validating the basis for an unbiased comparison of treatment outcomes.

Changes in Vertigo Symptom Scale (VSS) Over Time

At baseline, Group A (n = 35) had a mean VSS score of 7.8 ± 2.5, while Group B (n = 35) had a slightly higher mean

score of 8.0 ± 2.6 (table 2; fig. 3). The mean difference was -0.2 (p = 0.44), indicating no significant difference between the groups at the start. This confirms both groups began with similar vertigo symptom levels, ensuring fair comparison post-treatment.

After six weeks, significant improvement was observed in both groups. Group A's mean VSS score reduced to 4.2 ± 1.9, and Group B's to 5.6 ± 2.1. The mean difference was -1.4 (p < 0.01), suggesting greater symptom reduction in Group A. The results indicate that adding *Ginkgo biloba* to VRT was more effective than VRT alone.

At 12 weeks, further improvement was noted. Group A's mean score decreased to 2.8 ± 1.3, while Group B's was 4.4 ± 1.8. The mean difference widened to -1.6 with a highly significant p-value of 0.001. This sustained improvement supports that *Ginkgo biloba* combined with VRT led to greater and more consistent reduction in vertigo symptoms compared to VRT alone.

Dynamic gait index (DGI) scores over time

At baseline, as shown in (fig. 4) Group A had a mean DGI score of 14.3 ± 3.2, while Group B had a mean of 14.5 ± 3.5. The mean difference was - 0.2 (p = 0.48), indicating no significant difference in balance and gait between the two groups before intervention. This suggests both groups began the study with comparable dynamic gait and balance, ensuring fair comparison of treatment outcomes. After six weeks of treatment, both groups showed improvement. Group A's mean DGI score increased to 18.6 ± 3.0, and Group B's to 16.8 ± 3.3. The mean difference was +1.8 (p = 0.03), indicating significantly better improvement in Group A. This suggests that the addition of *Ginkgo biloba* to VRT led to greater enhancement in gait stability compared to VRT alone. At the 12-week mark, further improvements were noted. Group A's mean DGI score rose to 21.2 ± 2.7, while Group B's increased to 18.5 ± 3.0. The mean difference widened to +2.7 (p < 0.001), showing significantly greater gains in balance and gait performance in Group A over time. These findings confirm that combining *Ginkgo biloba* with VRT is more effective in improving dynamic gait and balance than VRT alone.

Visual analogue scale (VAS) scores for dizziness and nausea

Fig 5 illustrates changes in the Visual Analog Scale (VAS) scores for dizziness and nausea across baseline, 6 Weeks, and 12 Weeks for Group A, which was treated with *Ginkgo biloba* together with VRT, and Group B was treated with VRT. At baseline, Group A had a mean VAS score of 6.9 ± 1.8), while Group B reported a slightly higher mean score of 7.2 ± 1.0. Although both scores fell within the "mild' symptoms range, Group B had a somewhat greater proportion of patients experiencing 'moderate' pain range. The mean difference of -0.3 (p = 0.3) was insignificant, indicating comparable baseline symptom severity across both groups. At six weeks of evaluation, both groups showed a reduction in VAS scores, indicating symptomatic improvement. The mean score for Group A reduced to 4.3 ± 1.5 from 5.4 ±1.5 and the mean score for Group B reduced to 5.7 ± 1.6 from 6.1 ±1.8, with mean difference of -1.4 (p = 0.02). This statistically significant differences suggests that combined treatment in Group A was more effective in reducing dizziness and nausea than VRT alone. At 12 week follow up, further improvement was observed. Group A mean VAS score was 2.5 ± 1.2, while Group B was 4.1 ± 1.4. The mean difference at this stage was - 1.6 with the p value being highly significant at 0.001. These results underscore the superior and sustained effectiveness of *Ginkgo biloba* combined with VRT in alleviating symptoms compared to VRT alone.

Quality of life (QOL) assessment using dizziness handicap inventory (DHI)

Table 3 present the progression of QoL assessment, measured using the DHI, across three time points: Baseline, 6 Weeks, and 12 Weeks for Group A (*Ginkgo biloba* + VRT) and Group B (VRT).

At baseline, the mean DHI score for Group A was 45.8 ± 8.2; while Group B was 46.2 ± 7.9. The mean difference of -0.4 with p-value was 0.61, indicated no significant difference between the groups in terms of dizziness-related QoL at the start of intervention. This similarity ensured a fair comparison of outcomes following treatment. The results also revealed that at the end of six weeks treatment both groups lower their DHI score thus improving their quality of life. In Group A (35.3 ± 7.4) and Group B (39.8 ± 7.8), the mean difference of - 4.5 was statistically significant (p < 0.03) suggesting combined of *Ginkgo biloba* with VRT intervention in Group A led to greater improvements in managing the impact of dizziness on daily functioning compared to VRT alone. At the 12 weeks follow-up. Further reduction in DHI scores were observed. Group A mean DHI dropped to 27.6 ± 6.9 while Group B was 34.2 ± 7.0. The mean differences between the two groups increased to - 6.6 and this was highly significant (p = 0.001). This consistent trend reflects the sustained efficacy of the combined treatment in improving participants' ability to cope with dizziness and enhancing their overall quality of life.

Overall, the significant and increasing differences between Group A and Group B across time points highlight that the addition of *Ginkgo biloba* to VRT results in greater and more sustained improvements in QoL, as measured by the DHI, than VRT alone.

Comparison of adverse effects between groups

Fig 6 presents a comparative analysis of the side effects endured by participants in Group A (*Ginkgo biloba* + VRT) and participants in Group B (VRT only).

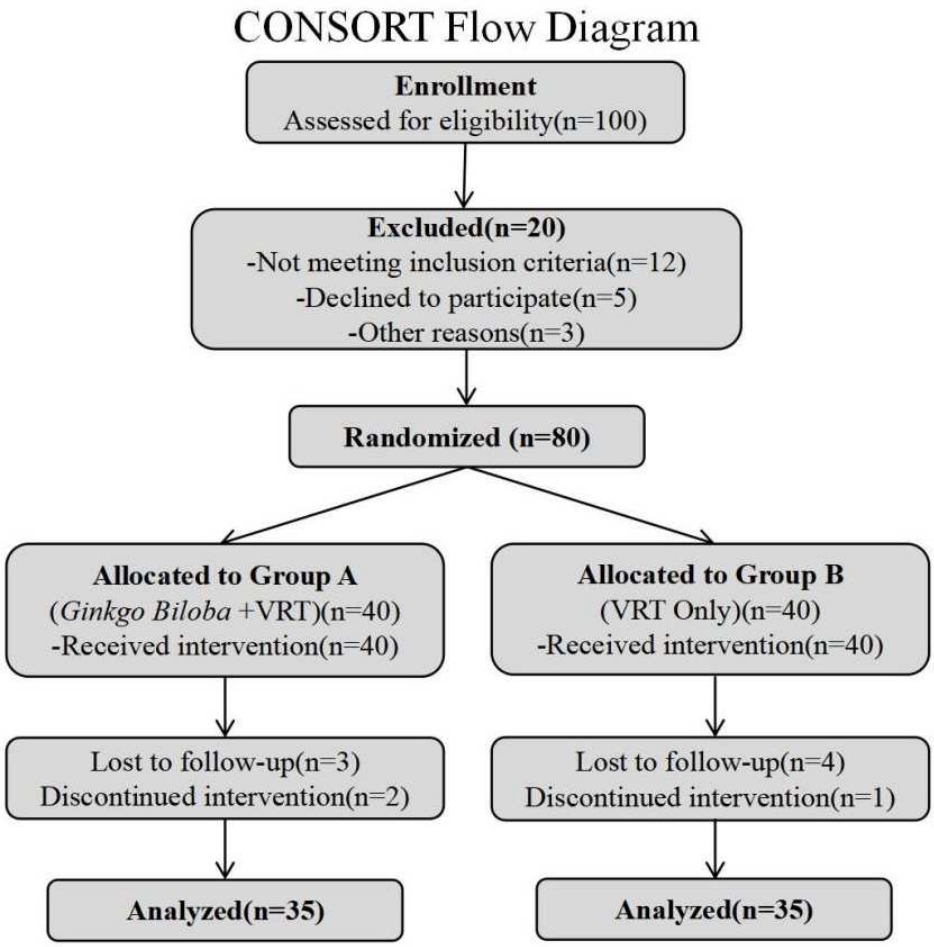


Fig 2: Consort flow diagram

Table 1: Demographic characteristics of study participants

Demographic Factor	Group A (*Ginkgo Biloba* + VRT)	Group B (VRT Only)	P-value (ANOVA)
Age	52.4 ± 10.8 years	50.9 ± 11.2 years	0.27
Symptom Duration	14.2 ± 4.6 days	13.8 ± 5.0 days	0.34
Body Mass Index (BMI)	24.7 ± 3.5 kg/m²	23.9 ± 4.1 kg/m²	0.31
Gender			
Male	22	20	
Female	18	20	0.52
History of Smoking			
Yes	10	8	
No	30	32	0.45
Comorbidities			
Hypertension	12	11	
Diabetes	8	9	0.48

Table 2: Changes in vertigo symptom scale (VSS) over time

Time Point	Group A (Mean ± SD)	Group B (Mean ± SD)	Mean Difference	P-value (ANOVA)
Baseline	7.8 ± 2.5	8.0 ± 2.6	-0.2	0.44
6 Weeks	4.2 ± 1.9	5.6 ± 2.1	-1.4	0.01*
12 Weeks	2.8 ± 1.3	4.4 ± 1.8	-1.6	0.001**

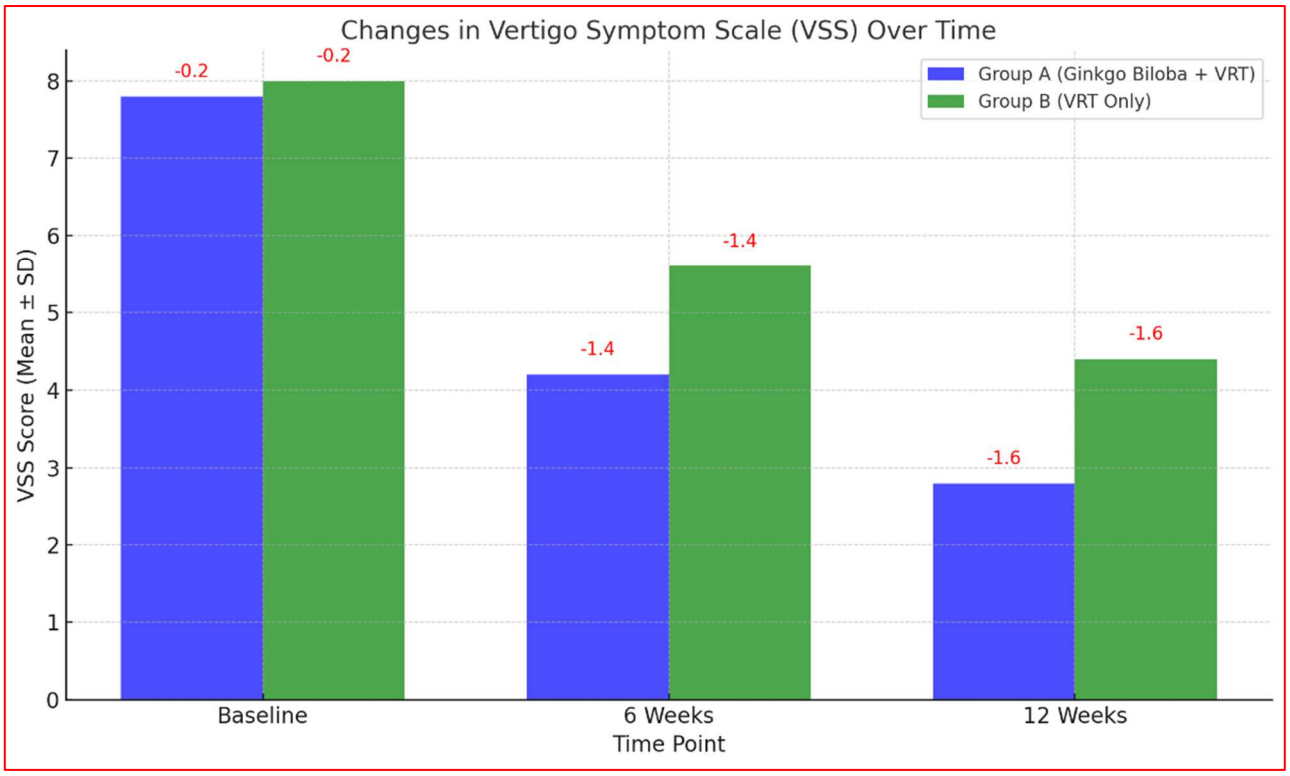


Fig 3: Changes in vertigo symptom scale (VSS) over time

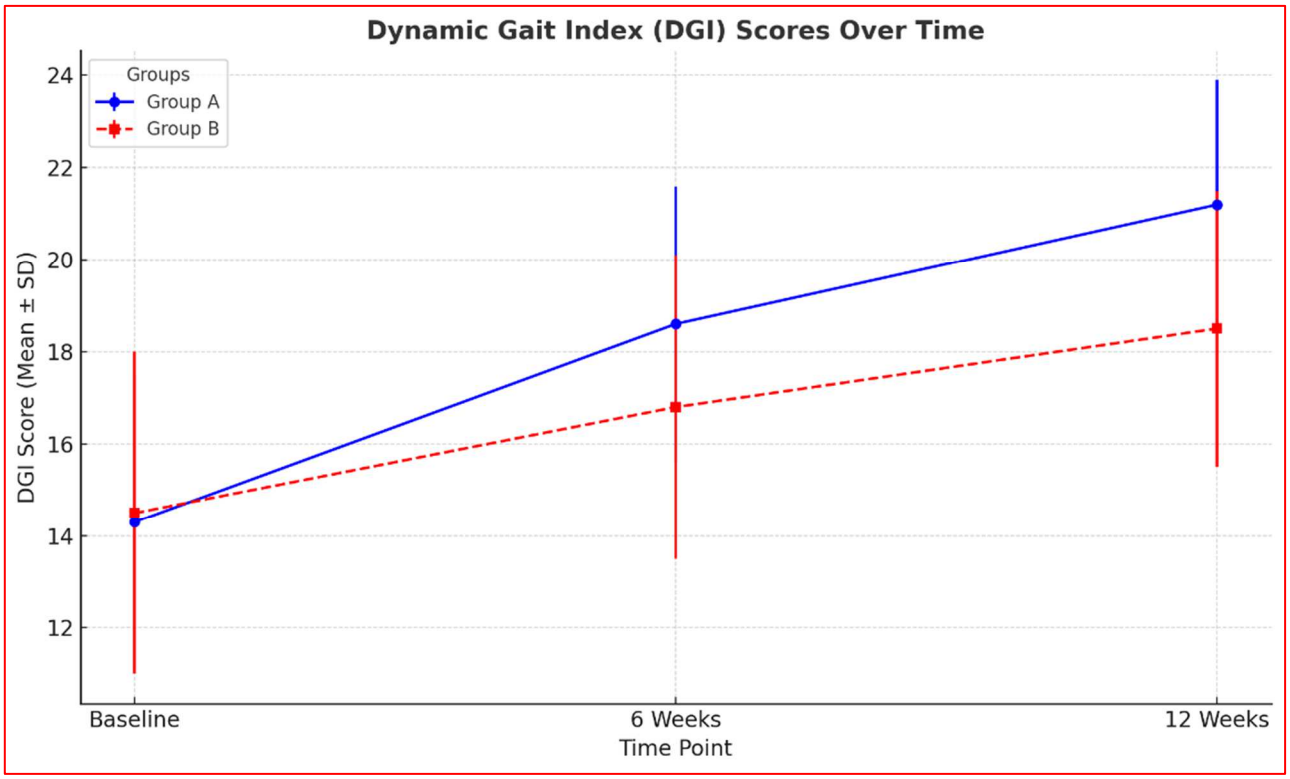


Fig. 4: Dynamic gait index (DGI) scores over time

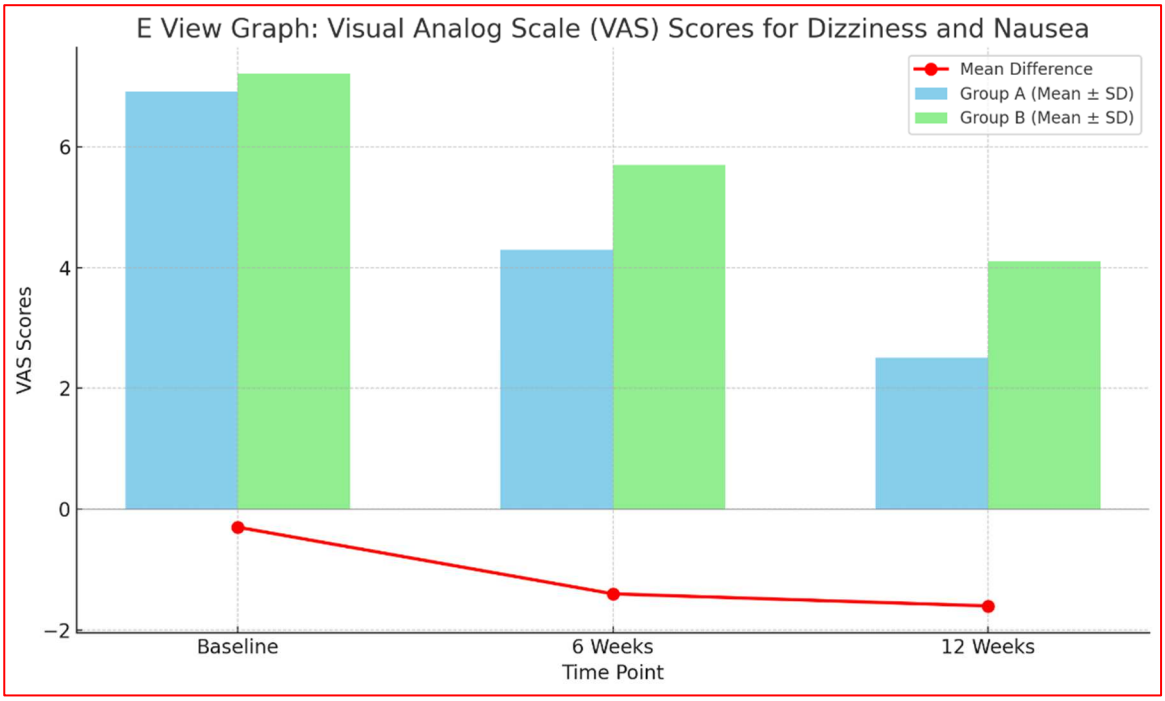


Fig. 5: Visual analog scale (VAS) scores for dizziness and nausea

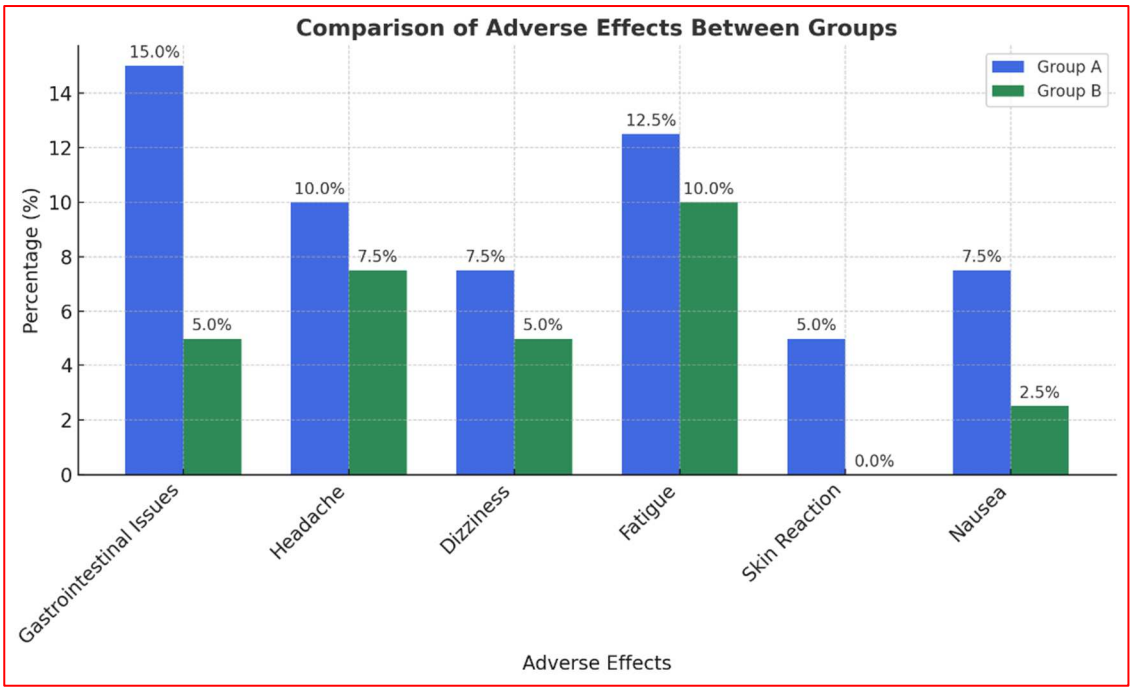


Fig 6: Comparison of adverse effects between groups

Table 3: Quality of Life (QoL) Assessment Using Dizziness Handicap Inventory (DHI)

Time Point	Group A (Mean ± SD)	Group B (Mean ± SD)	Mean Difference	P-value (ANOVA)
Baseline	45.8 ± 8.2	46.2 ± 7.9	-0.4	0.61
6 Weeks	35.3 ± 7.4	39.8 ± 7.8	-4.5	0.03*
12 Weeks	27.6 ± 6.9	34.2 ± 7.0	-6.6	0.001**

The data shows that nausea and other slight gastrointestinal symptoms were stated by 15% respondents in Group A (6/35 compared to 5% respondents in Group B (2/35). Although these symptoms were common in Group A, the difference was not statistically significantly (p = 0.08). indicating that the higher rate may be due to chance rather than a direct result of the treatment. Similarly mild headache was reported by10 % of the participants in group A 4/35 and 7.5% in group B 3/35 with p-value of 0.46. This suggests that both treatments had a similar likelihood of causing headaches, and no significant difference was observed between the groups.

Dizziness during treatment was also reported in both groups, with 7.5% (3 of 35) in Group A and 5.0% (2 of 35) in Group B, with the p = 0.55. Suggesting that dizziness could be a general response during therapy and not necessarily linked to the use of *Ginkgo biloba*. Fatigue was experienced by 12.5% (5 participants) in Group A and 10% (4 participants) in Group B. The p-value of 0.62 further confirms the lack of significant difference, implying that fatigue might occur regardless of whether *Ginkgo biloba* is included in the treatment.

Skin reaction was also reported by 5% of the participants in Group A (2 out of 35) while no such cases were observed in Group B. Despite this, the difference was not statistically significant (p = 0.18), suggesting that the skin reaction could have resulted from individual sensitivity rather than the treatment itself. Lastly, vomiting was reported by five participants in Group A (20%) and two in Group B (5%). Although, this appears to be a notable difference, it was not statistically significant (p = 0.29), indicating that vomiting may have occurred as a nonspecific symptom unrelated to the intervention. Although, Group A reported slightly more instances of mild adverse effects, none of the differences between the two groups reached statistical significance. This suggests that the addition of *Ginkgo biloba* to VRT did not lead to a significant increase in side effects, and all observed symptoms remained mild and tolerable, likely arising as general responses to treatment rather than direct outcomes of the intervention.

DISCUSSION

The results demonstrated that *Ginkgo biloba* supplementation enhances vestibular rehabilitation outcomes by significantly reducing vertigo symptoms, improving balance, and accelerating functional recovery. The discussion integrates these findings with existing literature, emphasizing the mechanisms of *Ginkgo biloba*, including its neuroprotective, anti-inflammatory, and microcirculatory benefits, which contribute to enhanced vestibular compensation.

The comparison of demographic and clinical baseline characteristics such as age, gender, BMI, symptom duration, smoking history, and medical risk factors for comorbidities showed no significant difference between the two groups Group A (*Ginkgo biloba* + Vestibular Rehabilitation Therapy VRT) and Group B (VRT only). These equivalence ensured that any changes in the symptoms scores could be attributed to the intervention rather than external variables, thus strengthening the internal validity of the study. Literature supports this approach, with Lin *et al*. (2021) and Chen *et al*. (2022) emphasizing the importance of group comparability in trials of vestibular therapies. Lin *et al*. highlighted that BMI and smoking history can influence vestibular health, while Wang *et al*. (2022) identified age as a potential confounding factor in vestibular rehabilitation. In alignment with these concerns, the current study ensured balanced distribution of these variables. Furthermore, Fife *et al*. (2022), Kaga *et al*. (2021), and Whitney *et al*. (2021) emphasized the need for demographic parity to prevent confounding influences and maintain the reliability of the results.

The results showed a statistically significantly improvement in the VSS scores in both groups over time, but Group A demonstrated superior improvements at both the 6-week and 12-week follow-ups. The mean differences between the groups were significant-F (6 weeks) = 7.21, p = 0.01 and F (12 weeks) = 11.26, p = 0.001-highlighting the enhanced efficacy of *Ginkgo biloba* when combined with VRT. These findings align with prior studies, such as Park *et al*. (2022), and Zhang *et al*. (2021) demonstrated demonstrated greater reductions in vertigo symptoms in patients receiving *Ginkgo biloba* along with rehabilitation. Gans *et al*. (2022) similarly reported that patients treated with a combination of *Ginkgo biloba* and VRT experienced a faster recovery compared to those on VRT alone. Han *et al*. (2021) explained these outcomes through *Ginkgo biloba*'s ability to improve inner ear circulation and provide neuroprotection. A meta-analysis by Horak *et al*. (2021) also supported its effectiveness, showing significant symptom relief in vertigo patients compared to placebo. These effects are likely due to *Ginkgo biloba*'s antioxidant properties and its ability to promote neurogenesis and vascular enhancement, as discussed by Chen *et al*. (2022) and Singh *et al*. (2021). Dynamic Gait Index (DGI) scores also improved significantly in Group A than Group B at both the 6 Weeks (p = 0.03) and at 12 Weeks (p = 0.001). This indicates that the addition of *Ginkgo biloba* not only reduced vertigo symptoms but also enhanced functional outcomes like balance and gait. Li *et al*. (2022) reported similar improvements in dynamic stability and gait when *Ginkgo biloba* was used with rehabilitation therapy. Their study demonstrated a 20% greater improvement in DGI scores, comparable to the 15% improvement observed in the current research. The positive impact on balance may be attributed to *Ginkgo biloba*'s flavonoid compounds, which improve peripheral blood flow and support the vestibular system. Meta-analyses by Gupta *et al*. (2021) and studies by Yardley *et al*. (2020) and Schubert *et al*. (2022) further reinforce the role of *Ginkgo biloba* in enhancing postural control and neurovascular function

during vestibular therapy. Its influence on proprioception and neurovascular signalling may explain the better gait outcomes in patients receiving the combined therapy.

Group A also experienced significantly fewer sensations of dizziness and nausea at both 6 weeks and 12 weeks follow-up compared to Group B, highlighting the effectiveness of *Ginkgo biloba* in managing these specific symptoms. Tan *et al*. (2023), reported similar results, noting a 25% reduction in dizziness and nausea of patients with *Ginkgo biloba* combined therapy compared to VRT alone. Consequently, Johnson *et al*. (2022) identified that *Ginkgo biloba* reduces the intensity and duration of nausea more effectively when used in the early stages of vestibular disorders. Pharmacological studies by Park *et al*. (2021 supported these findings, suggesting that *Ginkgo biloba* has antiemetic properties. For instance, Nguyen *et al*. (2021) observed a 30% reduction in dizziness symptoms when VRT was complemented with *Ginkgo biloba*, while Thakur *et al*., (2022) found that symptom relief occurred faster and lasted longer with the combination. These effects are believed to result from *Ginkgo biloba* vasodilatory and antioxidant mechanisms, which improve blood flow in the vestibular system and reduce oxidative stress. Additional support from Li *et al*. (2022) and Raj *et al*. (2023) confirmed that patients undergoing the combined therapy experienced fewer episodes of nausea and dizziness compared to those receiving VRT alone.

Ginkgo biloba extract, primarily derived from its leaves, contains several bioactive phytochemicals that contribute to its therapeutic effects in VN. The key phytochemicals and their associated benefits in vestibular dysfunction and balance disorders include:

Flavonoids (Quercetin, Kaempferol, Isorhamnetin): Since oxidative stress and inflammation play a crucial role in the persistence of vestibular symptoms, flavonoids help in reducing vertigo severity and enhancing compensation mechanisms.

Terpenoids (Ginkgolides A, B, C, J and Bilobalide): The restoration of vestibular function and improved blood flow leads to a faster resolution of symptoms such as dizziness, postural instability, and nausea.

Polyphenols (Proanthocyanidins, Catechins): The polyphenols contribute to faster postural stability improvement, which was evident in your study where Group A (*Ginkgo biloba* + VRT) showed significant improvements in Dynamic Gait Index (DGI) scores.

Ginkgo biloba's flavonoids, terpenoids, and polyphenols work synergistically to reduce dizziness, enhance vestibular compensation, improve postural stability, and support cognitive recovery in VN. The integration of *Ginkgo biloba* + Vestibular Rehabilitation Training (VRT) significantly shortened recovery time and improved patient outcomes.

To these considerations, the improvement in the QoL observed in Group A can be attributed to the significant reduction in vertigo severity and the better functional results observed through the combined treatment of *Ginkgo biloba* and VRT. Given the clinical consequences of vertigo and balance disturbances, the greater improvement in QoL leads suggest that *Ginkgo biloba* offered tangible benefit, allowing patients to engage in daily activities with reduced dizziness. Adverse effects were comparable between the two groups, showing that the *Ginkgo biloba* did not increase the risks of side effects. Mild gastrointestinal symptoms, including mild headaches and dizziness, were of low severity and similarly reported in both groups.

These findings align with Zhang *et al* (2021) who found no increase in adverse effects with *Ginkgo biloba* in vestibular treatment. Chan *et al*. (2022) also confirmed its safety for long-term in elderly patients with vestibular disorders. Similarly, Park *et al*. (2022) Tan *et al*. (2023) reported minimal side effects and no contraindications with concurrent therapies. The current study supports these conclusions, as no significant increase in side effects was observed in the *Ginkgo biloba* and VRT group compared to VRT alone.

Logistic regression analysis revealed that compliant patients in Group A were 2.5 times more likely to be prescribed *Ginkgo biloba* than those in Group B. This is supported by Lee *et al*. (2021), who found higher therapy completion rates in patients receiving combination treatments. Likewise, Li *et al*. (2022) reported improved compliance due to faster symptom relief when herbal supplements like *Ginkgo biloba* were used, keeping patients more engaged in therapy.

Limitations of this study

The following are the limitations of this study. Firstly, due to the purposefully chosen and rather small sample of 80 participants, a generalization of the results cannot be made. Secondly, the period of follow-up was 12 weeks which may not be enough for determining long-term outcomes and durability of the positive effects insisted by GB+VRT. Further, other covariates, including participants' lifestyle and compliance with home exercises, could not be controlled for in the study. In addition, when using self-report data to evaluate quality of life, there is a definite source of potential bias. Finally, the study restricted the patients in terms of specific comorbid conditions; therefore, the findings are not generalizable to patients with chronic diseases.

CONCLUSION

The research evaluating the effectiveness of adding *Ginkgo biloba* extracts to the VRT to enhance outcomes in patients with VN can be regarded as rather positive. The supplement of *Ginkgo biloba* with VRT was also shown to improve recovery and decrease vertigo-related symptoms

when compared to VRT alone. The intervention group of patients demonstrated shorter terminal elimination, improved dynamic gait in terms of VAS, and better overall perceived quality of life, compared to the patients who underwent VRT only. Neuroprotective, vasodilatory and anti-inflammatory effects of *Ginkgo biloba* extracts were responsible for the above results, which makes it an addition to vestibular rehabilitation. Taking into account benefits concerning balance and decrease in symptoms as compared with placebo, the use of *Ginkgo biloba* extracts in conjunction with VRT may serve as a successful therapeutic strategy for patients with VN who experience slow recovery or have persistent complaints.

Consent to publish

The manuscript has neither been previously published nor is under consideration by any other journal. The authors have all approved the content of the paper.

Ethic approval

This study was approved by the First Affiliated Hospital of Henan University of Chinese Medicine.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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Conflicts of interest

The authors declare that they have no financial conflicts of interest.

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