pagepress

Geriatric Care

Geriatric Care 2026; 12:14699
doi:10.4081/gc.2026.14699

Visual cue training for balance, gait and cognition in post-menopausal women: a randomized controlled trial

Aneesa Farooq,[1] Sarah Parveen,[1] Chhavi Arora Sehgal,[1] Arshya Anwar,[1] Muhammad Azharuddin,[2] Syed Naznin Fatma,[1] Md. Dilshad Manzar,[3] Majumi M. Noohu[1]

[1]Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, New Delhi, India; [2]Regional Institute of Paramedical and Nursing Sciences, Zemabawk, Aizwal, India; [3]Department of Nursing, College of Applied Medical Sciences, Majmaah University, Al Majmaah, Saudi Arabia

Abstract

Post-menopausal women frequently exhibit balance and gait impairments associated with hormonal changes, increasing their risk of falls and reduced functional independence. This study investigated the effect of visual cue training on balance and gait in post-menopausal women. A total of 48 eligible participants were randomly allocated into two groups: group A received visual cue training combined with conventional exercises, and group B received conventional training only. Both groups underwent an 8-week intervention, and balance, gait performance, cognitive function, and depression were assessed before and after training. Significant improvements over time were observed in step length, cadence, center of pressure (COP) range, and Berg Balance Scale scores. Between-group differences favored the visual cue group for step length and COP range. Cadence demonstrated a significant time × group interaction, indicating a differential pattern of improvement between groups, without a significant overall group effect. Both groups showed significant improvements in P300 latency over time, with no significant time × group interaction ($p=0.81$). No significant between-group differences were found for gait speed, stride length, COP sway, or P300 amplitude. These findings suggest adding visual cues to conventional training enhances specific aspects of postural control and cognitive processing but does not provide additional benefits for all gait-related parameters. Visual cue-based training may therefore be a valuable adjunct to conventional rehabilitation programs aimed at improving functional mobility in post-menopausal women.

Key words: post-menopause, visual cue training, balance, gait, cognition, depression.

Correspondence to: Chhavi Arora Sehgal, Centre for Physiotherapy & Rehabilitation Sciences, Jamia Millia Islamia, New Delhi-110025, India.
E-mail: dr.chhaviarora@gmail.com

Introduction

Menopause is the permanent cessation of menstruation, and it is divided into three categories: pre-menopause, peri-menopause, and post-menopause.[1] The ovarian follicular activity starts declining in the late 30's and by the early 50's it may reach its lowest point, followed by complete cessation, in the majority of women, resulting in menopause.[2] In India, the average age of women transitioning to menopause is 46.6 years, which is earlier than the global average.[3,4] This early menopausal onset presents with metabolic disorders, vasomotor symptoms, psychological problems, musculoskeletal disorders, cardiovascular diseases, and urogenital disorders.[5]

During menopause, the estrogen levels significantly reduce, which could lead to changes in the neuronal activity. The vestibular system contains estrogen receptors, whose regulation can affect how balance and spatial orientation are interpreted.[6] Post-menopausal women with more severe psychological symptoms rated in the menopause rating scale, showed increased center of pressure (COP) velocity, longer stabilogram length, and greater anteroposterior sway.[7] Menopause was found to be an independent predictor of balance, and estrogen therapy tends to increase the balance in post-menopausal women. Changes in gait and balance have been identified as significant fall risk factors.[8] Increased body sway among post-menopausal women substantially raises the risk of falling.[9,10] Luteinizing hormone rises after menopause and is accompanied by a reduction in cognitive function.[11]

Balance and gait are complex functions that require the coordinated input of visual, vestibular, and proprioceptive systems. Among these, vision plays a critical role by providing external reference cues for spatial orientation and movement planning.[12] Visual cue training gives visual signals to train balance and gait. Visual cueing has been proven to be useful in enhancing parameters related to balance and gait in people with Parkinson's disease,[13] geriatric people,[14] and people with stroke.[15] Despite its proven benefits in other populations, its specific application in post-menopausal women is underexplored. Considering the heightened risk of falls, mobility deficits, and cognitive decline in post-menopausal women, there is a need to explore innovative, cost-effective, and non-invasive interventions. Thus, this study aimed to evaluate the effect of visual cue training on balance, gait, and cognitive function in post-menopausal women. We hypothesized that integrating visual cues to conventional training would lead to significant improvements in spatiotemporal gait parameters (particularly step length and cadence) and postural stability (COP range) in comparison with conventional exercise alone. Additionally, we hypothesized that the dual-task aspect of visual cueing would result in an increased cognitive processing speed, as indicated by P300 latency compared to the control group.

Materials and Methods

Study design and setting

This study was a single-blinded, two-arm parallel, randomized controlled trial. Participants were recruited from the Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, New Delhi, India. Recruitment was also done from the community. A convenient sampling method was used, and potential participants were contacted through flyers and information brochures. The Institutional Ethics Committee at Jamia Millia Islamia gave its approval to the study (ethical approval no. 12/10/402/JMI/IEC/2022). The trial was registered prospectively in the Central Trial Registry of India (CTRI) *via* registration number CTRI/2023/03/050837.

Sample size

Software G. Power 3.1.9.2 was used to determine the sample size with expected changes in post-intervention gait speed value. Based on the effect size of 0.85, α-level of 0.05, and power (1-β) of 0.95, 44 participants (22 per group) were found to be required. Taking 10% dropout rate into account, a total sample size of 48 individuals (24 per group) was obtained.[16]

Participants

A total of 75 post-menopausal women were screened for pre-decided eligibility criteria. Post-menopausal women within the age range of 51 to 70 years were included in the study. Women who were on hormonal therapy or had a history of hysterectomy were excluded from the study. Table 1 provides a detailed description of the eligibility criteria.

Intervention

Participants in group A received visual cue-based balance exercise training. Visual cues were made on the floor using the colorful paper strips on a 10-meter walkway. Line spacing was according to the individual stride length (average 14 cm). Subjects were instructed to perform exercises on these colorful marks and not to drag their feet, but to lift and move on to the next step. Exercise was discontinued if a subject asked to stop due to extreme exhaustion or complained of acute dyspnea, chest pain, or vertigo. The exercises included: stepping forward (on marked points), stepping forward right, stepping forward left, stepping left, stepping right, stepping backward right, stepping backward left. Walking on a straight path on the marked cues (6 m), walking and turning, walking with the obstacles in between, tandem walking on marked cues, and reaching forward and sideways to take the bright-colored ball in a standing position.[14] Participants in group B received balance exercises without visual cues. In this group, the above-mentioned exercises were given in the same manner but without the visual cues to the subjects. The total duration of the intervention was 8 weeks, 3 times a week, and a single session lasted for around 1 hour. Table 2 shows the dosage and progression of the exercise.

Outcome measures

Primary outcomes included the spatiotemporal gait parameters (gait speed, cadence, step length, stride length), balance measures [center of pressure range, center of pressure sway, Berg Balance Scale (BBS)], and Event-Related Potential (ERP) P300. The secondary outcomes were depression symptoms assessed using the Beck Depression Inventory (BDI).

Balance assessment

COP range, COP sway, in all four directions, that is, front, back, left, and right, was measured using Pedalo®-Sensamove Balance Test Pro with Miniboard (Utrecht, The Netherlands). The device consists of a mini-board with hemispherical-shaped sensors placed below. It functions as a three-dimensional accelerometer and gyroscope with a sampling frequency of 100 Hz. The mini-board was positioned on top of a 3.5 cm cushion. A computer was connected to the board. The monitor's visual display was at eye level for the participant.

Participants stood on the board without footwear, with feet 4 cm apart and arms at the pelvis. In this position, they were instructed to tilt to maximum range without taking a step or losing balance in four directions (front, back, left, and right). It was recorded as the COP range. Then the subjects stood for 30 seconds on the board. A colored spot (target) appeared on the computer screen, and the participants were instructed to maintain the COP within the target. The COP deviation of the subjects was recorded as COP sway.[17,18]

Table 1. Eligibility criteria.

	Pre-specified criteria
Inclusion criteria	Post-menopausal women 51-79 years old Ability to walk independently without an assistive device Having normal or corrected to normal hearing and vision Ability to understand the commands Having a minimum high school level of education
Exclusion criteria	Vestibular disorders, neurological disorders, psychological disorders, and psychiatric disorders Active cancers requiring chemotherapy Participants using centrally active medications Participants using four or more medications Participants with lower limb surgery

The subjects were then instructed to touch the colored spot as soon as possible as it appeared on the screen with their displayed COP. The time taken to respond to stimuli was recorded as reaction time, and it was measured for all four directions.[17]

BBS is a reliable and valid gold standard tool used to measure balance in older adults.[19] It consists of 14 functional components ranging from sitting, standing, turning, and reaching. It is a five-point scale ranging from 0 to 4, wherein 0 and 4 represent the lowest and highest functioning levels, respectively. The total score of the BBS is 56.[20]

Assessment of gait

Subjects walked at a self-selected pace on a paper 10-m walkway with ink patches on their shoes, which left behind a footprint. To avoid the variable steps related to gait start and termination, only the middle five steps were assessed. The gait speed, step length, stride length, and cadence were measured. The stride length (cm) was calculated from the line of progression between the heel points of two successive footprints of the same foot, and the step length (cm) was measured from the geometric heel center of the left footprint to the same point of the preceding footprint on the opposite foot. The walking speed (cm/s) was calculated by dividing the distance by the walking time. The cadence (number of steps/ minute) was computed by counting the number of steps taken during a minute walk down a straight path. Each participant received one practice walk to get accustomed to their walking condition.[21]

Recording of Event-Related Potential P300

For the assessment of the cognitive function, particularly cognitive processing speed, attention, and working memory (ERP), P300 is used. The P300 wave was captured using the RMS Salus 20. Participants were asked to sit comfortably and keep their eyes closed. Neu-Prep™skin preparing gel (Weaver and Company, USA) was used to gently clean the scalp before Ten20™ conductive electroencephalography paste was applied on the scalp for the placement of Ag-AgCl electrodes. The auditory oddball paradigm was used to elicit P300. The subjects were made to hear two different sounds through headphones: S1 and S2. They were asked to count the S2 sound.[22] Table 3 depicts the settings used for recording of P300.

Depression assessment

For the assessment of depression, the BDI was used. It consists of 21 items and examines the symptoms of depression. Each item is rated on a 4-point Likert scale ranging from 0 to 3. A global score was produced by adding the individual item scores. The score ranges from 0 to 63, where a higher score indicates more severe depression.[23]

Table 2. Details of the intervention used.

Exercises	Repetition/time	Progression
Stepping forward (on marked points)	10 repetitions	Increased number of repetitions by 5, every 2 weeks. Increase spacing (0.05)
Forward right	10 repetitions	
Forward left	10 repetitions	
Left	10 repetitions	
Right	10 repetitions	
Backward right	10 repetitions	
Backward left	10 repetitions	
Walking on a straight path on the marked cues (6 m)	5 repetitions	Increased number of repetitions by 2, every 2 weeks.
Walking and turning	5 repetitions	
Walking with the obstacles in between	5 repetitions	
Tandem walking on marked cues	5 repetitions	
Reaching forward and sideways to take the bright colored ball in standing	5 minutes	Increased by 2 minutes after every 2 weeks.

Table 3. Description of the settings used for capturing Event-Related Potential P300.

Domain	Setting
Low filter	2 Hz
High filter	100 Hz
Electrode placement	Active electrode: at the vertex (Cz) Ground electrode: forehead (Fpz) Reference electrode: mastoid process (A1/A2)
Impedance	≤5 kilo-ohms
Types of sound delivered	Sound 1 (S1): low pitch, frequent, non-target tone Sound 2 (S2): high pitch, rare, target tone
Randomness of presentation of sound	Frequent: 80% Rare: 20%
Time duration between presentation of each sound	1 second

Procedure

A total of 48 participants who fulfilled the eligibility criteria were enrolled in the study (Figure 1). The risks and benefits of the study were explained to the participants, and all of them signed an informed consent before the intervention. The participants were randomly allocated to one of two groups. Random allocation software was used, and block randomization with two block sizes, with an allocation ratio of 1:1, was adopted in the study. The random allocation sequence was generated by an independent investigator, and group assignments were concealed until the completion of baseline assessments. The demographics and clinical characteristics of the participants were recorded. This was followed by the assessment of balance, gait, cognitive function, and depression. All assessments and interventions were provided by physiotherapists with more than 5 years of experience. An assistant was also present during training and assessment sessions to prevent falls and injuries of the participants. All the outcome measures were examined again after eight weeks of intervention. A familiarization session was provided to all the participants.

Statistical analysis

Statistical analysis was performed using IBM SPSS software, version 29.0.1.0. (IBM Corp., Armonk, NY, USA). Normality of distribution was assessed using the Shapiro-Wilk test. An independent *t*-test was used to analyze demographic characteristics and outcome measures at baseline. Repeated measure analysis of variance (ANOVA) with group, time, and interaction effect was used to find the difference between the groups after the intervention. A p-value of <0.05 was considered significant.

Results

The demographic and clinical characteristics of the participants are presented in Table 4. The mean ± standard deviation was calculated for all the variables except comorbidities, for which a frequency distribution was calculated. There was no significant difference between the groups at baseline measurement of outcome variables except body mass index (Table 5).

For P300 latency, the results of repeated measures ANOVA showed a significant main effect for group (p=0.01) and time (p=0.0001), whereas group × time (p=0.81) interaction was found to be insignificant. For P300 amplitude, the results of repeated measures ANOVA showed insignificant main effect for group (p=0.97), time (p=0.097), and group × time interaction (p=0.22) (Table 6).

For the reaction time, the results of the repeated measures ANOVA showed an insignificant main effect for group in all four conditions, a significant main effect for time in left (p=0.0001), right (p=0.0001), front (p=0.0001), and back (p=0.0001) conditions, and an insignificant main effect for group × time interaction for all four conditions. The repeated measures ANOVA showed a significant main effect for group for COP range for front (p=0.0001), back (p=0.0001), left (p=0.0001), and right (p=0.009). The repeated measures ANOVA showed a significant main effect for time for COP range for front (p=0.0001), back (p=0.0001), left (p=0.0001), and right (p=0.0001) (Table 6).

For BBS, the repeated measures ANOVA showed a significant main effect for group (p=0.001) and time (p=0.0001), whereas the group × time (p=0.71) interaction was found to be insignificant.

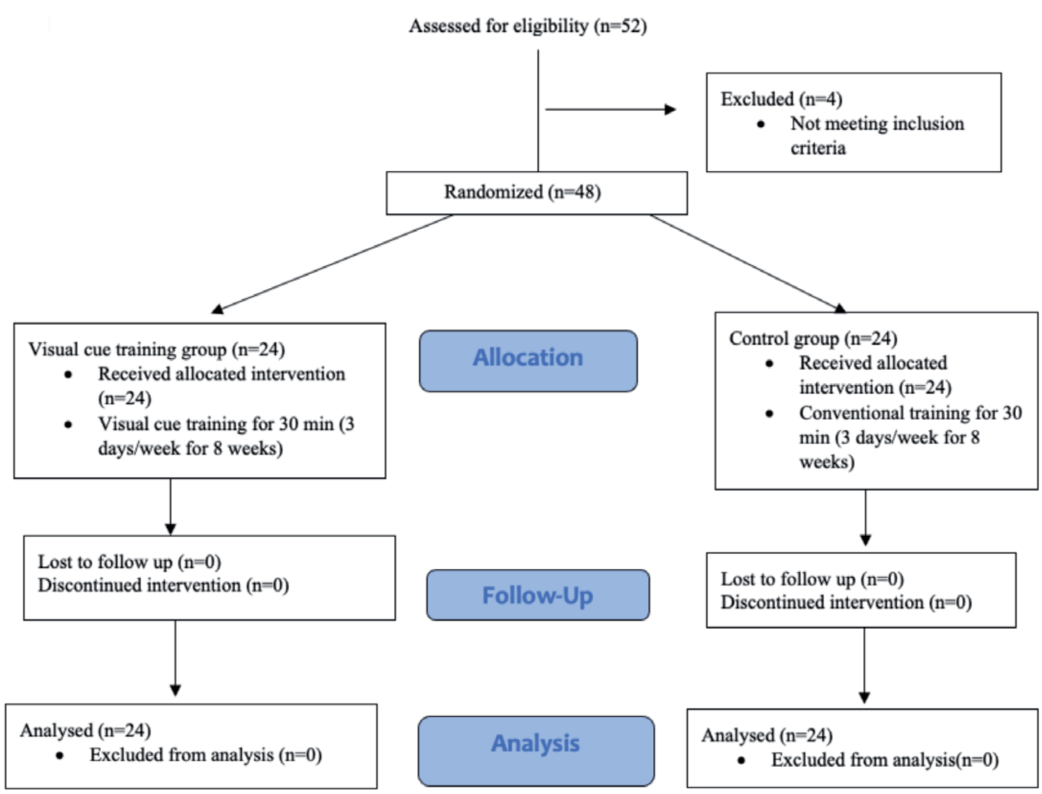

Figure 1. CONSORT flow diagram of participant enrolment, allocation, follow-up, and analysis.

Similar findings were observed with scores of BDI, where a significant main effect for time (p=0.001) was found and no significant main effect for group (p=0.424) and group × time interaction (p=0.444) (Table 6).

The main effect for group was found to be significant only for step length (p=0.007), whereas the main effect of time for gait speed (p=0.0001), cadence (p=0.0001), step length (p=0.0001), and stride length (p=0.06) were significant. The group × time interaction for gait speed, cadence, step length, and stride length was insignificant (Table 6).

Table 4. Demographic characteristics of the participants.

Parameters	Group A (n=24) Mean±standard deviation	Group B (n=24) Mean±standard deviation	t	p
Age (years)	58.83±2.97	59.58±4.38	-6.94	0.49
Height (cm)	155.79±3.57	158.00±4.56	-1.86	0.06
Weight (kg)	64.92±5.37	63.08±4.82	1.244	0.22
Body mass index (kg/cm²)	26.93±3.42	24.97±2.11	2.37	0.02
Duration of menopause	11.08±4.52	11.83±4.77	-0.62	0.53
Systolic blood pressure	122.57±26.08	127.08±18.76	-0.69	0.48
Diastolic blood pressure	83.33±13.72	80.42±10.82	0.81	0.41
Beck Depression Inventory	2.42±0.83	2.75±1.18	-1.12	0.26
Number of falls	0.63±0.71	0.54±0.54	0.42	0.67
Type 2 Diabetes Mellitus (n)*	10	7		
Hypertension (n)*	13	10		
Asthma (n)*	2	1		
Thyroid dysfunction (n)*	13	10		

*Frequency.

Table 5. Baseline comparison of all variables.

Parameters	Group A (n=24) Mean±standard deviation	Group B (n=24) Mean±standard deviation	t	p
Gait speed (m/s)	0.68±0.18	0.66±0.20	-0.21	0.83
Cadence (steps/min)	100.71±12.61	96.46±10.98	1.24	0.22
Stride length (cm)	86.74±17.19	80.87±16.69	1.19	0.23
Step length	41.43±9.15	36.52±8.43	1.93	0.06
Center of pressure range (degrees)				
Forward	9.24±2.08	9.04±1.89	0.34	0.73
Backward	8.60±2.16	7.88±2.15	1.14	0.25
Left	8.92±2.27	9.10±2.46	-0.25	0.79
Right	9.22±2.20	9.04±2.00	0.21	0.83
Center of pressure sway				
Forward and backward	0.54±0.23	0.63±0.30	-1.11	0.21
Left and right	0.45±0.22	0.59±0.29	-1.86	0.069
Reaction time				
Forward	2.77±1.30	3.04±3.49	-0.34	0.73
Backward	3.29±1.81	3.1±1.82	0.24	0.80
Left	2.99±1.25	3.02±2.06	-0.06	0.94
Right	3.34±1.76	2.67±1.75	-1.26	0.21
Berg Balance Scale	49.92±1.81	50.75±2.23	0.165	-1.877
P300 latency	361.78±28.56	362.32±28.18	-.06	0.94
P300 amplitude	5.94±0.676	4.43±3.33	1.50	0.14
Beck Depression Inventory	20.12±3.84	18.96±2.16	0.15	1.06

Table 6. Measures of all variables before and after eight weeks of intervention.

Variables	Group A Mean±SD	Group B Mean±SD	Time (T) effect F	p	ηp²	Group (G) effect F	p	ηp²	T×G effect F	p	ηp²
Gait speed											
Baseline	37.49±8.98	39.57±11.05	22.08	0.000	0.93	0.39	0.53	0.006	1.00	0.32	0.006
8th week	38.91±9.12	40.49±11.22									
Cadence											
Baseline	100.71±12.61	96.46±10.98	41.55	0.0001	0.47	1.89	0.17	0.09	4.94	0.03	0.04
8th week	102.33±12.56	97.25±10.75									
Step length											
Baseline	41.43±9.15	36.52±8.43	20.07	0.0001	0.30	8.01	0 .007	0.14	4.41	0.04	0.08
8th week	42.54±9.49	36.77±8.11									
Stride length											
Baseline	86.74±17.19	80.87±16.69	3.57	0.06	0.072	0.42	0.52	0.009	1.39	0.24	0.02
8th week	86.94±17.13	81.28±16.61									
Center of pressure range											
Front											
Baseline	9.24±2.08	9.04±1.89	63.25	0.0001	0.57	15.36	0.0001	0.25	1.57	0.21	0.03
8th week	10.60±1.59	9.50±1.73									
Back											
Baseline	8.60±2.16	7.88±2.15	89.86	0.0001	0.66	28.75	0.0001	0.38	5.85	0.02	0.11
8th week	10.46±1.76	8.40±2.00									
Left											
Baseline	8.92±2.27	9.10±2.46	46.13	0.0001	0.50	16.69	0.0001	0.26	16.69	0.0001	0.26
8th week	10.68±1.74	9.53±2.32									
Right											
Baseline	9.22±2.20	9.09±2.00	36.64	0.0001	0.43	7.40	0.009	0 .13	7.40	0.009	0.13
8th week	10.47±1.85	9.55±1.83									
Reaction time											
Front											
Baseline	2.77±1.30	3.04±3.49	30.00	0.0001	0.39	1.28	0.26	0 .27	0.43	0.51	0.001
8th week	1.83±1.13	2.42±2.43									
Back											
Baseline	3.29±1.81	3.16±1.82	74.02	0.0001	0.61	15.08	0.001	0.24	0.85	0.77	0.002
8th week	2.40±1.60	2.83±1.78									
Left											
Baseline	2.99±1.25	3.02±2.06	36.34	0.0001	0.44	8.41	0.006	0.15	0.45	0.50	0.01
8th week	2.10±0.95	2.71±2.19									
Right											
Baseline	3.34±1.76	2.67±1.75	35.33	0.0001	0.43	7.07	0.11	0.13	0.36	0.54	0.008
8th week	2.01±0.92	2.16±1.62									
Berg Balance Scale											
Baseline	49.92±1.81	50.75±2.31	82.63	0.000	0.64	0.13	0 .001	0.23	13.78	0.01	0.23
8th week	52.00±2.26	51.63±2.46									
Event-Related Potential P300											
Latency											
Baseline	361.78±28.56	362.32±28.18	48.01	0.0001	0.51	5.90	0.01	0.11	0.56	0.81	0.001
8th week	356.46±26.28	359.76±29.05									
Amplitude											
Baseline	5.94±3.63	4.43±3.33	2.90	0.97	0.32	0.05	0.97	0.02	1.49	0.22	0.03
8th week	4.55±3.31	4.06±3.12									
Beck Depression Inventory											
Baseline	20.04±3.98	19.00±2.20	33.82	0.00	0.97	0.94	0.33	0.01	0.59	0.44	0.01
8th week	19.04±3.67	18.33±2.33									

Discussion

In post-menopausal women, adding visual cue training to balance exercise did not result in greater improvement in cognitive function and depression, but did result in a greater increase in the cadence, step length, and COP range for right, left, and backward directions. These findings indicate that while conventional balance and gait exercises contribute to overall functional improvements, visual cue training may provide additional benefits in selected spatiotemporal and postural control parameters.

Improvement in the scores of BBS was found in both groups. This improvement may be attributed to the well-established effects of therapeutic exercise on balance and postural control in post-menopausal women. Regular balance and gait training enhances neuromuscular coordination, proprioceptive integration, and postural stability through repeated task- specific practice and progressive sensorimotor engagement. Exercise-induced adaptations at both peripheral and central levels contribute to improved movement efficiency and balance confidence, which are important determinants of functional mobility and fall risk reduction in this population.[7,9,10]

In addition, structured physical exercise is known to facilitate neuroplastic changes, including improved cerebral perfusion, enhanced synaptic connectivity, and more efficient sensory-motor integration, which may partly explain the comparable improvements observed in cognitive processing speed and functional performance in both groups.[24] These exercise-related adaptations are independent of cueing modality and represent the foundational benefits of regular therapeutic exercise in post-menopausal women.

Similar findings were reported in another study where visual cue training improved the BBS score by 35.9%.[25] The positive change observed in balance might be attributed to the improvement in gaze behavior as visual cues help in maintaining effective and safe gaze behavior and improvement in visuo-motor processing in the post-menopausal women.[14,26]

The improvement in the gait characteristics was found in both groups. These findings were in accordance with a study in which it was concluded that the use of visual cueing approaches can be used to train elderly people's gait with the greatest possible success.[27] Similar findings were reported in two more studies done on Parkinson's disease and stroke patients, where it was found that cueing training is more successful and superior to conventional training alone in terms of effectiveness. The allocation of attention when walking, which plays a significant role in gait regulation, may be the neurophysiological mechanism underlying the improvement in the visual training group.[28] For the maintenance of the locomotor pattern, stepping on a line of a specific length promotes attention along with induction in the dynamic visual flow.[29] As attention gets better, the task becomes corticalized.[30] Visual motor process refers to the transformation of visual information into action. For the purpose of generating movement, the sensory information gathered during visually guided movement reaches the dentate nucleus of the cerebellum.[31] The cerebellum and basal ganglia, which have a reciprocal relationship with the brain stem and cerebral cortex for control of the automatic motor process, are activated by this focus on visual information.[32] The visual feedback, which improves motor function, may also be a factor in the considerable improvement in gait velocity.[33] A shift in muscle coordination pattern results in regulated gait movement because the oculomotor and locomotor pathways are linked.[34] According to Peper, guided ambulation by visual cues was more difficult than other cues and increased participants' attention to task-oriented information. As a result, the present study used visual cues to educate about balance and gait. The justification for this was linked to the indigenous reliance on visual information for gait.[35] Visual cue training stimulates the visual motor pathway, and improvements in balance and gait measurements can be attributed to the brain's compensatory and preventative mechanisms after training sessions.

The findings of the present study revealed that changes in ERP P300 latency value has been found to be significant with time and group but non-significant with respect to time × group interaction. Results for ERP P300 amplitude showed no significant difference in time, group, and time × group interaction following 8-week treatment. Superior results were shown in a study that focused on the intervention's cognitive components.[36] The improvement in cognitive domains can be attributed to an increase in the density and quantity of cerebrovascular dendritic connections, which leads to a better cerebral oxygen intake, stimulates the production of neurotransmitters, and speeds up nerve conduction, exercise may potentially have effects on the brain regions responsible for motor and sensory function as well as enhance cognitive abilities in older adults, according to research.[37] A similar finding was reported in a study by Maria-Luisa Benitez-Lugo examining feedback-based technology in elderly participants in improving memory and reaction times, though attention networks remained unaffected. The partial cognitive improvements were attributed to the task design, physical capacity gains, mood enhancement, or their combination. Feedback integration enables simultaneous physical and cognitive stimulation.[37]

A positive change was also reported in the scores of the BDI. These findings were in line with previously done study where regular exercise training and an increase in physical activity were strongly linked to a reduced risk of depression and an improvement in mental health.[38] According to a recent umbrella systematic review, it was reported that physical exercise improved depression in post-menopausal women.[39] However, the exact mechanism behind the antidepressant effects that exercise brings remains unclear. Multiple physiological and psychological mechanisms, like the endorphin hypothesis, thermogenic hypothesis, and distraction hypothesis, were supposed to be responsible for the improvement in depressive symptoms.[40] Visual cue training is also hypothesized to work through these mechanisms to improve depressive symptoms in post-menopausal women. Also, a recent systematic review and network meta-analysis conducted by Noetel *et al.* reported the effect of exercise on depression. They found comparable results of exercises and cognitive behavior therapy on depression. They also found the results of exercise training to be superior to antidepressants; however, a combination of the two subsequently improved the effects of the drugs.[41]

The study serves as a basis for the use of visual cue training as a treatment approach to improve balance and gait measures in a clinical setting. This technique requires minimal investment with low-cost, readily available materials. Integrating visual cueing with conventional therapy enhances adherence, motivation, and enjoyment. Its feasibility for home use and affordability are additional advantages.

From the clinical perspective, the observed improvements in step length, cadence, COP range, and BBS scores are likely to be functionally meaningful in post-menopausal women. Increases in step length and cadence are associated with improved gait stability and walking efficiency, while greater COP range reflects enhanced limits of stability during functional tasks such as turning and reaching. Collectively, these contribute to reduced fall risk, improved functional mobility, and better quality of life.

The present study has potential limitations because we have only included clinically stable post-menopausal women. Therefore, the results cannot be generalized to unstable post-menopausal women. Additionally, a placebo intervention was not feasible in this rehabilitation setting; therefore, the new intervention was compared with standard care, which represents a pragmatic and clinically relevant approach. However, future studies may consider the use of a waiting-list control design, in which participants receive the intervention at a later stage while outcomes are measured simultaneously, to further strengthen methodological rigor. Lastly, the study did not include a long-term follow-up period to determine the sustainability of treatment effects. Hence, future studies are recommended to evaluate long-term effects. Due to limited literature on visual-cue training in post-menopausal women, larger studies are needed to strengthen the evidence. The efficacy of visual cue training can be evaluated across different menopause onset groups.

Conclusions

Results of the present study suggest that visual cues have an additional effect in some measures of gait and balance when combined with the balance exercise only. Adherence to the exercise regime was also found to be good. However, it has no additional effects in reducing depressive symptoms and P300 amplitude. Therefore, it could be inferred that the addition of a visual cue to conventional balance training could be considered in women with menopause, considering that it has some benefits over conventional balance training in post-menopausal women.

References

1. Kumar R, Rizvi MR, Sami W. Impact of a 12-week obesity intervention on menopausal symptoms and psychological well-being across menopause stages: a cross-sectional analysis. Front Reprod Health 2025;7:1524790.
2. Cobin RH, Goodman NF. American association of clinical endocrinologists and American college of endocrinology position statement on menopause - 2017 update. Endocr Pract 2017;23:869-80.
3. Prasad JB, Tyagi NK, Verma P. Age at menopause in India: a systematic review. Diabetes Metab Syndr 2021;15:373-7.
4. Ahuja M. Age of menopause and determinants of menopause age: a PAN India survey by IMS. J Midlife Health 2016;7:126-31.
5. Iwanowicz-Palus G, Świst D, Skurzak A, et al. Impact of menopause on women's health. Medycyna Ogólna i Nauki o Zdrowiu 2019;25:1-5.
6. El Khiati R, Tighilet B, Besnard S, Chabbert C. Vestibular disorders and hormonal dysregulations: state of the art and clinical perspectives. Cells 2023;12:656.
7. Santo JE, Aibar-Almazán A, Martínez-Amat A, et al. Menopausal symptoms, postural balance, and functional mobility in middle-aged post-menopausal women. Diagnostics 2021;11:2178.
8. Melzer I, Kurz I, Oddsson LIE. A retrospective analysis of balance control parameters in elderly fallers and non-fallers. Clin Biomech 2010;25:984-8.
9. Cheng MH, Wang SJ, Yang FY, et al. Menopause and physical performance - a community-based cross-sectional study. Menopause 2009;16:892.6.
10. Sinaki M, Brey RH, Hughes CA, et al. Balance disorder and increased risk of falls in osteoporosis and kyphosis: Significance of kyphotic posture and muscle strength. Osteoporosis Int 2005;16:1004-10.
11. Thurston RC, Joffe H. Vasomotor symptoms and menopause: findings from the study of women's health across the nation. Obstet Gynecol Clin North Am 2011;38:489-501.
12. Sozzi S, Nardone A, Schieppati M. Specific posture-stabilising effects of vision and touch are revealed by distinct changes of body oscillation frequencies. Front Neurol 2021;12:756984.
13. Rawat S, Balyan J, Sonia. Evaluating the efficacy of cueing strategies versus walking aids in Parkinson's disease: an interventional study. J Clin Diagn Res 2025;19:YC32-5.
14. Sunny S, Bhat SPS. Effect of visual cue training on balance and walking in elderly: A single blind randomized controlled trial. J Clin Diagn Res 2017;11:YC01-04.
15. Upadhyay S, Verma N. Effect of visual cue training on gait and walking velocity in chronic stroke patients- a quasi-experimental study. J Clin Diagn Res 2022;16:YC06-10.
16. Schlick C, Ernst A, Bötzel K, et al. Visual cues combined with treadmill training to improve gait performance in Parkinson's disease: a pilot randomized controlled trial. Clin Rehabil 2016; 30:463-71.
17. Ahmad I, Noohu MM, Verma S, et al. Validity and responsiveness of balance measures using Pedalo®-Sensomove balance device in patients with diabetic peripheral neuropathy. J Clin Diagn Res 2019;13:YC01-4.
18. Ahmad I, Noohu MM, Verma S, et al. Effect of sensorimotor training on balance measures and proprioception among middle and older age adults with diabetic peripheral neuropathy. Gait Posture 2019;74:114-20.
19. Sturnieks DL, St George R, Lord SR. Balance disorders in the elderly. Neurophysiol Clin 2008;38:467-78.
20. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. Can J Public Health 1992;83:S7-11.
21. Riley M, Goodman M, Fritz VU. An objective measure of gait using ink footprints. South African J Physiother 1999;55:a560.
22. Aseem A, Hussain ME. Circadian variation in cognition: a comparative study between sleep-disturbed and healthy participants. Biol Rhythm Res 2021;52:1-9.
23. Beck AT, Beck RW. Screening depressed patients in family practice. A rapid technic. Postgrad Med 1972;52:81-5.
24. Festa F, Medori S, Macrì M. Move your body, boost your brain: the positive impact of physical activity on cognition across all age groups. Biomedicines 2023;11:1765.
25. Sihvonen SE, Sipilä S, Era PA. Changes in postural balance in frail elderly women during a 4-week visual feedback training: a randomized controlled trial. Gerontology 2004;50:87-95.
26. Hatzitaki V, Amiridis IG, Nikodelis T, Spiliopoulou S. Direction-induced effects of visually guided weight-shifting training on standing balance in the elderly. Gerontology 2009; 55:145-52.
27. Bank PJM, Roerdink M, Peper CE. Comparing the efficacy of metronome beeps and stepping stones to adjust gait: steps to follow! Exp Brain Res 2011;209:159-69.
28. Morris ME, Iansek R, Matyas TA, Summers JJ. Stride length regulation in Parkinson's disease: Normalization strategies and underlying mechanisms. Brain 1996;119:551-68.
29. Azulay JP, Mesure S, Amblard B, et al. Visual control of locomotion in Parkinson's disease. Brain 1999;122:111-20.

30. Rubinstein TC, Giladi N, Hausdorff JM. The power of cueing to circumvent dopamine deficits: A review of physical therapy treatment of gait disturbances in Parkinson's disease. Mov Disord 2002;17:1148-60.
31. Allen G, Buxton RB, Wong EC, Courchesne E. Attentional activation of the cerebellum independent of motor involvement. Science 1997;275:1940-3.
32. Takakusaki K. Functional neuroanatomy for posture and gait control. J Mov Disord 2017;10:1-17.
33. Archer DB, Kang N, Misra G, et al. Visual feedback alters force control and functional activity in the visuomotor network after stroke. Neuroimage Clin 2017;17:505-17.
34. Lewek MD, Bradley CE, Wutzke CJ, Zinder SM. The relationship between spatiotemporal gait asymmetry and balance in individuals with chronic stroke. J Appl Biomech 2014;30:31-6.
35. Peper CLE, Oorthuizen JK, Roerdink M. Attentional demands of cued walking in healthy young and elderly adults. Gait Posture 2012;36:378-82.
36. Cheng ST, Chow PK, Song YQ, et al. Mental and physical activities delay cognitive decline in older persons with dementia. Am J Geriatr Psychiatry 2014;22:63-74.
37. Moreira NB, Gonçalves G, da Silva T, et al. Multisensory exercise programme improves cognition and functionality in institutionalized older adults: a randomized control trial. Physiother Res Int 2018;23:e1708.
38. Erickson KI, Miller DL, Roecklein KA. The aging hippocampus: interactions between exercise, depression, and BDNF. Neuroscientist 2011;18:82-97.
39. Fausto DY, Leitão AE, Silveira J, et al. An umbrella systematic review of the effect of physical exercise on mental health of women in menopause. Menopause 2023;30:225-34.
40. Craft LL, Perna FM. The benefits of exercise for the clinically depressed. Prim Care Companion Companion J Clin Psychiatry 2004;6:104-11.
41. Noetel M, Sanders T, Gallardo-Gómez D, et al. Effect of exercise for depression: systematic review and network meta-analysis of randomised controlled trials. BMJ 2024;384:e075847.

Received: 5 December 2025; Accepted: 18 March 2026.

Contributions: Aneesa Farooq: conceptualization, methodology, investigation, data curation, writing – original draft. Sarah Parveen: data analysis, writing – review and editing. Chhavi Arora Sehgal: conceptualization, supervision, writing – review and editing. Arshiya Anwar: methodology, resources. Muhammad Azharuddin: review and editing. Syed Naznin Fatma: formal analysis, visualization. Md. Dilshad Manzar: statistical review, review and editing. Majumi M. Noohu: supervision, project administration, writing – final approval.

Conflict of interest: the authors declare that they have no conflicts of interest, either real or perceived, related to this work.

Ethics approval and consent to participate: the Institutional Ethics Committee (IEC) at Jamia Millia Islamia gave its approval to the study (ethical approval no. 12/10/402/JMI/IEC/2022).

Informed consent: written informed consent was obtained from all participants.

Patient consent for publication: written informed consent for publication of anonymized data was obtained from all participants.

Availability of data and materials: the datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Acknowledgments: the authors acknowledge the support of the Centre for Physiotherapy & Rehabilitation Sciences, Jamia Millia Islamia, New Delhi, India, for providing access to research facilities and logistical support during data collection.

Trial registration: this trial was prospectively registered with the Clinical Trials Registry-India (CTRI) under the registration number CTRI/2023/03/050837.