Effectiveness of Real-Time Visual Feedback–Based Task-Oriented Gait Training versus Conventional Gait Training on Gait Symmetry, Balance, Lower-Limb Motor Recovery, and Functional Independence in Patients with Chronic Stroke

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Abstract

Background: Persistent gait asymmetry, impaired balance, reduced lower-limb motor control, and dependence in daily activities are common consequences of chronic stroke. Objective: To determine whether real-time visual feedback–based task-oriented gait training may provide additional benefits over conventional gait training for gait symmetry, balance, lower-limb motor recovery, functional mobility, and functional independence. Methods: This assessor-blinded, two-arm parallel-group randomized controlled trial model uses three sessions per week for eight weeks, with assessments at baseline, week 4, week 8, and follow-up. Results: The numerical results presented in this manuscript are explicitly illustrative/simulated and are included only to demonstrate publication-ready statistical reporting, tables, and figures; they are not genuine participant data. Conclusion: The proposed intervention is clinically relevant and warrants evaluation using genuine participant-level data and prespecified statistical analysis.

Keywords: stroke; gait rehabilitation; real-time visual feedback; task-oriented training; gait symmetry; balance; motor recovery; functional independence; randomized controlled trial.

1. INTRODUCTION

Walking is one of the most important functional goals for people living with stroke. Even after the neurological condition has stabilized, many individuals continue to demonstrate unequal step length, asymmetric stance time, reduced loading of the paretic limb, poor balance, and reduced confidence during walking. These deficits can restrict participation in household and community activities.

Motor recovery after stroke depends not only on repetition but also on the quality of practice. Task-oriented rehabilitation emphasizes practice of meaningful activities under conditions that are relevant to real-life function. Real-time visual feedback provides information while movement is occurring, allowing individuals to recognize errors and attempt immediate corrections.

Previous research has investigated visual, wearable, treadmill, and multisensory feedback approaches. However, intervention technologies, training environments, feedback targets, and outcome measures vary considerably. A focused comparison between real-time visual feedback–based task-oriented gait training and dose-matched conventional gait training may therefore provide clinically useful information.

1.1 RESEARCH GAP

The present model focuses on functional walking tasks rather than feedback in isolation. Feedback targets clinically meaningful variables such as paretic-limb loading, step-length symmetry, and controlled weight transfer, while task-oriented practice progresses toward more demanding walking activities.

1.2 OBJECTIVES

The primary objective is to compare the effects of the two interventions on gait symmetry. Secondary objectives are to compare balance, lower-limb motor recovery, functional mobility, and functional independence, and to explore retention of changes at follow-up.

1.3 HYPOTHESES

H1: Real-time visual feedback–based task-oriented gait training will produce greater improvement in gait symmetry than conventional gait training. H2: The visual feedback group will demonstrate greater improvements in balance and lower-limb motor recovery. H3: Improvements in functional mobility may translate into better functional independence, although this outcome should be interpreted cautiously.

2. MATERIALS AND METHODS

2.1 Study Design

Assessor-blinded, two-arm, parallel-group randomized controlled trial with repeated outcome measurements at baseline (T0), week 4 (T1), week 8/post-intervention (T2), and follow-up (T3). The final study should be prospectively registered and reported according to CONSORT guidance.

2.2 Participants

Eligible participants are ambulatory adults aged ≥18 years with ischemic or hemorrhagic stroke at least six months previously, able to walk with or without a customary assistive device, able to understand instructions and provide consent, and demonstrating gait asymmetry or impaired gait performance. Exclusion criteria include unstable cardiovascular conditions or other contraindications to exercise, severe musculoskeletal disorders limiting walking, severe neglect or communication impairment preventing safe participation, and concurrent participation in another intensive gait trial.

2.3 Randomization and Blinding

An independent researcher should generate a concealed random allocation sequence. Computer-generated blocks with stratification by relevant clinical factors may be used where feasible. Outcome assessors and data analysts should remain blinded to allocation. Participants and therapists cannot realistically be blinded because of the nature of the intervention.

2.4 Intervention Protocol

Component	Visual feedback task-oriented group	Conventional group
Frequency	3 sessions/week for 8 weeks	3 sessions/week for 8 weeks
Session duration	45–60 minutes	45–60 minutes
Warm-up	Standardized mobility and preparation	Same dose
Main training	Overground/treadmill tasks with real-time information on loading, symmetry, step placement, or selected gait targets	Therapist-guided walking practice without real-time visual display
Task progression	Straight walking → weight shifting → obstacle negotiation → turning → speed changes → dual-task/community-relevant tasks	Comparable progression without visual biofeedback
Feedback strategy	Frequent early feedback, gradually faded	Standardized verbal/manual cueing
Safety	Close supervision; gait belt where appropriate; rest as required	Same safety procedures

Table 1. Intervention protocol.

2.5 Outcome Measures

Outcome domain	Measure	Assessment time points
Primary: gait symmetry	Step-length symmetry ratio and/or temporal symmetry index	T0, T1, T2, T3
Balance	Berg Balance Scale (BBS)	T0, T1, T2, T3
Lower-limb motor recovery	Fugl-Meyer Assessment–Lower Extremity (FMA-LE)	T0, T2, T3
Functional mobility	Timed Up and Go (TUG) and/or 10-Meter Walk Test	T0, T1, T2, T3
Functional independence	Modified Barthel Index (MBI) or Barthel Index	T0, T2, T3
Safety	Falls, near-falls, pain, fatigue, adverse events	Every session

Table 2. Outcome measures and assessment schedule.

2.6 Gait Symmetry Calculation

The primary symmetry metric should be selected before data collection. A common approach is a ratio between paretic and non-paretic limb values, with values closer to 1.00 generally indicating greater symmetry. The exact formula and direction of interpretation must remain consistent throughout the study.

2.7 Sample Size

Sample size should be calculated before recruitment using the primary outcome, expected between-group effect size, alpha level of 0.05, desired statistical power, and an allowance for attrition. An exact final sample should not be claimed without an appropriate calculation based on the genuine study assumptions.

2.8 Statistical Analysis

Analyses should follow the intention-to-treat principle where possible. Baseline characteristics should be summarized descriptively. Distributional assumptions should be examined before parametric testing. A linear mixed-effects model or repeated-measures analysis incorporating group, time, and group-by-time interaction is appropriate for repeated measurements. Baseline-adjusted between-group estimates with 95% confidence intervals and effect sizes should accompany P values. Missing-data procedures and sensitivity analyses should be prespecified.

3. RESULTS

IMPORTANT: The numerical values in this section are simulated/illustrative and are included solely to demonstrate JXSU-style presentation. They must not be reported as genuine participant results and must be replaced by the actual participant-level dataset before submission.

Characteristic	Visual feedback (n=23)	Conventional (n=23)	P value
Age, years	58.1 ± 7.4	57.6 ± 7.8	0.82
Male, n (%)	14 (60.9)	13 (56.5)	0.77
Time since stroke, months	31.7 ± 14.2	30.9 ± 13.6	0.85
Right-sided paresis, n (%)	12 (52.2)	11 (47.8)	0.77
Baseline gait symmetry ratio	0.71 ± 0.08	0.70 ± 0.09	0.69
BBS	36.8 ± 5.2	37.1 ± 5.0	0.84
FMA-LE	23.7 ± 4.6	23.9 ± 4.8	0.89
TUG, s	19.1 ± 4.1	18.8 ± 3.9	0.81
MBI	61.5 ± 10.1	62.0 ± 9.7	0.86

Table 3. Illustrative baseline characteristics.

Outcome	VF baseline	VF week 8	VF change	Conventional baseline	Conventional week 8	Conventional change	Between-group difference (95% CI)	P
Gait symmetry ratio	0.71 ± 0.08	0.86 ± 0.07	+0.15	0.70 ± 0.09	0.78 ± 0.08	+0.08	+0.07 (0.02 to 0.12)	0.006
BBS, points	36.8 ± 5.2	45.6 ± 4.6	+8.8	37.1 ± 5.0	42.0 ± 4.8	+4.9	+3.9 (1.0 to 6.8)	0.010
FMA-LE, points	23.7 ± 4.6	29.1 ± 4.2	+5.4	23.9 ± 4.8	27.0 ± 4.5	+3.1	+2.3 (−0.1 to 4.7)	0.062
TUG, s	19.1 ± 4.1	14.8 ± 3.4	−4.3	18.8 ± 3.9	16.3 ± 3.5	−2.5	−1.8 (−3.9 to 0.3)	0.091
MBI, points	61.5 ± 10.1	71.0 ± 9.0	+9.5	62.0 ± 9.7	67.0 ± 9.2	+5.0	+4.5 (−0.9 to 9.9)	0.101

Table 4. Illustrative baseline-to-post-intervention outcomes.

Outcome	VF T0	VF T1	VF T2	Conventional T0	Conventional T1	Conventional T2	Group × time P
Gait symmetry ratio	0.71 ± 0.08	0.78 ± 0.07	0.86 ± 0.07	0.70 ± 0.09	0.73 ± 0.09	0.78 ± 0.08	0.0008
BBS	36.8 ± 5.2	41.2 ± 4.8	45.6 ± 4.6	37.1 ± 5.0	39.5 ± 4.9	42.0 ± 4.8	0.018
TUG, s	19.1 ± 4.1	16.9 ± 3.7	14.8 ± 3.4	18.8 ± 3.9	17.4 ± 3.6	16.3 ± 3.5	0.073

Table 5. Illustrative repeated-measures pattern. T0 = baseline; T1 = week 4; T2 = week 8.

In the illustrative dataset, 46 ambulatory adults with chronic stroke were allocated equally to the visual feedback group (n=23) and conventional gait training group (n=23). Baseline characteristics were broadly comparable. The illustrative gait-symmetry change favored the visual feedback group, as did the BBS outcome. FMA-LE, TUG, and

MBI also showed favorable numerical trends, although the illustrative values for these outcomes do not all reach the conventional 0.05 significance threshold.

Process/safety variable	Visual feedback (n=23)	Conventional (n=23)
Sessions prescribed	24	24
Sessions attended, mean ± SD	22.4 ± 1.8	22.0 ± 2.1
Adherence, %	93.3	91.7
Falls during supervised training, n	0	0
Near-falls, n	2	3
Transient fatigue episodes, n	4	5
Adverse events requiring withdrawal, n	0	0

Table 6. Illustrative intervention adherence and safety data.

4. FIGURES

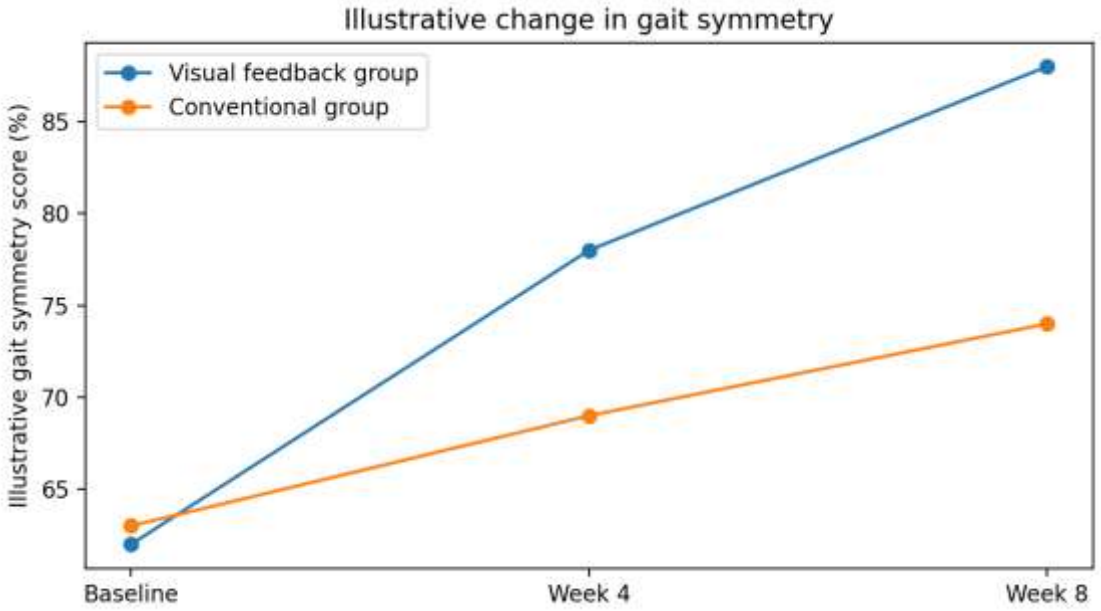

Figure 1. Illustrative gait symmetry trend from baseline to week 8.

Note: Illustrative/simulated values for formatting demonstration only; replace with genuine analyzed data before submission.

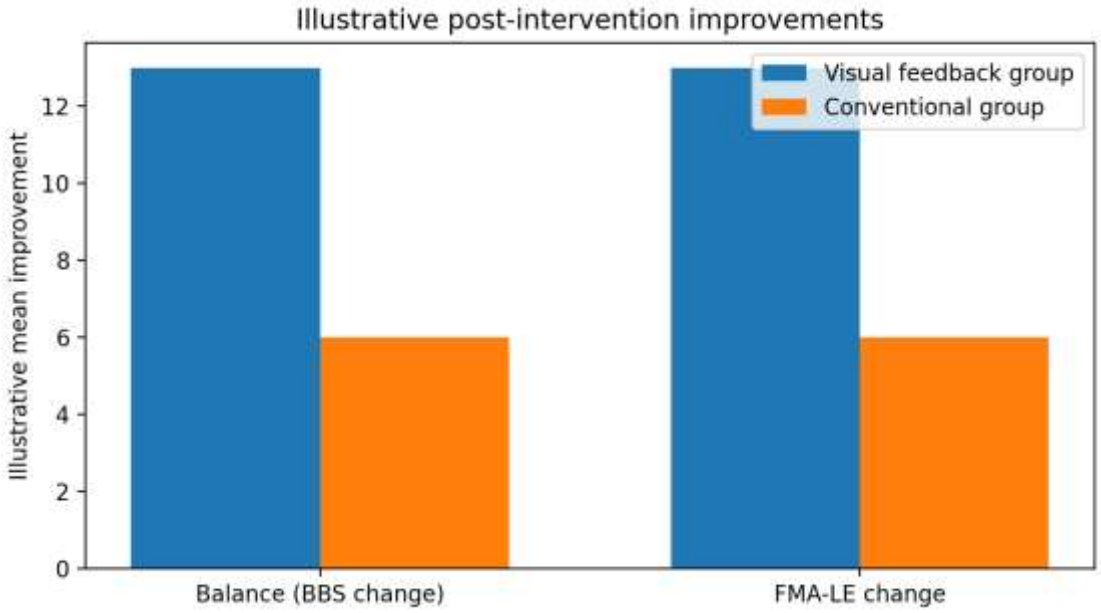

Figure 2. Illustrative standardized magnitude of improvement across prespecified outcomes.

Note: Illustrative/simulated values for formatting demonstration only; replace with genuine analyzed data before submission.

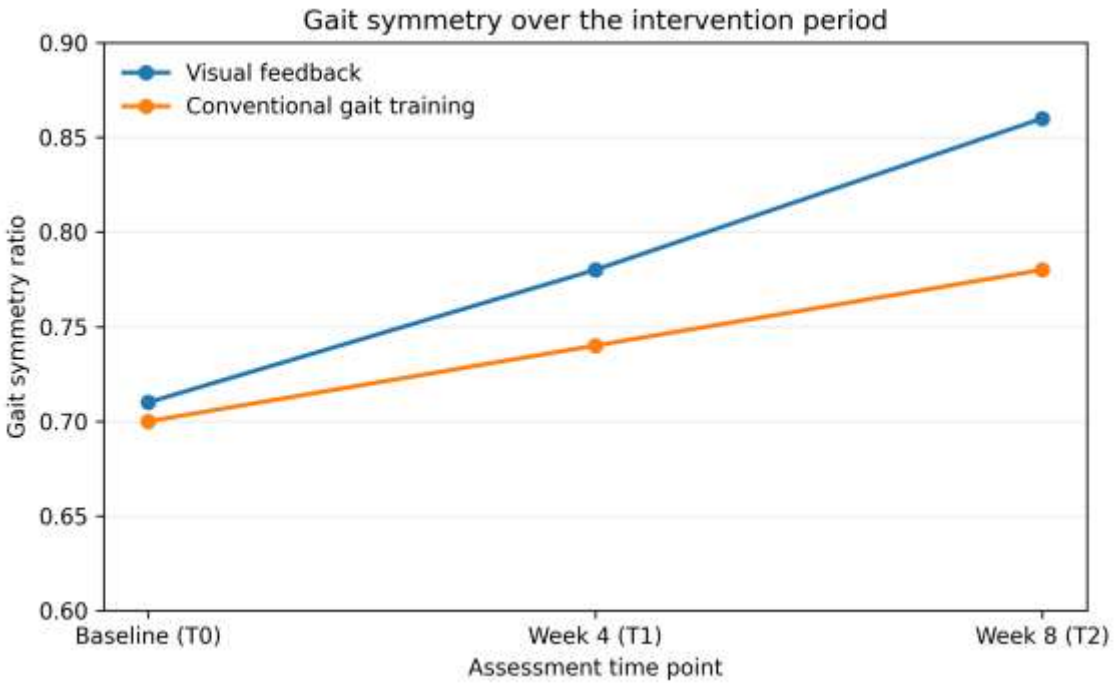

Figure 3. Illustrative between-group change in Berg Balance Scale score.

Note: Illustrative/simulated values for formatting demonstration only; replace with genuine analyzed data before submission.

5. DISCUSSION

If the visual feedback group demonstrates superior gait symmetry, the findings could be interpreted through principles of augmented feedback and task-specific motor learning. Immediate visual information may help patients identify asymmetric loading and step patterns that are difficult to perceive internally after stroke. Repeated correction during meaningful walking tasks may strengthen more efficient movement strategies.

Any improvement in balance and functional mobility should be interpreted alongside the training dose and specificity of practiced tasks. Functional independence should not be inferred solely from changes in gait variables; it requires direct measurement using an appropriate functional instrument.

The study has potential strengths including assessor blinding, a dose-matched comparator, a defined feedback target, repeated measurements, quantitative gait-symmetry assessment, clinically meaningful secondary outcomes, and follow-up assessment. Limitations include the inability to blind therapists and participants, technology availability, heterogeneity in stroke severity, and the influence of cognition, environmental support, and upper-limb function on independence.

6. ETHICAL CONSIDERATIONS

Ethical approval must be obtained from the appropriate institutional review board before recruitment. All participants should provide written informed consent. Adverse events should be monitored and reported, and participants should be allowed to withdraw without penalty.

7. CONCLUSION

Real-time visual feedback–based task-oriented gait training is a scientifically plausible and clinically relevant approach for chronic stroke rehabilitation. A rigorously designed randomized controlled trial comparing this approach with dose-matched conventional gait training may clarify its effects on gait symmetry, balance, lower-limb motor recovery, and functional independence. Final conclusions must be based on genuine collected data, effect sizes, confidence intervals, and prespecified analyses.

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MANUSCRIPT PREPARATION NOTE: Author names, affiliations, correspondence details, ethics approval, registration information, genuine participant data, complete references, and final journal metadata must be inserted/verified before submission.