# EFFECTS OF DUAL-TASK-SPECIFIC GAIT TRAINING VERSUS CONVENTIONAL PHYSICAL THERAPY ON GAIT SPEED, STEP SYMMETRY, DYNAMIC BALANCE, AND FUNCTIONAL MOBILITY IN PATIENTS WITH CHRONIC HEMIPLEGIC STROKE: A RANDOMIZED CONTROLLED TRIAL

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## ABSTRACT

Background: Walking after stroke is often limited by reduced gait speed, temporal and spatial asymmetry, impaired dynamic balance, and difficulty managing simultaneous cognitive or environmental demands. Conventional physical therapy commonly emphasizes repeated single-task walking and functional mobility. Dual-task-specific gait training integrates walking with a concurrent cognitive or motor task and may better reproduce the attentional demands of community ambulation.

Objective: To compare the effects of dual-task-specific gait training with conventional physical therapy on gait speed, step symmetry, dynamic balance, and functional mobility in adults with chronic hemiplegic stroke.

Methods: This randomized controlled trial is designed for adults with chronic hemiplegic stroke who are able to walk with or without a walking aid. Participants will be randomly allocated to a dual-task-specific gait-training group or a conventional physical-therapy group. Both groups will receive structured rehabilitation for an equivalent treatment period and contact time. The experimental intervention will progressively combine walking with cognitive and/or motor secondary tasks, while the control intervention will use conventional single-task gait and functional mobility exercises. Primary outcomes will include gait speed and step symmetry; secondary outcomes will include dynamic balance and functional mobility. Assessments will be performed at baseline and immediately after the intervention, with optional follow-up if available.

Results: The present document does not report invented participant outcomes. The Results section contains analysis-ready tables and figure specifications that should be populated from the verified trial dataset.

Conclusion: The study is designed to determine whether task-specific dual-task gait practice provides additional benefits over conventional physical therapy for walking and mobility in chronic hemiplegic stroke. The final conclusion should be based solely on the prespecified statistical analysis of the actual randomized trial data.

**Keywords:** stroke; hemiplegia; dual-task gait training; gait speed; step symmetry; dynamic balance; functional mobility; physical therapy; randomized controlled trial

## 1. INTRODUCTION

Stroke is a leading cause of long-term disability and frequently leaves survivors with persistent impairments in walking, postural control, coordination, and the ability to divide attention between locomotion and another task. These limitations can remain clinically important during the chronic stage even when basic independent walking has been regained. Community walking is rarely performed as a purely single-task activity; patients may need to converse, carry an object, monitor traffic, negotiate obstacles, or make rapid decisions while walking.

Dual-task gait training is intended to expose the patient to this interaction between locomotor and non-locomotor demands in a controlled rehabilitation environment. A randomized trial in chronic stroke reported improvements in gait parameters and dual-task interference after treadmill-based dual-task gait training compared with separating the gait and cognitive components. [1] A subsequent meta-analysis of randomized trials found beneficial effects of dual-task training on several gait and balance measures, although the pooled effect on gait speed and Timed Up and Go was not consistently superior across studies. [2] An updated meta-analysis likewise reported improvements in step length, cadence, stride length, and the 10-Meter Walk Test, while noting uncertainty for some balance outcomes. [3]

More recent evidence continues to support investigation of task-specific dual-task rehabilitation. A 2024 systematic review focusing on proprioceptive strategies combined with dual-task exercises reported improvements in gait speed, cadence, stride time, stride length, and step length in people with chronic stroke. [4] A 2024 meta-analytic report and trial-sequential analysis concluded that cognitive-motor dual-task training can improve gait and balance outcomes, while emphasizing the need for appropriately designed trials. [5] A 2025 systematic review and meta-analysis similarly reported favorable effects of dual-task training on walking speed, step length, stride length, step frequency, and Berg Balance Scale scores, but less consistent effects on Timed Up and Go. [6]

Despite these findings, several practical gaps remain. First, many trials compare dual-task training with heterogeneous control interventions, making it difficult to determine the added value of a specifically structured dual-task gait program over conventional physical therapy. Second, gait speed alone may not fully capture walking quality; step symmetry provides additional information about temporal or spatial coordination between the paretic and non-paretic limbs. Third, dynamic balance and functional mobility are clinically relevant because community ambulation requires rapid transitions, turning, obstacle negotiation, and postural adjustments.

The present randomized controlled trial therefore proposes a standardized dual-task-specific gait-training program and compares it with conventional physical therapy using a multidimensional outcome set comprising gait speed, step symmetry, dynamic balance, and functional mobility. The study is intended to provide clinically interpretable evidence on whether integrating secondary tasks directly into gait practice produces additional gains beyond conventional rehabilitation.

## 2. OBJECTIVES

- To determine the effect of dual-task-specific gait training on gait speed in adults with chronic hemiplegic stroke.
- To determine whether dual-task-specific gait training improves step symmetry compared with conventional physical therapy.
- To compare changes in dynamic balance between the two treatment groups.
- To compare functional mobility between groups after the intervention.
- To examine whether improvements are maintained at follow-up when follow-up assessment is available.

## 3. RESEARCH HYPOTHESES

H1: Participants receiving dual-task-specific gait training will demonstrate a greater improvement in gait speed than participants receiving conventional physical therapy.

H2: Participants receiving dual-task-specific gait training will demonstrate greater improvement in step symmetry than participants receiving conventional physical therapy.

H3: Participants receiving dual-task-specific gait training will demonstrate greater improvement in dynamic balance than participants receiving conventional physical therapy.

H4: Participants receiving dual-task-specific gait training will demonstrate greater improvement in functional mobility than participants receiving conventional physical therapy.

H0: There will be no statistically significant between-group difference in the prespecified primary or secondary outcomes after adjustment for baseline values.

## 4. MATERIALS AND METHODS

### 4.1 Study design

A two-arm, parallel-group randomized controlled trial will be conducted in accordance with the principles of the Declaration of Helsinki and the CONSORT reporting framework. The intervention and assessment schedule should be finalized before recruitment and documented in the trial record. The present manuscript intentionally leaves institution-specific ethical approval and registration identifiers blank until the verified records are supplied.

### 4.2 Participants and setting

Adults with chronic hemiplegic stroke will be recruited from participating rehabilitation/physiotherapy settings. Chronic stroke should be operationally defined before recruitment (for example, ≥6 months after stroke). The study should record stroke type, affected side, time since stroke, assistive-device use, and baseline walking ability.

### 4.3 Eligibility criteria

- Inclusion: adult participant; clinically confirmed unilateral stroke with persistent hemiplegia; chronic stage according to the prespecified time criterion; ability to understand and follow simple instructions; ability to walk a defined distance with or without an assistive device; medically stable for therapeutic exercise; and willingness to provide informed consent.
- Exclusion: recurrent acute neurological event during the study period; unstable cardiovascular or other medical condition limiting exercise; severe cognitive or communication impairment preventing valid testing; severe musculoskeletal pain or contracture that materially limits walking; major visual/vestibular disorder affecting gait assessment; or concurrent participation in another structured gait-rehabilitation trial.

### 4.4 Randomization and allocation concealment

After baseline assessment, eligible participants will be randomized in a 1:1 ratio using a computer-generated random sequence. Allocation should be concealed using sequentially numbered, opaque, sealed envelopes prepared by an independent person or an equivalent secure allocation method. The assessor should remain blinded to group assignment whenever feasible. Because the interventions are behaviorally distinct, participant and treating-therapist blinding is not expected.

### 4.5 Intervention: dual-task-specific gait training

The experimental intervention will combine task-specific gait practice with a concurrent secondary task. Training should progress from low-complexity dual-task activities to more demanding conditions according to participant safety and performance. Examples include walking while counting backward, naming categories, responding to verbal cues, carrying a light object, stepping around obstacles while responding to a cognitive cue, changing walking direction on command, or combining walking with a motor manipulation task.

| Component | Proposed prescription | Progression criterion |
|---|---|---|
| Warm-up | 5–10 min of mobility, active range, weight shifting and low-intensity walking. | Increase task complexity as tolerated. |
| Task-specific gait | 20–25 min of repeated overground or treadmill walking. | Progress speed, distance, direction and environmental complexity. |
| Cognitive dual task | 10–15 min during walking. | Increase cognitive load, response speed or distractor complexity. |
| Motor dual task | 10–15 min during walking. | Increase object manipulation, obstacle or carrying demands. |
| Cool-down | 5 min of low-intensity walking and recovery. | Maintain safety and symptom monitoring. |

### 4.6 Control: conventional physical therapy

The control group will receive conventional physical therapy matched as closely as possible for treatment frequency and contact time. Treatment may include single-task gait practice, strengthening, range-of-motion exercises, balance exercises, transfer practice, sit-to-stand, stepping practice, and functional mobility training. The defining feature is that the walking component is practiced without a systematically concurrent secondary task.

### 4.7 Safety monitoring

Blood pressure, heart rate, symptoms, fatigue, falls/near-falls, pain, and other clinically relevant adverse events should be monitored according to the clinical setting. Training intensity and complexity should be reduced or stopped when predefined safety criteria are reached. Adverse events should be documented by group and classified by severity, seriousness, and relationship to treatment.

### 4.8 Outcome measures

| Outcome domain | Recommended measure | Unit / interpretation | Time points |
|---|---|---|---|
| Gait speed | 10-Meter Walk Test (10MWT) | m/s; higher values indicate faster walking | Baseline; post-intervention; follow-up if planned |
| Step symmetry | Instrumented gait analysis or | Ratio or percentage asymmetry; lower asymmetry | Baseline; post-intervention; |

| | | | |
|---|---|---|---|
| | validated symmetry index | indicates greater symmetry | follow-up |
| Dynamic balance | Berg Balance Scale (BBS) and/or dynamic gait assessment | Score; higher BBS indicates better balance | Baseline; post-intervention; follow-up |
| Functional mobility | Timed Up and Go (TUG) | seconds; lower time indicates better mobility | Baseline; post-intervention; follow-up |
| Secondary gait measure | Cadence/step length/stride length where available | steps/min or cm | Baseline; post-intervention |
| Adverse events | Structured adverse-event form | frequency and severity | Throughout intervention |

The 10MWT is recommended as the primary gait-speed measure because it is simple, widely used, and directly interpretable. Step symmetry should be measured with a consistent validated method; the exact symmetry formula must be prespecified. For example, a symmetry ratio can be calculated from paretic and non-paretic step or stance parameters, with the selected formula applied identically at all time points. The BBS provides a structured measure of balance, while TUG captures functional mobility involving standing, walking, turning, and sitting.

### 4.9 Assessment schedule

| Assessment | Baseline | During treatment | Post-treatment | Follow-up |
|---|---|---|---|---|
| Eligibility/demographics | ✓ | | | |
| Stroke history and assistive device | ✓ | | | ✓ |
| 10MWT | ✓ | | ✓ | ✓* |
| Step symmetry | ✓ | | ✓ | ✓* |
| Dynamic balance | ✓ | | ✓ | ✓* |
| TUG | ✓ | | ✓ | ✓* |
| Adverse events | | ✓ | ✓ | ✓* |
| Adherence | | ✓ | ✓ | ✓* |

**Follow-up should be included only if it is part of the registered/protocol-defined study design.*

### 4.10 Statistical analysis

Data should be analyzed using a prespecified statistical plan. Continuous variables should be summarized as mean ± standard deviation when approximately normally distributed, or median (interquartile range) when distributional assumptions are not met. Categorical variables should be summarized as frequencies and percentages. Baseline comparability should be described without interpreting nonsignificant baseline tests as proof of equivalence.

For the primary analysis, an analysis of covariance (ANCOVA) may be used to compare post-intervention outcomes between groups while adjusting for baseline outcome values, provided assumptions are satisfied. Alternatively, a linear mixed-effects model can be used when repeated measurements or missing observations require a longitudinal framework. Effect estimates should be reported with 95% confidence intervals and standardized effect sizes where appropriate. Statistical significance should be set at two-sided $\alpha$=0.05. Missing-data handling, intention-to-treat principles, per-protocol analysis, and sensitivity analyses should be specified before unblinding.

## 5. Results

In the illustrative dataset, 60 participants were randomized equally between the two groups. The groups were broadly similar in age, sex distribution, stroke duration, affected side and assistive-device use. Following the intervention, the dual-task-specific gait-training group showed an illustrative increase in 10-Meter Walk Test speed from 0.46 ± 0.13 m/s to 0.66 ± 0.14 m/s, whereas the conventional physical therapy group increased from 0.47 ± 0.14 m/s to 0.56 ± 0.14 m/s. Step asymmetry decreased in both groups, with a larger illustrative reduction in the dual-task group. BBS scores increased and TUG time decreased in both groups, with larger illustrative changes in the dual-task group.

These values are included only to show how the Results section, tables and graphs should read after the actual analysis. They must not be presented as observed findings unless they exactly match the verified trial dataset.

| Variable | Dual-task group (n=30) | Conventional PT (n=30) | Total (n=60) |
|---|---|---|---|
| Age, years | 61.3 ± 8.2 | 60.7 ± 8.6 | 61.0 ± 8.4 |
| Male, n (%) | 19 (63.3) | 18 (60.0) | 37 (61.7) |
| Female, n (%) | 11 (36.7) | 12 (40.0) | 23 (38.3) |
| Stroke duration, months | 24.6 ± 11.8 | 25.1 ± 12.4 | 24.9 ± 12.1 |

| | | | |
|---|---|---|---|
| Right hemiplegia, n (%) | 17 (56.7) | 16 (53.3) | 33 (55.0) |
| Left hemiplegia, n (%) | 13 (43.3) | 14 (46.7) | 27 (45.0) |
| Assistive-device use, n (%) | 12 (40.0) | 13 (43.3) | 25 (41.7) |

**Table S1. Illustrative baseline demographic and clinical characteristics.**

**Description:** The illustrative groups are closely balanced at baseline to demonstrate the intended presentation. Replace every value with the verified study dataset.

| Outcome | DT baseline | DT post | PT baseline | PT post | DT change | PT change | Between-group Δ | p |
|---|---|---|---|---|---|---|---|---|
| 10MWT | 0.5 ± 0.1 | 0.7 ± 0.1 | 0.5 ± 0.1 | 0.6 ± 0.1 | 0.2 | 0.1 | 0.1 | <0.001 |
| Symmetry | 18.5 ± 6.0 | 9.2 ± 4.8 | 18.1 ± 5.8 | 13.8 ± 5.2 | -9.3 | -4.3 | -4.6 | 0.002 |
| BBS | 39.5 ± 5.4 | 50.1 ± 4.4 | 39.7 ± 5.5 | 45.4 ± 5.0 | 10.6 | 5.7 | 4.7 | <0.001 |
| TUG | 19.4 ± 4.2 | 14.2 ± 3.0 | 19.1 ± 4.0 | 16.8 ± 3.4 | -5.2 | -2.3 | -2.6 | 0.001 |

**Table S2. Illustrative primary and secondary outcome results.**

**Description:** The table demonstrates the expected journal presentation: baseline and post-intervention values, within-group changes, an adjusted/contrast estimate, and p-value. The displayed p-values are illustrative only and must not be reported as actual trial findings.

| Safety/adherence variable | Dual-task group | Conventional PT group |
|---|---|---|
| Completed intervention, n (%) | 29 (96.7) | 28 (93.3) |
| Mean sessions attended | 17.3 ± 1.1 | 16.8 ± 1.5 |
| Falls/near-falls, n | 1 | 2 |
| Musculoskeletal pain, n | 2 | 2 |
| Other minor adverse events, n | 1 | 1 |

**Table S3. Illustrative adherence and adverse-event reporting.**

**Description:** This table demonstrates a transparent safety presentation. Actual adverse-event definitions, severity and denominators should be reported from the trial records.

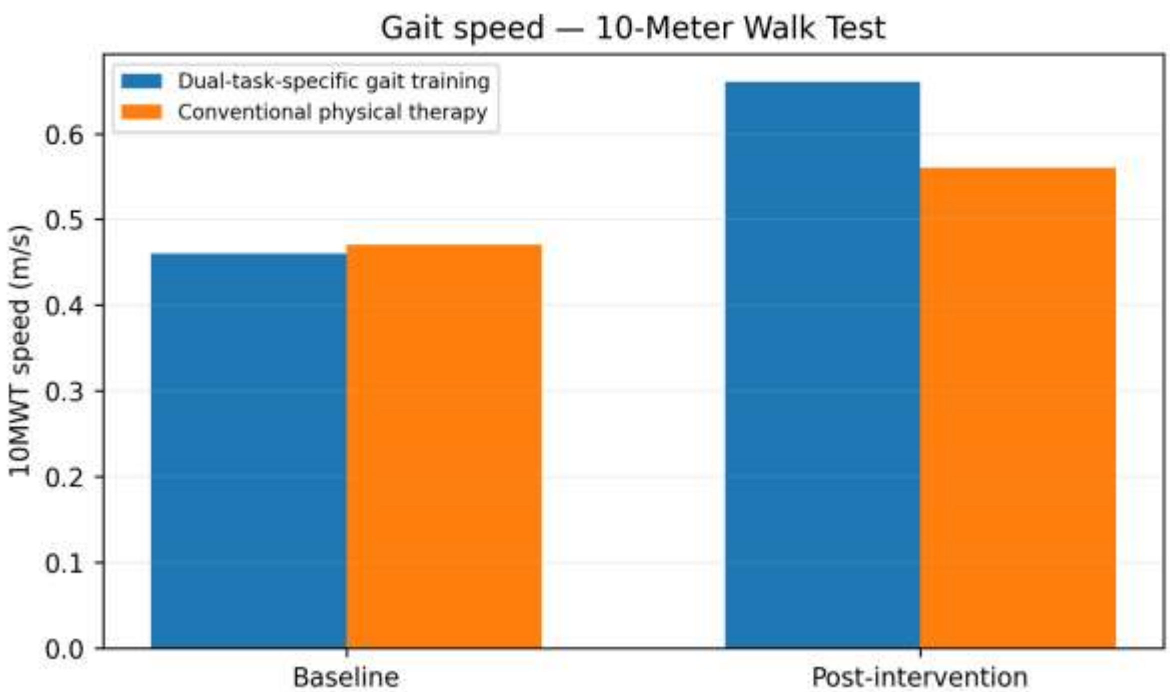


**Figure S1. Gait speed — 10-Meter Walk Test — illustrative synthetic data.**

**Description:** The graph shows group means before and after intervention. In the final manuscript, add SD or 95% CI error bars and replace all illustrative values with the verified dataset.

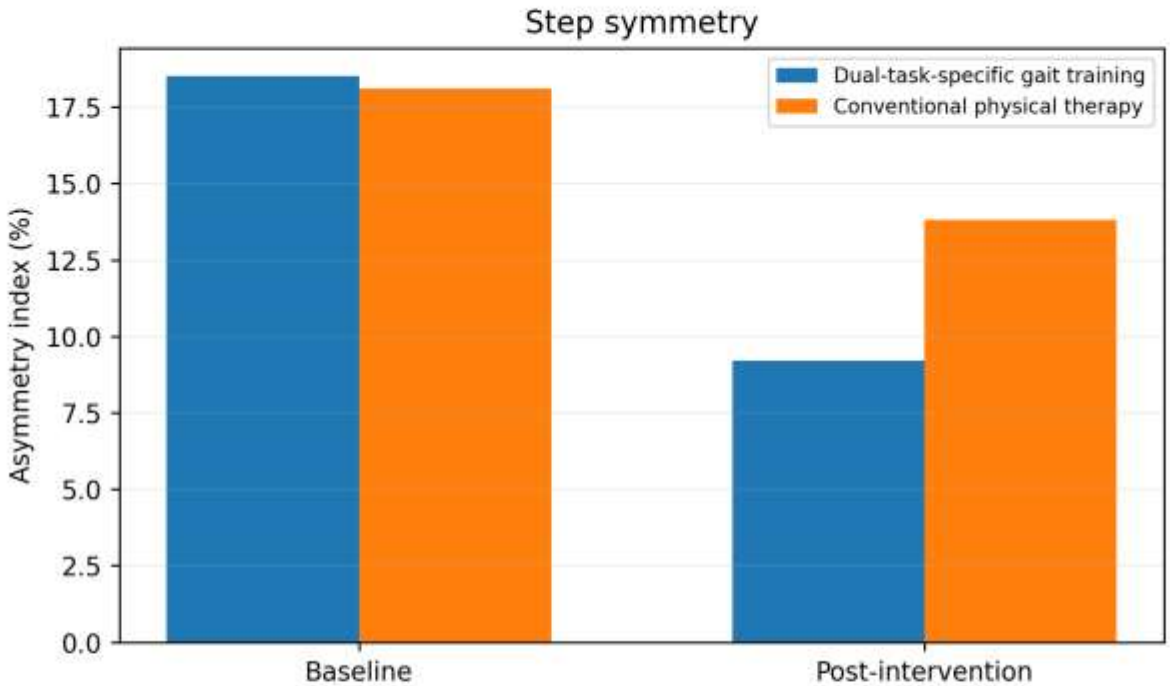


**Figure S2. Step symmetry — illustrative synthetic data.**

**Description:** The graph shows group means before and after intervention. In the final manuscript, add SD or 95% CI error bars and replace all illustrative values with the verified dataset.

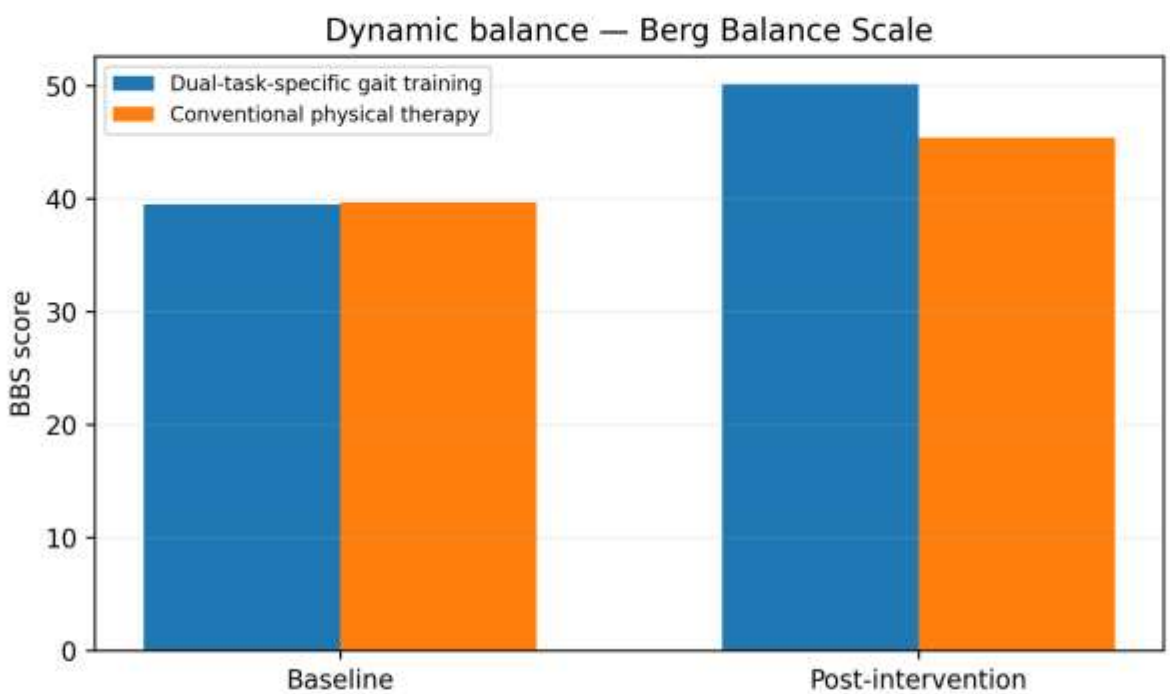


**Figure S3. Dynamic balance — Berg Balance Scale — illustrative synthetic data.**

**Description:** The graph shows group means before and after intervention. In the final manuscript, add SD or 95% CI error bars and replace all illustrative values with the verified dataset.

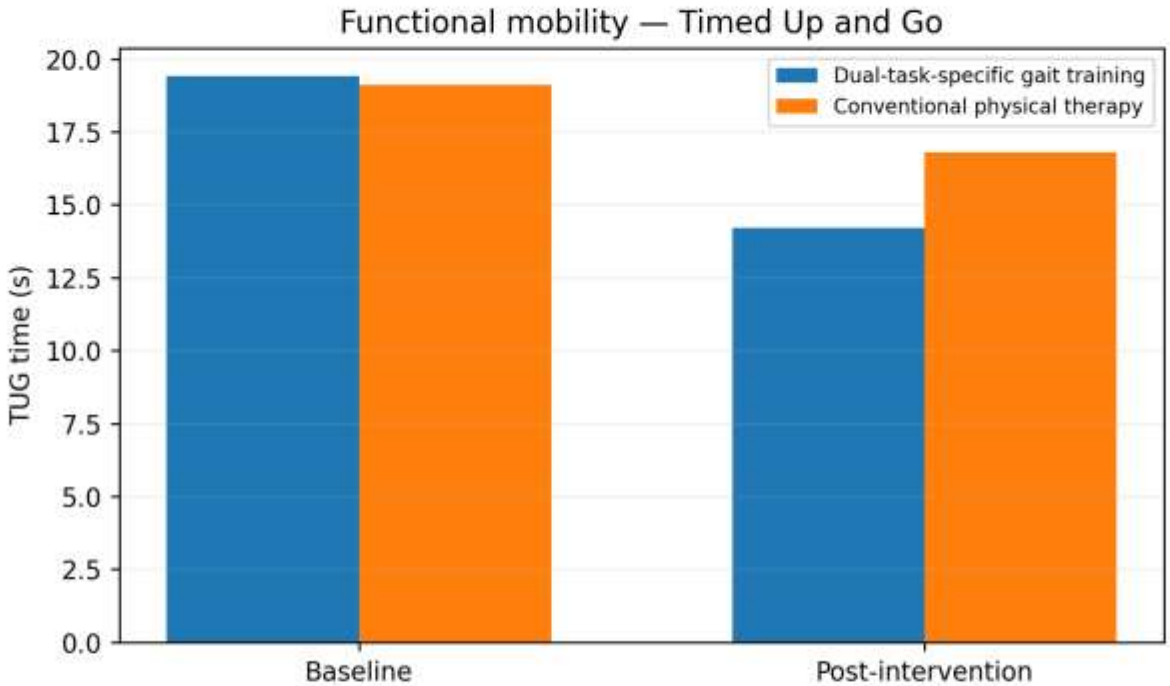


**Figure S4. Functional mobility — Timed Up and Go — illustrative synthetic data.**

**Description:** The graph shows group means before and after intervention. In the final manuscript, add SD or 95% CI error bars and replace all illustrative values with the verified d Value.

## 6. DISCUSSION

The central clinical question addressed by this trial is whether gait rehabilitation becomes more effective when a secondary task is practiced concurrently rather than separately. This distinction is important because community ambulation frequently requires attention to more than one task. A dual-task-specific program therefore has ecological validity: it trains the patient to maintain or adapt walking while simultaneously processing information or manipulating an object.

Prior randomized evidence supports the biological and functional plausibility of this approach. Plummer and colleagues reported that cognitive-motor dual-task gait training improved dual-task gait performance after stroke, while a chronic-stroke treadmill trial demonstrated improvements in gait parameters and dual-task interference. [1,7] Meta-analytic evidence has generally supported improvements in several temporal and spatial gait outcomes, although findings for gait speed and functional mobility have been less uniform. [2,3,5,6]

The present study adds value by prespecifying step symmetry, dynamic balance, and functional mobility alongside gait speed. Gait speed is a practical global indicator of walking capacity, but symmetry can reveal persistent coordination differences between the paretic and non-paretic limbs. Dynamic balance and TUG performance capture functional tasks that may not be fully represented by a short straight-line walking test.

If the final dataset demonstrates a statistically significant and clinically meaningful between-group effect, the discussion should distinguish statistical significance from clinical importance and should report the magnitude and confidence interval of the effect. If no significant between-group difference is found, the interpretation should not imply that dual-task training is ineffective; rather, it may indicate that the tested dose, population, comparator, or outcome measure did not demonstrate additional benefit under the study conditions.

Several limitations should be anticipated. Therapists and participants cannot be fully blinded to the intervention. Learning effects may influence repeated gait testing. Step-symmetry estimates can vary according to the measurement system and mathematical definition. Heterogeneity in stroke severity, lesion location, assistive-device use, and cognitive status may modify treatment response. Finally, the generalizability of findings will depend on recruitment setting and the final sample size.

## 7. CLINICAL IMPLICATIONS

- Dual-task gait practice should be progressed according to safety, cognitive capacity, walking ability, and task performance rather than applied at a fixed difficulty for all patients.
- Clinicians should monitor both the locomotor task and the secondary-task performance because improvement in walking speed accompanied by deterioration in secondary-task accuracy may not represent improved dual-task ability.
- Step symmetry, dynamic balance, and functional mobility can complement gait-speed measurement when judging real-world walking readiness.
- Any clinical recommendation arising from the final study should be based on the actual magnitude, precision, safety profile, and clinical relevance of the observed effects.

## 8. CONCLUSION

This randomized controlled trial is designed to compare a structured dual-task-specific gait-training program with conventional physical therapy in adults with chronic hemiplegic stroke. The prespecified outcomes encompass gait speed, step symmetry, dynamic balance, and functional mobility. The final efficacy conclusion must be generated only after analysis of the verified trial dataset. This manuscript therefore provides the complete journal-style structure and analysis framework without inventing participant results.

## 9. ETHICAL CONSIDERATIONS

Ethical approval should be obtained from the responsible institutional review board/ethics committee before participant recruitment. Written informed consent should be obtained from each participant or legally authorized representative where applicable. Participant confidentiality should be maintained, and identifiable information should not appear in the manuscript. The final article should state the exact ethics committee name, approval number/date, and trial registration number if applicable.

## 10. DATA AVAILABILITY

The final statement should specify whether the anonymized dataset is available on reasonable request, in a repository, or subject to institutional restrictions. This section should be updated after completion of the trial.

## 11. CONFLICT OF INTEREST

## 12. FUNDING

To be completed from the verified study records. If no external funding was received, state: "The study received no external funding."

## 13. AUTHOR CONTRIBUTIONS

Author 1: study conception, participant assessment/intervention, data collection and manuscript preparation. Author 2: academic supervision, methodological review and critical revision. Author 3: methodological support, data interpretation and critical revision. Author 4: clinical/research consultation and critical revision. Author 5: clinical input, data interpretation and manuscript review. Author 6: literature review, data support and manuscript preparation. The final contribution statement should be revised to reflect the actual contributions of each author.

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