ORIGINAL ARTICLE

Optimizing Motor Recovery: Dual-Task Training versus Motor Relearning Program for Ambulatory Left-Hemiplegic Stroke Patients

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Abstract

Background: Stroke has been one of the major causes of long-term disability, leading to chronic impairments of balance and gait. Successful rehabilitation may help improve mobility and the quality of life among stroke survivors. The current study compares the effects of DTT with MRP on dynamic balance and gait parameters in patients with chronic stroke with left hemiplegia.

Methods: This is a prospective randomized double-blinded controlled trial. The 40 subjects with chronic left hemiplegic stroke were conducted in a tertiary care hospital from March to August 2023. The subjects were randomly assigned to a DTT group or MRP group, which received treatment three times per week for 12 weeks in 45-minute sessions. The two major outcomes measured from the test were 10-meter Walk Tests (10MWT) and the Timed Up and Go Test (TUG), whereas the secondary outcomes pertain to gait parameters, step length, cadence, cycle time, and stride length. Statistical analyses were done by analyzing the results of the study using paired and independent t-tests with a set level of significance based on $p<0.05$.

Results: The statistical improvements in the DTT group show in the gait speed (10MWT) and TUG scores, which are significantly better than in the MRP group ($p<0.05$). Likewise, the DTT group's step length, cadence, cycle time, and stride length also improved significantly ($p<0.05$).

Conclusion: The use of DTT significantly improves the dynamic balance and gait of chronic stroke patients with left hemiplegia compared to MRP. This underscores the effectiveness of DTT as a tool for rehabilitating motor function in stroke patients. Further research should be pursued to optimize its application and evaluate long-term outcomes.

Keywords
Balance, Gait, Impairments, Stroke Rehabilitation.

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Introduction

Stroke is a major cause of long-term disability globally and is frequently linked to chronic difficulties with movement, balance, and cognition[1]. These impairments greatly affect the quality of life of stroke survivors, reducing their ability to perform daily tasks and often making them dependent on a caregiver[2]. After a stroke, balance and gait deficits can be particularly debilitating as they hinder the patient's ability to walk independently and safely[3]. Therefore, rehabilitation focuses on improving these functions to enhance overall mobility and quality of life.

These deficits are typically managed using conventional physical rehabilitation techniques, which primarily include exercises for muscle strengthening, coordination, and flexibility[4]. Among these techniques, the Motor Relearning Program (MRP) is the most efficient method, relying on repetitive exercises in which functional tasks are associated with attaining motor skills and relearning[5]. Thus, MRP effectively improves the balance and ambulation of stroke patients[6]. However, despite these therapeutic benefits, most patients require assistance with tasks primarily involved in dual-tasking activities.

Dual-task training is one of the most promising rehabilitation techniques for meeting these challenges faced by stroke survivors[7]. During DTT, which can be cognitive or motor, the patient performs an instrumental activity such as walking while performing a secondary task—for example, counting backwards or doing simple math[8]. The underlying rationale is that training individuals to execute two tasks simultaneously enhances the automaticity of walking and reduces cognitive-motor interference, improving overall mobility[8-9].

Research into the effectiveness of DTT versus conventional single-task rehabilitation remains inconclusive. Other literature suggests that, compared with conventional single-task training, DTT may have more potent effects on enhancing walking ability, reducing the risk of falls, and increasing independence with daily activities[10].

Patients with chronic stroke and left hemiplegia experience significant and long-lasting difficulties with balance and walking. These challenges affect their ability to walk independently and increase their risk of falls, which can limit their participation in community and social activities[11-12]. Therefore, effective rehabilitation in such patients must target static and dynamic

balance and gait parameters. Further research is necessary to determine whether DTT or MRP is more effective in patients with chronic stroke, particularly those with left hemiplegia. This study seeks to compare the effects of DTT and MRP on dynamic balance and gait parameters in chronic stroke patients with left hemiplegia. Additionally, we aim to address critical gaps and provide valuable insights into the optimal rehabilitation strategies to achieve the best treatment outcomes for stroke patients.

Methodology

Study Design

This was a randomized, double-blinded, controlled trial of two different intervention strategies for enhancing motor function in patients with chronic left hemiplegic stroke. In this double-blinded design, neither the participants nor the assessor evaluating outcomes were aware of the treatment group to which participants were assigned. This was aimed at avoiding possible biases of assessment and behavior in participants of either group.

Setting and Participants Enrollment

This single-centered study was conducted in a tertiary care hospital from March to August 2023. Consecutive sampling from the neurological outpatient department was undertaken to ensure the presence of a heterogeneous population of stroke survivors receiving outpatient rehabilitation.

Inclusion Criteria

- Age 45-70 years.
- Chronic left hemiplegic stroke > six months from stroke onset.
- Patients could walk independently or with minimal assistance for a distance of>10 meters.
- Mini-Mental State Examination score >24, indicating no severe cognitive impairment.
- No severe cardiovascular or orthopedic conditions that might interfere with participation.

Exclusion Criteria

- Severe aphasia or any other communication disability.
- Severe spasticity of>3 by the Modified Ashworth Scale.
- Enrollment in any other rehabilitation program during the trial.
- Uncontrolled hypertension or other medical conditions are known to be a counter-indication to exercise.

Sample Size

A total of 40 patients were recruited and randomly allocated to either DTT) or MRP, with n=20 participants assigned to each group.

Interventions

Dual-Task Training Group (DTT)
The participants in the DTT group received 45-minute, three-times-a-week intervention for 12 weeks as follows:

- Walking exercises with weighted sandbag addition of 5 – 10% body weight.
- Walking while performing a cognitive task, such as counting or naming anything like animals or vehicles and doing uncomplicated mathematical sums.
- Exercise programs target both motor and also cognitive abilities with the specific aim of improving dual-task performance and functional mobility.

Motor Relearning Program (MRP)
The MRP group attended 45-minute sessions three times a week for 12 weeks. The intervention was developed according to MRP principles and included the following:

- Core stability exercises for trunk control.
- Resistance band exercises and weight exercises to strengthen the affected limbs.
- Gait training focusing on coordination, stride length, and balance.
- Regular feedback by physiotherapists regarding proper technique and progression.

Outcome Measures
The assessments occurred at baseline and 12 weeks post-intervention on the following outcomes:

Primary Outcome Measures

- ***The 10-Meter Walk Test (10MWT)***[13] is utilized to quantify an individual's gait speed over a 10-meter distance. It assesses a patient's functional mobility by capturing their self-selected gait speed, which generally mirrors their average daily walking pace. This metric provides a baseline reference for the participant's mobility and facilitates the evaluation of progress after an intervention. The 10MWT demonstrates commendable test-retest reliability. While average gait speed is influenced by age and overall health, even marginal enhancements in the range of 0.1 to 0.3 meters per second after an intervention should be deemed clinically meaningful within stroke rehabilitation.

- ***Time Up and Go Test (TUG)***[14] measures the time taken by the patient to get up from the chair, walk 3 meters, turn around, walk back, and sit again in the chair. This test reflects mobility, dynamic balance, and functional ability in everyday activities and thus can be used to monitor changes in mobility and balance after intervention. TUG is a reliable measure of functional mobility with adequate intra-rater and inter-rater reliability. The

average TUG scores are variable, but in stroke patients, post-intervention improvements range from a few seconds to over 10 seconds, depending on the initial impairment.

Secondary Outcome Measures

Gait Analysis Parameters[15]

- **Step Length:** Length of a single step.
- **Cadence:** Steps taken per minute.
- **Cycle Time:** Time duration of a single gait cycle (time duration from one heel strike to the subsequent heel strike of the homonymous foot).
- **Stride Length:** Distance between successive placements of the same foot.

These parameters provide information regarding the gait quality, symmetry and effectiveness, and changes in motor function and gait pattern after intervention.

Statistical Analysis

Descriptive statistics summarized demographic and clinical characteristics, while inferential statistics were computed with paired t-tests for within-group and independent t-tests for between-group comparisons in outcomes. A significance level of $p<0.05$ was used to assess the effectiveness of the DTT and MRP interventions.

Ethical Considerations

The research design is according to the institutional review board's ethical guidelines. Written informed consent was taken from all participants before they were enrolled in the study. Participants have been assured that their data are highly confidential and that they can withdraw from the study at any time without impacting their ongoing treatment.

Results

Out of the 40 participants, an equal number were randomly assigned to DTT and MRP groups. The average age was around 58 years, and there was an equal gender distribution in the DTT group, with a slightly higher number of females in the MRP group. The average duration from the stroke onset was approximately 14 months in both groups. These demographic characteristics indicate that the groups were well-balanced, allowing for a fair comparison of the outcomes of the interventions between the two groups (Table-1).

Table-1 Demographic Characteristics		
Characteristic	**DTT Group (n=20)**	**MRP Group (n=20)**
Age (years), Mean ± SD	58.5±6.2	58.3±6.1
Gender (M/F), n (%)		
Male	10 (50%)	8 (40%)
Female	10 (50%)	12 (60%)
Stroke Duration (months), Mean ± SD	14.3±3.5	13.9±3.1

Compared to the MRP group, the gait speed difference in the DTT group was significant with $p<0.05$. In line with this, TUG scores were also significantly different in the DTT compared to the MRP group with $p<0.05$, representing improved mobility and dynamic balance post intervention (Table-2).

Table-2 Dynamic Balance Measures			
Outcome Measure	**DTT Group (Mean±SD)**	**MRP Group (Mean±SD)**	**p-value**
10-Meter Walk Test (m/s)			
Pre-Intervention	0.45±0.06	0.47±0.05	-
Post-Intervention	0.62±0.08	0.55±0.07	<0.05
Time Up and Go Test (seconds)			
Pre-Intervention	25.6±3.1	26.1±2.8	-
Post-Intervention	19.8±2.5	22.0±2.3	<0.05

Parameters of gait, like step length, cadence, cycle time, and stride length, have shown significant improvement in the DTT group compared to the MRP group ($p<0.05$). Results in this respect show that as practiced and applied, DTT effectively improves the gait parameters of motor function.

Table-3 Gait Analysis Parameters					
Group	**Step Length (cm), Mean±SD**	**Cadence (steps/min), Mean±SD**	**Cycle Time (seconds), Mean±SD**	**Stride Length (cm), Mean±SD**	**p-value**
DTT	70.5±5.2	90.2±8.3	1.2±0.1	135.8±10.4	<0.05
MRP	68.2±4.8	85.6±7.5	1.3±0.2	130.5±9.7	

Discussion

The study revealed that DTT significantly enhanced gait parameters and dynamic balance in individuals with chronic left hemiplegia after a stroke, in contrast to the MRP. Existing literature supports that DTT enhances walking performance and balance by reducing the demand for attention resources and promoting neural plasticity[16]. It was noted that repeated walking training and automated walking devices activated the same areas of the brain involved in executive function, ultimately leading to improved motor control[17].

Some trials have reported minor effects on walking speed and balance function that might be related to alterations in brain activity during single-task and dual-task walking[18]. Excessive sensorimotor and cerebellar activations and reduced prefrontal cortex activation during dual-task walking may negatively influence both walking and cognitive performance. Another possible reason is that the fixed mode of dual-tasking may become too easy in the later phases of training, thus leading to inferior effects[19].

While MRP, especially when combined with adjunctive therapies, may further improve functional recovery, the current literature must include high-level evidence and detailed intervention descriptions, reducing its effectiveness. It was highlighted that more evidence is needed regarding the effectiveness of MRP for restoring upper limb function after stroke[20].

The combined use of different approaches for functional recovery was noted to be suitable in previous studies, but the limited evidence for any combination hinders drawing solid conclusions about their effectiveness[21]. Furthermore, the time after the onset of a stroke is an important consideration, as most spontaneous recovery occurs in the first three months following a stroke, possibly contaminating the actual effect of interventions applied during this time[22].

The study's strengths include the randomized controlled trial design, which minimizes bias and provides a fair comparison between DTT and MRP. However, the relatively small sample size and the variability in DTT implementation due to rehabilitation therapists' skill levels may limit the findings' generalizability.

Conclusion

The study showed that DTT significantly improved gait and dynamic balance parameters in individuals with chronic left hemiplegia following stroke compared to MRP. Although DTT effectively increases step length, cadence, cycle time, and stride length, it does not significantly affect gait speed and balance function. This suggests that DTT holds potential as a rehabilitative intervention for enhancing motor function in stroke survivors. However, more research is needed to determine its optimal implementation and long-term effects.

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None.

Conflict of Interest
None.

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None.

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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

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Acquisition, Analysis or Interpretation of Data: Valecha J, Khalid S, Mumtaz U, Khalid I

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All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.