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CASE REPORT

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Effect of a 12-Week multimodal physiotherapy rehabilitation program on walking endurance, gait speed, balance, and cognitive status in a chronic stroke survivor: A case report

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ABSTRACT

Background: Stroke commonly causes persistent motor and cognitive deficits that limit functional independence. This case report evaluated the effects of multimodal rehabilitation in a chronic stroke survivor. A 58-year-old male with chronic left hemiparesis following a right-sided ischemic stroke presented with impaired gait, balance, strength, endurance, and executive function.

Methods: A 12-week supervised multimodal physiotherapy rehabilitation program included treadmill aerobic training, resistance-band strengthening, task-specific gait training, stationary cycling, balance training, and dual-task cognitive activities. Outcomes were assessed using the 6-minute walk test (6MWT), 10-meter walk test (10MWT), Berg Balance Scale (BBS), Manual Muscle Testing (MMT), and Montreal Cognitive Assessment (MoCA).

Results: Improvements were observed in walking endurance, muscle strength, gait speed, balance, and cognitive function. The 6-minute walk distance increased from 215 m to 338 m, representing an absolute improvement of 123 m (57%), with corresponding improvements in BBS and MoCA scores.

Conclusion: Multimodal rehabilitation was associated with improvements in functional performance and cognitive status in chronic stroke.

KEYWORDS

Chronic stroke; Gait; Stationary cycling; Cognition

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Introduction

Although stroke is a major cause of long-term disability worldwide, it also continues to impose an economic burden on health systems. The management of acute stroke has improved, and more survivors now live longer; however, they frequently experience residual sensorimotor and cognitive impairment that can restrict independence, community participation and quality of life. Muscle strength, walking endurance, posture, functional balance, endurance, gait speed and executive functioning deficits have been extensively reported amongst chronic stroke patients limiting functional performance despite well-illustrated conventional rehabilitation. These long-term impairments often limit daily activities, raise the risk of falls, and harm overall recovery. This highlights the need for rehabilitation strategies that tackle multiple impairments at once [1].

However, neuroplasticity extends beyond the acute and subacute stroke phases enabling functional improvement to take place in a task-specific manner after rehabilitation interventions for lower limb rehabilitation. Aerobic exercise improves cardiovascular fitness, increases cerebral perfusion, and induces neuroplastic changes via mechanisms involving brain-derived neurotrophic factor [2].

Resistance training has been shown to improve strength and functional mobility in addition to the acute effects on gait, while gait training leads to motor relearning which may result in improvements in walking efficiency [3]. Likewise, training on balance improves postural stability and thus decreases fall risk, whereas cognitive rehabilitation aims at cognitive deficits [4,5].

While all these interventions have been established as effective, rehabilitation after stroke is usually necessarily multi-faceted: functional limitations are caused by multiple interacting impairments [2]. Thus, it is possible that multimodal rehabilitation may offer more clinical benefits by addressing endurance, muscle strength, gait, balance and cognition simultaneously. However, the available data detailing these types of integrated rehabilitation protocols in stroke survivors with chronic impairments is sparse [6]. Although the individual benefits of aerobic, resistance, gait, balance, and cognitive training are well established, evidence on their concurrent, integrated delivery - particularly in patients presenting more than a year after stroke onset - remains limited, representing a gap this case report aims to illustrate.

This Case report describes clinical outcomes of a supervised 12-week rehabilitation program that includes treadmill training, resistance exercises, gait training, balance training, stationary biking and cognitive rehabilitation in a chronic stroke survivor [1]. The purpose was to assess post-intervention changes in functional endurance, muscle strength, gait speed, balance and cognition. The findings of this report could add to the current evidence supporting combined rehabilitation methods and offer helpful clinical insights for physiotherapists managing people with chronic stroke over the long term [7].

Patient Information

The patient was a 58-year-old right-handed male who presented to the outpatient neurorehabilitation department with residual left-sided hemiparesis 18 months after the onset of right middle cerebral artery ischemic stroke. The first medical management consisted of hospital admission, pharmacological treatment and traditional physiotherapy. Although his neurological status had stabilized, he continued to complain of difficulty with walking long distances, decreased strength in his lower limbs, impaired balance during community ambulation, fatigue with prolonged activity, and mild concentration and memory deficits.

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Patient's medical history included hypertension and dyslipidaemia, which were both controlled on medication. There was no history of recurrent stroke, traumatic brain injury, or other neurological disease. The patient was independent community ambulator without an assistive device and displayed decreased walking speed with limited endurance, impacting his ability to participate in social and recreational activities.

The overarching rehabilitation goal, established collaboratively with the patient using a Goal Attainment Scaling (GAS) framework, was to achieve safe, independent community ambulation with improved functional endurance and cognitive performance within 12 weeks. Specific objectives were: (1) increase 6-Minute Walk Test distance by ≥50 m (primary outcome); (2) improve Berg Balance Scale score by ≥6 points, the established minimal clinically important difference; (3) improve lower-limb Manual Muscle Testing grade by at least one grade in weak muscle groups; (4) increase 10-Meter Walk Test speed by ≥0.16 m/s and (5) and improve MoCA score by ≥2 points (secondary outcomes) [8,9].

The patient was assessed at baseline before commencement of the rehabilitation program and subsequently underwent a 12-week supervised multimodal physiotherapy intervention, with post-intervention assessment performed at the completion of the program.

Clinical Findings

Baseline clinical assessment was performed by a licensed physiotherapist prior to initiation of the rehabilitation program, using standardized examination procedures and validated outcome measures under consistent testing conditions. Examination revealed mild left hemiparesis with diminished voluntary motor control on the lower extremity. Muscle strength testing revealed weakness in the hip flexors, extensors, abductors and knee flexors, knee extensors and ankle dorsiflexors. Gait analysis showed reduced cadence, shorter gait length of the affected limb, slower walking speed and slight asymmetry of stance and swing time.

During weight shifting and obstacle negotiation tasks there was impairment of dynamic balance. The patient also exhibited diminished exercise tolerance, as fatigue was induced after brief ambulating intervals. Cognitive screening revealed mild deficits in attention, delayed recall and executive functioning; but language and orientation were almost entirely intact.

Baseline standardized outcome measures were as follows:

- Six-Minute Walk Test (6MWT): **215 m**
- 10-Meter Walk Test (10MWT): **0.58 m/s**
- Berg Balance Scale (BBS): **35/56**
- Montreal Cognitive Assessment (MoCA): **21/30**
- Manual Muscle Testing (MMT): Lower-limb muscle grades ranging from **3/5 to 4-/5**

These findings confirmed limitations in functional endurance, gait performance, balance, lower-limb strength, and cognition. The 6-Minute Walk Test (6MWT) measures functional endurance as the total distance walked in six minutes [10]. The 10-Meter Walk Test (10 MWT) measures gait speed over a 10-meter distance, reflecting functional mobility [11]. The Berg Balance Scale (BBS) is a 14-item, 0–56 point performance measure of static and dynamic balance, with higher scores indicating better balance and lower fall risk [12]. The Montreal Cognitive Assessment (MoCA) is a 30-point screening tool assessing attention, memory, executive function, language, and visuospatial ability, validated for detecting post-stroke cognitive impairment [13]. Manual Muscle Testing (MMT) grades muscle strength on a standard 0–5 scale using manual resistance.

Diagnostic Assessment

Chronic ischemic stroke with residual left hemiparesis was diagnosed based on clinical examination and neuroimaging conducted in the acute phase. The patient was medically stable and cleared to participate in moderate-intensity exercise at the time of the rehabilitation.

Instruments were selected based on established properties (i.e., reliability and validity) in stroke rehabilitation and a high rate of usage across studies [10,13,14].

Therapeutic Intervention

The patient participated in a supervised rehabilitation program three times per week for 12 consecutive weeks. Each session lasted approximately 80–90 minutes and was delivered by a physiotherapist experienced in neurological rehabilitation.

Heart rate and rating of perceived exertion (Borg scale) were monitored throughout each session to ensure exercise remained within the prescribed moderate-intensity range, and the patient was continuously observed for adverse events, none of which occurred during the 12-week program.

The intervention consisted of six integrated components:

1. **Treadmill Training:** Moderate-intensity treadmill walking was performed for 20–30 minutes at 40–60% of target heart rate, with gradual progression in speed and duration according to patient tolerance.

2. **Resistance Training:** Strengthening exercises targeted the hip, knee, and ankle musculature using resistance bands and ankle weights. Training intensity was progressively increased based on the patient's performance.

3. **Gait Training:** Functional walking practice emphasized weight shifting, step length symmetry, obstacle negotiation, turning, and dual-task walking to improve gait efficiency and community mobility.

4. **Balance Training:** Static and dynamic balance exercises included tandem standing, reaching tasks, perturbation training, multidirectional stepping, and single-leg support as tolerated.

5. **Stationary Cycling:** Moderate-intensity cycling was performed for 15–20 minutes to improve cardiovascular endurance and lower-limb conditioning while minimizing joint stress.

6. **Cognitive Rehabilitation:** Structured cognitive exercises focused on attention, memory, executive functioning, problem-solving, and dual-task activities integrating cognitive and motor demands.

Results

The patient attended all 36 scheduled sessions of the 12-week rehabilitation program (3 sessions/week) with no adverse events.

Following completion of the 12-week multimodal rehabilitation program, clinically meaningful improvements were observed across all assessed outcome measures.

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Table 1. Therapeutic intervention exercises.

Component	Frequency	Duration / Sets–Reps	Intensity	Progression
Treadmill Training	3x/week	20–30 min/session	Moderate (40–60% target heart rate)	Gradual increase in speed and duration as tolerated
Resistance Training	3x/week	3 sets x 10–12 reps per exercise (hip, knee, ankle musculature)	Progressive resistance via resistance bands and ankle weights	Resistance/band tension increased as strength improved
Gait Training	3x/week	15–20 min/session	Task-specific, moderate challenge (weight shifting, step symmetry, obstacle negotiation, dual-task walking)	Complexity increased from single-task to dual-task walking as tolerated
Balance Training	3x/week	15–20 min/session	Static and dynamic (tandem standing, reaching, perturbation, multidirectional stepping, single-leg support)	Base of support progressively narrowed; perturbation difficulty increased
Stationary Cycling	3x/week	15–20 min/session	Moderate	Resistance/duration increased as cardiovascular tolerance improved
Cognitive Rehabilitation	3x/week	10–15 min/session	Structured tasks targeting attention, memory, executive function; dual-task (cognitive-motor) integration	Task complexity increased; dual-task load added progressively

Table 2. Pre- and Post-Intervention Outcome Measures.

Outcome Measure	Pre-intervention	Post-intervention	Change
Six-Minute Walk Test (6MWT)	215 m	338 m	+123 m
10-Meter Walk Test (10MWT)	0.58 m/s	0.89 m/s	+0.31 m/s
Berg Balance Scale (BBS)	35/56	48/56	+13
Montreal Cognitive Assessment (MoCA)	21/30	26/30	+5

Table 3. Pre- and Post Manual Muscle Testing (Affected Lower Limb).

Muscle Group	Pre	Post
Hip Flexors	3+/5	4+/5
Hip Extensors	3/5	4/5
Hip Abductors	3+/5	4+/5
Knee Extensors	4-/5	4+/5
Knee Flexors	4-/5	4+/5
Ankle Dorsiflexors	3/5	4/5
Ankle Plantarflexors	3+/5	4+/5

Table 3 demonstrates an improvement of approximately one Manual Muscle Testing (MMT) grade across the major muscle groups of the affected lower limb, indicating enhanced muscle strength following the multimodal rehabilitation program.

Balance performance improved by 13 points on the Berg Balance Scale, reflecting better postural control and a reduced risk of falls. MMT grades improved by approximately one full grade across all assessed muscle groups of the affected lower limb (e.g., 3/5–4^{-}/5 pre-intervention to 4/5–4^{+}/5 post-intervention), reflecting a consistent, clinically meaningful gain in strength. All specific objectives were met or exceeded: the 6MWT gain of 123 m surpassed the ≥50 m target; the BBS improvement of 13 points exceeded the ≥6-point minimal clinically important difference; the 10MWT speed gain of 0.31 m/s (0.58 to 0.89 m/s) exceeded the ≥0.16 m/s target; MMT improved by approximately one grade across the major muscle groups assessed, as targeted; and the MoCA improvement of 5 points (21 to 26) exceeded the ≥2-point target.

The patient demonstrated enhanced confidence while walking, improved ability to carry out more activities of daily living independently, less fatigue impact on mobility-related activities, and increased participation in community mobility by the final stages of the rehabilitation program.

Discussion

The present case report illustrates that a 12-week multimodal rehabilitation program including treadmill training, resistance exercises, gait training, balance training, stationary cycling, and cognitive rehabilitation is associated with clinically important improvements in functional endurance, muscle strength (lower extremities), gait speed (10 MWT), balance and cognitive function of the chronic stroke survivor. These gains not only reached descriptive and clinical significance but also exceeded the a priori targets and established minimal clinically important differences set for each outcome measure, supporting the clinical - not merely statistical - relevance of this rehabilitation approach [14].

The most striking improvement was in functional endurance, which exceeded established clinically meaningful thresholds for stroke rehabilitation and presumably reflects the combined effects of aerobic treadmill training plus stationary cycling [7,15].

Aerobic exercise is thought to increase cardiovascular fitness and oxygen utilization efficiency and may contribute to increased cerebral perfusion and neuroplastic changes, potentially via modulation of neurotrophic factor expression. Physiological adaptations could be mechanisms for increasing walking endurance and functional mobility in chronic stroke survivors [7].

Resistance training produced consistent gains in lower-limb muscle strength across all major muscle groups. Muscle weakness, particularly in the lower extremities, is a significant contributor to gait dysfunction after stroke, and strengthening of hip, knee, and ankle musculature is associated with improvements in mobility and walking performance [4]. The relatively smaller gain at the knee extensors likely reflects a ceiling effect in manual muscle testing, as MMT has limited sensitivity to detect further improvement once muscles approach normal grades, alongside a training emphasis on

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hip- and ankle-dominant tasks [16].

Gait speed on the 10MWT improved from 0.58 to 0.89 m/s (+0.31 m/s), which corresponds to a clinically meaningful improvement. Gait speed is established as a sensitive index of functional mobility and community participation post-stroke. Gait training, combined with treadmill practice, may have enhanced motor relearning, improved step symmetry, and increased walking efficiency through repetitive, goal-directed practice [3,4,17].

Balance also improved substantially, exceeding the minimal clinically important difference for the Berg Balance Scale. Balance impairments are common following stroke and significantly increase the risk of falls and activity limitations. The balance intervention incorporated static and dynamic postural control exercises, multidirectional weight shifting, reaching tasks, obstacle negotiation, and perturbation training. Repetitive exposure to progressively challenging balance activities likely enhanced sensory integration, anticipatory postural adjustments, and reactive balance responses [12,18].

Besides the physical gains, rehabilitation practices resulted in improvements in cognitive performance that exceeded the pre-specified target [19,20]. New evidence indicates that aerobic exercise combined with cognitive training may provide gains in executive function, attention, perceptual speed and memory through effects on cortical plasticity and increased cerebral blood flow. Secondly, the cognitive integration tasks may have been more advanced than in previous studies through integrating structured cognitive tasks which is thought to be fundamental for community ambulation safely and effectively. Combining cognitive rehabilitation with physical exercise may have provided additional benefits by improving both motor and cognitive functions simultaneously. Dual-task training prepares patients for everyday situations that require thinking while walking or performing other movements. Therefore, including cognitive tasks during rehabilitation may help improve safe community walking and increase overall functional independence [13].

The nature of the intervention distinguishes this case from rehabilitation programs focusing on isolated impairments. Rather than addressing endurance, strength, balance, gait, or cognition independently, the integrated rehabilitation strategy targeted multiple domains simultaneously, reflecting the multifactorial nature of stroke-related disability. This holistic approach may explain the broad improvements observed across all outcome measures [10,14].

While each intervention component is individually supported by existing randomized controlled trials and international guidelines - aerobic and treadmill training, resistance training, gait training, balance training, and dual-task cognitive-motor training- as reflected in current stroke rehabilitation guidelines, the present report's contribution is the demonstration of their combined, simultaneous application in a chronic (rather than acute or subacute) stroke survivor, using an individualized, goal-attainment-based framework [1–8,16–20]. Most published multimodal protocols have evaluated no more than two or three impairment domains concurrently, most commonly pairing dual-task cognitive-motor training with gait or balance outcomes [6,19,20]. Furthermore, increasing the amount and intensity of usual rehabilitation has itself been shown to improve post-stroke activity outcomes, supporting the rationale for a higher-dose, multi-component protocol such as the one described here [21]. This report therefore extends existing evidence by illustrating feasibility, adherence, and the pattern of concurrent multi-domain gains - each exceeding established minimal clinically important differences - achievable with a pragmatic, clinic-based protocol in a population often considered to have a narrower window for meaningful recovery [8,9].

However, there are limitations to this report despite this promising result. As an uncontrolled, single-patient design, this report cannot establish causal efficacy or isolate the relative contribution of individual intervention components; observed gains cannot be distinguished from the effects of natural fluctuation, practice effects on repeated outcome testing, or non-specific benefits of supervised attention [8]. No blinded outcome assessor was used, and as an individual patient case report, the findings could not be generalized to the general stroke population. The lack of a control group restricts causal inference, and follow-up (with or without treatment) was not performed to evaluate persistence of change. Moreover, patient-reported outcomes evaluating quality of life and participation were not assessed. These constraints are inherent to the case-report design and are consistent with its intended purpose - hypothesis generation and clinical illustration - rather than confirmatory efficacy testing, which requires adequately powered randomized controlled trials, as called for in current stroke rehabilitation guidelines [1,2].

Conclusion

This case report suggests that a 12-week multimodal rehabilitation program - combining treadmill training, resistance exercises, gait training, balance training, stationary cycling, and cognitive rehabilitation was associated with clinically meaningful improvements in walking endurance, lower-limb strength, gait speed, balance, and cognition in a chronic stroke survivor. These findings support further investigation of multimodal rehabilitation through larger, controlled studies.

Patient Perspective

The patient reported increased confidence while walking, reduced fatigue during prolonged ambulation, improved balance while negotiating uneven surfaces and stairs, and greater independence in daily activities. The patient also perceived improvements in concentration and memory during routine tasks and expressed satisfaction with the rehabilitation program.

Informed Consent

As a single-patient case report, formal ethics committee approval was not required under institutional policy; written informed consent was obtained from the patient.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this work.

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Author Contributions

All authors contributed to the conception of the case report, patient management, data collection, interpretation of findings, manuscript preparation, critical revision, and approval of the final version.

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Data Availability

All relevant data supporting the findings of this case report are included within the manuscript. Additional anonymized clinical information is available from the corresponding author upon reasonable request.

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