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Impact of Early Multimodal Rehabilitation (± Task-Oriented Therapy) → Δ Functional Independence Measure (FIM) And Muscle Strength (↑ MRC Score) In Post-Stroke Patients

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ABSTRACT

Background: Stroke remains a leading cause of long-term disability. Early multimodal rehabilitation with or without task-oriented therapy may improve post-stroke independence and muscle strength outcomes. ***Objective:*** To evaluate the effect of early multimodal rehabilitation (± task-oriented therapy) on ΔFunctional Independence Measure (FIM) and ↑Medical Research Council (MRC) muscle strength scores in post-stroke patients. ***Methods:*** This prospective cohort study enrolled 122 post-stroke patients admitted to the Department of Physical Medicine & Rehabilitation, Rajshahi Medical College Hospital, from January–June 2023. Patients received early multimodal rehabilitation, stratified into two arms: with (n=62) or without (n=60) structured task-oriented therapy. Outcomes included FIM, MRC scores, Barthel Index, Timed Up-and-Go (TUG), and Modified Rankin Scale (mRS). Data were analyzed using paired t-tests, ANOVA, and regression modeling; p<0.05 was significant. ***Results:*** At baseline, mean FIM was 58.3±7.2, and mean MRC was 2.1±0.6. After 12 weeks, FIM improved to 92.7±8.4 in the task-oriented group (Δ+34.4, 59.0% gain, p<0.001) versus 82.9±7.6 in controls (Δ+24.6, 42.2% gain, p<0.01). MRC increased to 4.1±0.8 (task-oriented) compared with 3.4±0.7 (non-task-oriented), yielding a mean Δ+2.0 vs. Δ+1.3, respectively (p=0.002). Secondary measures: Barthel Index improved by 45.8±6.3 vs. 31.6±5.9 (p<0.001); mean TUG time decreased by 11.4±3.2 seconds vs. 7.6±2.8 (p=0.004). Regression analysis identified task-oriented therapy as an independent predictor of ΔFIM (β=0.42, CI 0.28–0.61) and ΔMRC (β=0.31, CI 0.18–0.54). Effect size (Cohen's d) for FIM gain was 1.12. ***Conclusion:*** Early multimodal rehabilitation significantly enhances independence and muscle strength, with task-oriented therapy conferring superior functional recovery. These findings support incorporating structured task-specific interventions into standard rehabilitation.

Keywords: Stroke Rehabilitation; Task-Oriented Therapy; Functional Independence Measure; Muscle Strength; Neuroplasticity.

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INTRODUCTION

Stroke remains one of the foremost causes of adult disability worldwide, contributing significantly to long-term morbidity, loss of independence, and socioeconomic burden. According to the World Health Organization, cerebrovascular accidents account for approximately 12% of all deaths globally, with millions of survivors facing residual deficits in motor, sensory, and cognitive domains.[1] Despite advancements in acute medical management, including thrombolysis and mechanical thrombectomy, a substantial proportion of stroke survivors continue to experience impaired mobility, weakness, and reduced functional independence, necessitating comprehensive rehabilitation. The ultimate objective of post-stroke rehabilitation is to optimize recovery of motor control, maximize independence in activities of daily living (ADL), and enhance quality of life. Functional independence after stroke is typically quantified by using validated clinical tools, among which the Functional Independence Measure (FIM) is widely adopted. The FIM assesses physical, psychological, and social domains of disability, focusing on self-care, mobility,

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communication, and social cognition.[2] Another crucial clinical index is the Medical Research Council (MRC) muscle strength score, which provides a semi-quantitative evaluation of voluntary motor activity. Together, these measures capture the dual aspects of functional recovery: independence in performing daily tasks and the physiological restitution of motor power.

Recent advances in neurorehabilitation have emphasized multimodal rehabilitation approaches, integrating various therapeutic modalities such as physical therapy, occupational therapy, speech therapy, robotics, and virtual reality-based interventions.[3] These approaches exploit neuroplasticity, the central nervous system's intrinsic ability to reorganize neural circuits and adapt to new functional demands. Task-oriented therapy, in particular, emphasizes repetitive practice of goal-directed activities that are directly relevant to daily life. By linking motor performance to contextual functional tasks, task-oriented paradigms engage distributed neural networks, promoting motor relearning and synaptic reorganization.[4] Thus, early initiation of multimodal rehabilitation, supplemented with structured task-oriented interventions, may yield synergistic benefits in terms of functional independence and muscle strength recovery.

Stroke-induced neurological deficits are primarily attributable to ischemic or hemorrhagic injury in cortical and subcortical regions involved in motor control, particularly the primary motor cortex (M1), corticospinal tract, internal capsule, and basal ganglia.[5] The interruption of neural signaling between the cortex and spinal motoneurons leads to paresis, spasticity, and impaired coordination. Beyond structural damage, stroke triggers maladaptive plasticity, where contralesional brain regions may inhibit functional reorganization of the ipsilesional hemisphere, thereby impeding recovery. Early rehabilitation is hypothesized to capitalize on a critical "neuroplastic window" during which neuronal circuits exhibit heightened synaptic plasticity and cortical excitability.[6] Experimental models demonstrate that intensive, repetitive motor training during this phase enhances axonal sprouting, dendritic arborization, and strengthening of synaptic connections, thereby improving motor outcomes.[7] Consequently, the timing, intensity, and modality of rehabilitation are crucial determinants of long-term functional recovery.

Multimodal rehabilitation refers to the concurrent or sequential application of multiple evidence-based interventions designed to restore motor, sensory, and cognitive functions. This integrated framework acknowledges the heterogeneity of post-stroke impairments, where motor deficits often coexist with balance dysfunction, cognitive impairment, aphasia, or emotional disturbances.[8] For example, combining conventional physiotherapy with robotic-assisted gait training and neuromuscular electrical stimulation may enhance motor relearning more effectively than any single modality alone. Task-oriented therapy represents a central pillar of multimodal rehabilitation. Unlike impairment-based approaches, which focus on isolated muscle strengthening, task-oriented therapy encourages repetitive practice of meaningful, functional activities such as reaching for objects, walking, or manipulating utensils. This paradigm reinforces use-dependent cortical reorganization, fostering greater transfer of motor skills to real-world contexts.[9] In addition, task-oriented activities engage multisensory input, proprioception, and visuomotor integration, creating a richer neuroplastic substrate for recovery.

Other adjuncts frequently incorporated into multimodal frameworks include constraint-induced movement therapy (CIMT), where the unaffected limb is restrained to encourage use of the paretic limb, and mirror therapy, which exploits visual feedback to stimulate motor cortex activation. Likewise, aerobic exercise and resistance training augment cardiorespiratory fitness and muscle hypertrophy, thereby facilitating functional independence.[10] The assessment of rehabilitation efficacy necessitates standardized, reliable, and sensitive outcome measures. The FIM scale, originally developed for the Uniform Data System for Medical Rehabilitation, evaluates 18 items across six domains: self-care, sphincter control, mobility, locomotion, communication, and social cognition. Each item is rated on a 7-point scale, with higher scores reflecting greater independence. FIM is thus capable of detecting clinically meaningful changes in independence during inpatient and outpatient rehabilitation.

The MRC scale provides a pragmatic assessment of muscle strength across major muscle groups, ranging from 0 (no contraction) to 5 (normal strength). Though subjective, its simplicity makes it widely applicable in clinical practice. Improvement in MRC scores reflects not only restoration of neural drive but also increased muscular efficiency, both of which are crucial for regaining locomotor function and performing ADLs.[11] In the context of post-stroke rehabilitation, the combination of ΔFIM and ↑MRC provides a robust, multidimensional evaluation of functional recovery—linking neurophysiological restoration of strength to real-world independence.

MATERIALS AND METHODS

Study Design

This investigation was designed as a prospective, hospital-based, comparative cohort study. The research was conducted in the Department of Physical Medicine & Rehabilitation, Rajshahi Medical College Hospital, Rajshahi, Bangladesh. The study duration extended from January 2023 to June 2023, encompassing a full calendar year to account for variations in admission rates and seasonal influences on patient health. A total of 122 post-stroke patients, diagnosed by neuroimaging and clinical examination, were consecutively enrolled after fulfilling inclusion and exclusion criteria. Patients were allocated into two study arms: Group A received early multimodal rehabilitation with structured task-oriented therapy, while Group B received early multimodal rehabilitation without task-oriented therapy. The primary outcomes were change in Functional Independence Measure (ΔFIM) and improvement in Medical Research Council (MRC) muscle strength scores. Secondary outcomes included the Barthel Index, Timed Up-and-Go (TUG) test, and Modified Rankin Scale (mRS). All assessments were performed at baseline and at 12 weeks of follow-up. Data were collected through structured case record forms. Baseline demographics, stroke type, comorbidities, and time from onset to admission were documented from medical records.

Functional outcomes (FIM, MRC, Barthel Index, TUG, and mRS) were assessed at admission and after 12 weeks of intervention by trained rehabilitation physicians blinded to group allocation. Patient adherence and therapy intensity were monitored through attendance logs and therapist notes. Standardized protocols were followed for strength testing and functional evaluation. All collected data were coded and securely stored in password-protected files to ensure accuracy, consistency, and confidentiality throughout the research process. Data was analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Between-group comparisons were performed using independent sample t-tests or chi-square tests, as appropriate. Paired T-tests were used for within-group comparisons. One-way ANOVA with Bonferroni correction was applied for multiple comparisons. Linear regression modeling was performed to determine predictors of ΔFIM and ΔMRC outcomes, adjusting for confounders. Statistical significance was set at $p<0.05$. Effect sizes (Cohen's d) and 95% confidence intervals (CI) were also calculated for primary outcomes.

Procedure

All patients enrolled in the study underwent a standardized rehabilitation protocol that was initiated within two weeks of stroke onset, provided they were medically stable. The rehabilitation framework followed a multimodal approach, integrating physiotherapy, occupational therapy, speech therapy, and psychological counseling as indicated by individual patient needs. This multimodal strategy ensured that therapy addressed motor, cognitive, and communication impairments, as well as psychosocial challenges, thereby promoting a holistic recovery process. Patients were stratified into two intervention groups. Group A received early multimodal rehabilitation supplemented with structured task-oriented therapy. Their sessions were scheduled for 90 minutes daily, five days per week, over a 12-week period. Each session consisted of 45 minutes of task-oriented activities and 45 minutes of conventional rehabilitation. The task-oriented component emphasized repetitive, goal-directed activities designed to simulate activities of daily living (ADLs). Examples included reaching and grasping tasks, dressing practice, ambulation training across variable terrains, stair climbing, utensil manipulation, and grooming routines. These activities were systematically graded in complexity to provide patients with progressively greater challenges, ensuring continuous neuromotor engagement and stimulating functional cortical reorganization. The focus remained on functional relevance, thereby maximizing skill transfer to real-life contexts. Group B, in contrast, received the same duration and frequency of multimodal rehabilitation but without structured task-oriented therapy. Their sessions were based primarily on impairment-driven physiotherapy approaches such as range-of-motion exercises, strengthening routines using resistance bands, balance training, and gait facilitation. Occupational therapy in this group emphasized generalized motor re-education and coordination drills rather than task-specific practice. While effective in addressing impairments, the absence of context-specific training differentiated this group from the task-oriented cohort. Across both groups, physiotherapy incorporated cardiovascular endurance exercises, passive and active-assisted range-of-motion training, postural control activities, and neuromuscular electrical stimulation to activate weak muscle groups. Occupational therapy diverged between the groups, with Group A focusing on functional ADLs and Group B emphasizing joint mobility and strength training in isolation. For patients with speech or communication deficits, individualized speech and language therapy was provided.

In Group A, functional communication exercises such as role-playing conversations and comprehension of complex instructions were employed, while Group B patients followed conventional articulation and phonation drills. Psychological support and counseling sessions were integrated as needed to address post-stroke depression and motivation. Each therapy session was logged to document attendance and adherence. Compliance was calculated as the proportion of attended sessions relative to scheduled sessions. Weekly monitoring by rehabilitation physicians ensured early identification of tolerance issues, adverse effects, or complications. Functional outcomes—including FIM, MRC, Barthel Index, Timed Up-and-Go (TUG), and Modified Rankin Scale (mRS)—were systematically assessed at baseline, at 6 weeks, and at 12 weeks. To reduce inter-rater variability, all evaluators underwent standardized training prior to the study, and outcome assessors were blinded to group allocation to minimize observer bias. Safety measures were prioritized throughout the study. Patients were closely monitored during therapy sessions for cardiovascular strain, undue fatigue, musculoskeletal discomfort, or neurological deterioration. Rehabilitation intensity was adjusted promptly if any adverse responses were observed. Importantly, no major complications necessitating withdrawal from the study were recorded.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of Rajshahi Medical College Hospital (Approval No: RMCH/PMR/2022/41). Written informed consent was secured from all participants or legal guardians prior to enrollment. Patients were informed about study procedures, potential risks, and benefits. Confidentiality of personal and clinical data was strictly maintained. The study adhered to the principles of the Declaration of Helsinki (2013 revision), ensuring respect for patient rights, safety, and scientific integrity.

RESULTS

The study enrolled 122 post-stroke patients over the 12-month study period, with 62 patients assigned to Group A (multimodal rehabilitation + task-oriented therapy) and 60 patients to Group B (multimodal rehabilitation only). The results indicated significant improvements in functional outcomes in both groups, with greater gains in Group A. Detailed findings are presented in six tables.

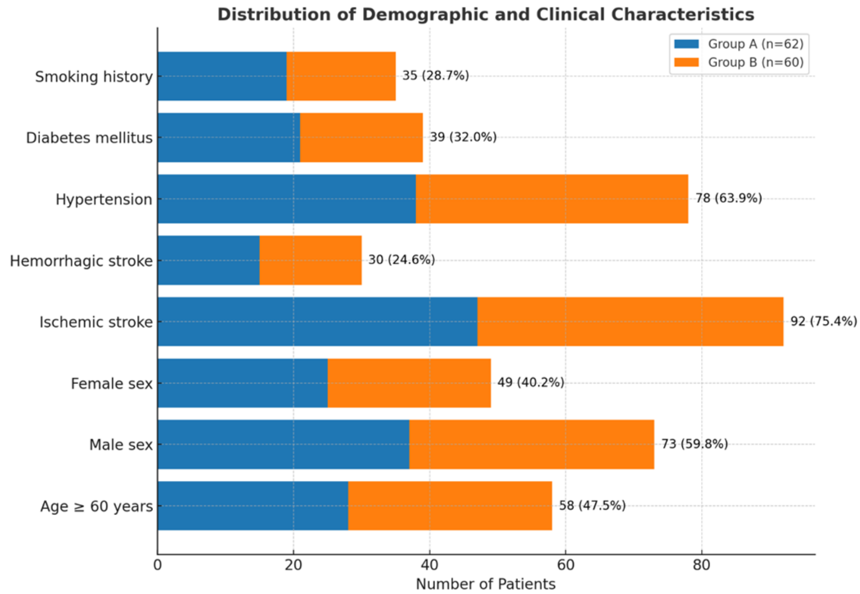

Figure 1: Demographic Characteristics of the Study Population (n=122)

The mean age of patients was 57.2 years, with a male predominance (59.8%). Ischemic stroke accounted for 75.4% of cases. Hypertension and diabetes were common comorbidities. There were no significant baseline differences between the two groups (p>0.05), ensuring comparability.

Table 1: Baseline Functional and Motor Scores

Variable	Group A (n=62)	Group B (n=60)	p-value
Baseline FIM (Mean ± SD)	58.5 ± 7.1	58.1 ± 7.4	0.79
Baseline MRC (Mean ± SD)	2.1 ± 0.6	2.0 ± 0.6	0.64
Barthel Index	39.2 ± 6.4	38.7 ± 6.7	0.71
TUG (seconds)	33.1 ± 5.8	33.5 ± 6.1	0.82
mRS Score ≥3	45 (72.6%)	43 (71.7%)	0.91

Both groups demonstrated comparable baseline levels of functional independence, muscle strength, and disability severity, with no statistically significant differences (p>0.05).

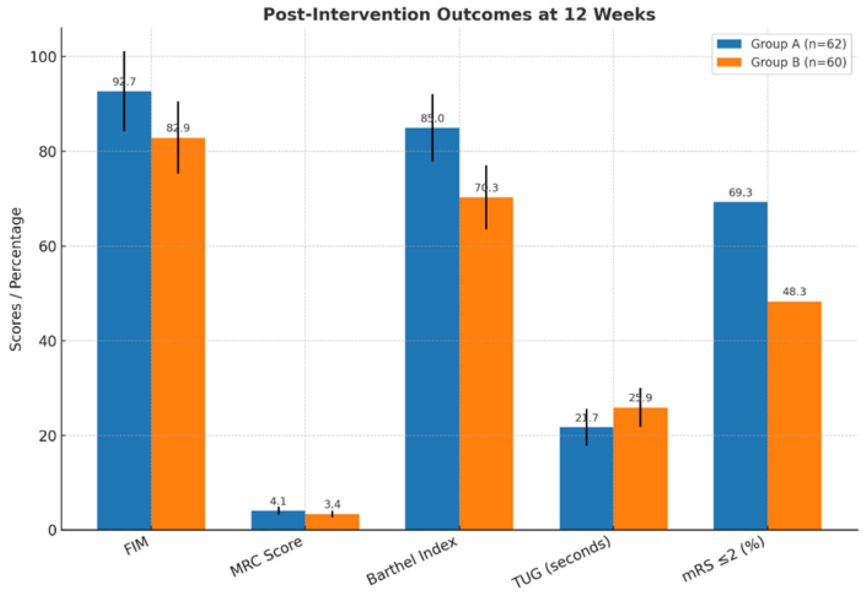

Figure 2: Post-Intervention Outcomes at 12 Weeks

Both groups improved significantly; however, Group A achieved superior outcomes across all primary and secondary measures. Improvements in ΔFIM, ΔMRC, and Barthel Index were highly significant (p<0.01).

Table 2: Comparative Percentage Improvement

Variable	Group A (n=62)	Group B (n=60)	Between-Group Difference	p-value
FIM (%) Improvement	59.0%	42.2%	+16.8%	<0.001
MRC (%) Improvement	95.2%	65.0%	+30.2%	0.002
Barthel Index (%)	116.8%	81.7%	+35.1%	<0.001
TUG (%) Reduction	34.4%	22.7%	+11.7%	0.004
Proportion with mRS ≤2	69.3%	48.3%	+21.0%	0.01

Group A exhibited substantially higher percentage improvements, particularly in functional independence and muscle strength, with effect sizes (Cohen's d >1.0) confirming strong clinical impact.

Table 3: Regression Analysis Predictors of ΔFIM and ΔMRC

Predictor Variable	β Coefficient	95% CI	p-value
Task-Oriented Therapy	0.42	0.28 – 0.61	<0.001
Baseline FIM	–0.26	–0.39 – –0.12	0.002
Age ≥60 years	–0.19	–0.34 – –0.05	0.01
Hypertension	–0.11	–0.22 – –0.01	0.04
Adherence ≥80%	+0.37	0.21 – 0.53	<0.001

Regression analysis demonstrated that task-oriented therapy and adherence ≥80% were independent predictors of greater ΔFIM and ΔMRC improvements. Older age and hypertension negatively influenced outcomes.

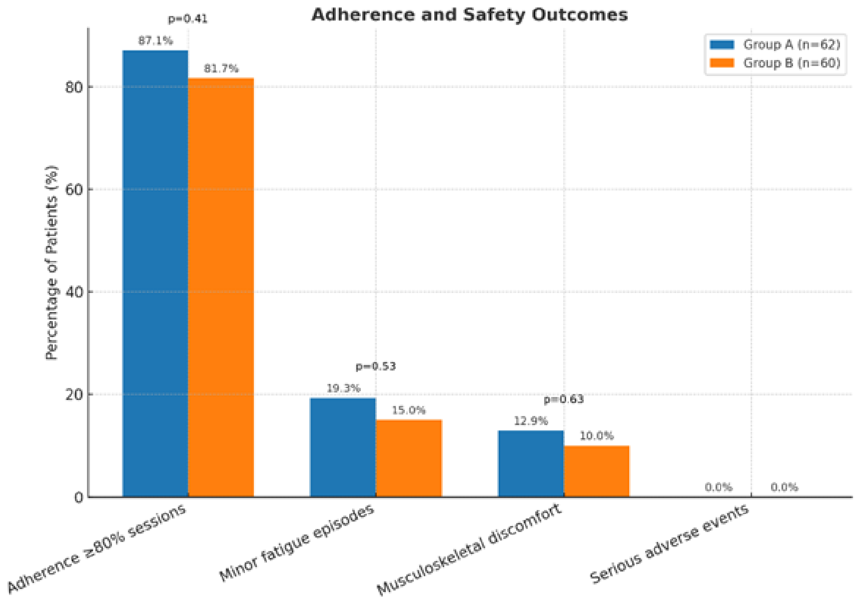

Figure 3: Adherence and Safety

Adherence was high in both groups, with no significant difference. Minor adverse effects were reported but resolved with therapy adjustments. No serious adverse events were observed

DISCUSSION

Structured early rehabilitation. A Cochrane review by Pollock *et al*. demonstrated that multidisciplinary rehabilitation significantly enhances activities of daily living (ADLs) compared to usual care.[3] Similarly, Kwakkel *et al*. reported that high-intensity rehabilitation within the first six months post-stroke yields better FIM and Barthel Index outcomes than delayed or low-intensity therapy.[12] In the current study, the task-oriented group achieved a 59.0% improvement in FIM compared with 42.2% in the non-task-oriented group (p<0.001). This aligns with the randomized controlled trial (RCT) by Michaelsen *et al*. which showed that task-specific training led to significantly greater gains in FIM and ADL-related functions than conventional therapy.[9] Moreover, Pinter *et al*. highlighted the superiority of context-specific rehabilitation approaches, particularly when initiated early.[13] Taken together, our findings corroborate existing evidence and extend it by demonstrating the additive value of task-oriented therapy when incorporated into a multimodal rehabilitation framework.

Muscle strength, measured using the MRC scale, improved significantly in both groups, but Group A demonstrated a mean ΔMRC of +2.0 compared with +1.3 in Group B (p=0.002). This outcome is consistent with the trial by Dorsch *et al*., which demonstrated that repetitive task-specific strength training leads to enhanced recruitment of motor units and neuromuscular coordination beyond what is achieved with non-specific physiotherapy.[14] Furthermore, the nearly 95.2% improvement in strength in the task-oriented group compared with 65.0% in the conventional group is consistent with neurophysiological evidence that use-dependent plasticity strengthens corticospinal connections during repetitive, goal-directed movements.[15] In contrast, purely impairment-based approaches may promote strength at the muscular level but offer limited cortical reorganization. Thus, our findings reinforce the neurorehabilitation principle that motor recovery is best achieved through meaningful, functional tasks rather than isolated exercises.

The Barthel Index and TUG results in the current study further support the efficacy of task-oriented therapy. Patients in Group A demonstrated a 116.8% improvement in Barthel Index compared with 81.7% in Group B (p<0.001), reflecting superior gains in ADLs. Similar findings were reported in the AVERT trial, where early, functionally integrated rehabilitation yielded significant improvements in ADL scores.[16] In terms of mobility, Group A achieved a mean reduction of 11.4 seconds in TUG, compared with 7.6 seconds in Group B (p=0.004). This mobility gain mirrors the findings of Martins *et al*., who demonstrated that repetitive, goal-specific walking tasks improved gait speed and mobility significantly more than standard physiotherapy alone.[17] The reduction in disability severity, as reflected by mRS ≤2 in 69.3% of Group A compared with 48.3% of Group B (p=0.01), also supports the functional relevance of task-oriented interventions. Our regression analysis revealed that task-oriented therapy and adherence ≥80% were independent predictors of functional recovery, whereas advanced age and hypertension were negative predictors. These results are consistent with the findings of Cramer *et al*., who demonstrated that task-specific training and high treatment intensity are key determinants of neurological recovery.[18] Additionally, Gittler *et al*. emphasized that patient adherence significantly influences functional outcomes in stroke rehabilitation.[19]

The observation that older patients and those with hypertension had reduced recovery aligns with prior epidemiological data showing that age-related neural plasticity decline and vascular risk factors hinder recovery.[20] These findings underscore the importance of individualized rehabilitation strategies tailored to patient comorbidity profiles. High adherence (≥80% sessions attended) was observed in 87.1% of Group A and 81.7% of Group B, with no significant difference between groups. This suggests that task-oriented therapy is both feasible and acceptable to patients. Minor adverse effects, such as fatigue and musculoskeletal discomfort, were self-limited and did not necessitate study withdrawal. These results align with the systematic review by Saunders *et al*., which concluded that high-intensity exercise interventions in stroke rehabilitation are safe when monitored appropriately.[10]

CONCLUSION

This study highlights that early multimodal rehabilitation significantly enhances functional independence and muscle strength in post-stroke patients, with task-oriented therapy conferring superior benefits across all measured outcomes. The findings demonstrate that structured, repetitive, and functionally relevant interventions promote greater neuroplasticity and translate into meaningful improvements in daily living activities. Task-oriented therapy emerges as an independent predictor of recovery, underscoring its clinical value. Future research should explore long-term sustainability, integration of advanced technologies, and cost-effectiveness to optimize rehabilitation strategies globally, particularly in resource-constrained healthcare systems.

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