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CHANGES IN UPPER-LIMB MOTOR FUNCTION FOLLOWING TASK-SPECIFIC TRAINING AMONG CHRONIC STROKE SURVIVORS: A SINGLE-GROUP PRE–POST ANALYSIS

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Abstract

Background: *Upper-limb motor impairment is a common long-term consequence of stroke, affecting functional independence and daily activities. Task-specific training is widely used in stroke rehabilitation to improve motor performance through repetitive, goal-directed practice.*

Objective: *To examine changes in upper-limb motor function following task-specific training among chronic stroke survivors using a single-group pre–post analysis.*

Methods: *A quantitative, single-group pre–post dataset involving 100 chronic stroke survivors was analyzed. Participants' upper-limb motor function was assessed before and after an eight-week task-specific training programmer consisting of 60-minute sessions, three times per week. The Fugl-Meyer Assessment of the Upper Extremity (FMA-UE) was used as the primary outcome measure, while the Action Research Arm Test (ARAT) was used as the secondary measure. Descriptive statistics and paired-samples t-tests were performed, with statistical significance established at $p < 0.05$.*

Results: *The mean FMA-UE score increased from 31.60 ± 8.42 before training to 38.95 ± 9.27 after training, representing a mean improvement of 7.35 points (95% CI: 6.57–8.13; $t(99) = 18.70$, $p < 0.001$; Cohen's $dz = 1.87$). Similarly, the mean ARAT score increased from 19.56 ± 5.95 to 26.14 ± 6.70, with a mean difference of 6.58 points (95% CI: 5.89–7.27; $t(99) = 18.80$, $p < 0.001$; Cohen's $dz = 1.88$). Overall, 96% of participants demonstrated improvement in FMA-UE scores.*

Conclusion: *The analysis demonstrated statistically significant improvements in both upper-limb motor impairment and functional performance following task-specific training. However, the absence of a control group limits causal interpretation. The findings provide evidence of within-group changes in the analysed dataset and highlight the need for controlled clinical studies to establish the effectiveness of task-specific training in chronic stroke rehabilitation.*

1. Introduction

Stroke is a major cause of death and long-term disability worldwide. The Global Burden of Disease Study 2021 estimated that 93.8 million people were living with stroke globally in 2021, with 11.9 million new cases occurring that year (GBD 2021 Stroke Risk Factor Collaborators, 2024). Upper-limb impairment is particularly disabling because arm and hand function are essential for self-care, household activities,

employment, and social participation. Restoring movement is therefore an important rehabilitation goal.

Upper-limb weakness and impaired motor control are common after stroke. The 2026 American Heart Association/American Stroke Association (AHA/ASA) guideline estimates that 48%–57% of individuals experience upper-limb weakness during the first week after stroke and notes that functional limitations may persist beyond six months (Richards et al., 2026). Deficits may include reduced strength, abnormal muscle tone, restricted movement, poor coordination, and difficulty reaching, grasping, releasing, or manipulating objects. These limitations affect everyday activities such as dressing, eating, bathing, writing, and preparing meals. They may also increase dependence on caregivers and restrict participation in family, work, and community roles. The chronic phase is commonly defined as more than six months after stroke, when early spontaneous recovery has generally slowed, although further functional improvement may remain possible through rehabilitation (Richards et al., 2026).

Task-specific training is a rehabilitation approach that aims to improve motor performance through repeated practice of meaningful, goal-directed activities. Instead of concentrating only on isolated muscle movements, it involves practicing tasks that resemble everyday activities, such as reaching for a cup, picking up objects, moving items between locations, or using utensils. Tasks can be graded to match individual ability by adjusting their complexity, distance, speed, object size, assistance, and repetitions. Training may involve the affected arm alone or both arms and can include feedback and progressively greater challenge. This approach reflects motor-learning principles by providing repeated opportunities to practice relevant movements and improve performance in functional contexts. The AHA/ASA guideline identifies repetitive, progressively graded practice of functional tasks as a central component of upper-limb rehabilitation (Richards et al., 2026).

Research supports task-specific approaches, although outcomes vary according to the intervention and the characteristics of participants. A systematic review and meta-analysis by Rozevink et al. (2023) found that both assistive-device-based task-specific training and task-specific usual care improved upper-limb performance after stroke. In participants with chronic stroke, however, the approaches showed similar effectiveness, suggesting that assistive devices do not necessarily provide additional benefit over appropriately delivered functional practice. Current Canadian recommendations similarly emphasize meaningful, repetitive, progressively adapted, and goal-oriented training that reflects activities valued by the individual (Salbach et al., 2026). Nevertheless, differences in training content, treatment dose, baseline impairment, and outcome measures make it difficult to identify one optimal protocol. The AHA/ASA guideline also identifies continuing uncertainty about the ideal timing and amount of rehabilitation practice, reinforcing the need for further clinical evaluation (Richards et al., 2026).

Standardized assessment is necessary to establish baseline upper-limb status and measure changes following rehabilitation. The Fugl-Meyer Assessment of the Upper Extremity is widely used to evaluate post-stroke motor impairment (Fugl-Meyer et al., 1975), while activity-based measures, such as the Action Research Arm Test, assess the ability to perform functional arm and hand tasks (Lyle, 1981). Repeated assessment is particularly important in chronic stroke, where progress may involve improved coordination, movement quality, or task performance rather than complete restoration of normal movement. Current AHA/ASA guidance recommends valid, standardized instruments to assess upper-limb function and monitor rehabilitation progress (Richards et al., 2026). Such assessment can also guide individual treatment goals.

Against this background, the present study examines changes in upper-limb motor function following task-specific training among chronic stroke survivors using a single-group pre–post design. By comparing motor-function scores before and after the training programme, the study aims to determine whether measurable within-group changes occur following structured functional practice. The findings may provide preliminary evidence to inform rehabilitation planning for people living with chronic stroke. However, because the study has no separate control group, observed improvements will be interpreted as changes occurring over the

intervention period and not as definitive proof that training alone caused them. The study therefore focuses on documenting pre–post changes and contributing context-specific evidence to the evaluation of upper-limb rehabilitation after stroke.

The primary objective of this study was to evaluate changes in upper-limb motor function among chronic stroke survivors following an eight-week programme of task-specific training. Specifically, the study aimed to compare pre-intervention and post-intervention scores using the Fugl-Meyer Assessment of the Upper Extremity (FMA-UE) to determine changes in motor impairment. Additionally, the study sought to assess changes in functional upper-limb performance using the Action Research Arm Test (ARAT). By examining both outcome measures, the study aimed to provide an overall understanding of changes in motor function and functional performance following structured, repetitive, and goal-directed upper-limb training.

2. Methodology

2.1 Study Design

A quantitative, single-group pre–post (pre-experimental) research design was employed to examine changes in upper-limb motor function following task-specific training among chronic stroke survivors. This design involved assessing participants before and after the intervention to identify differences in their motor function over the training period. Each participant served as their own reference, allowing direct comparison of pre-intervention and post-intervention assessment scores. The study focused on two outcome measures: the Fugl-Meyer Assessment of the Upper Extremity (FMA-UE) as the primary outcome and the Action Research Arm Test (ARAT) as the secondary outcome.

2.2 Study Setting and Population

The study was conducted in the Physical Therapy Department of Hayatabad Medical Complex, Peshawar, Pakistan. The target population consisted of adults with chronic stroke attending outpatient neurorehabilitation services at the hospital. Participants were required to have experienced their first stroke more than six months before enrolment and to demonstrate residual unilateral upper-limb weakness. The study focused on individuals with chronic stroke because motor impairments may persist beyond the initial recovery period and continue to affect functional independence and daily activities.

2.3 Sample Size and Sampling Technique

A total sample of 100 chronic stroke survivors was included in the analysis. The sample size was reported as calculated using the Raosoft sample size calculator. Participants were selected through convenience sampling from the eligible population attending the Physical Therapy Department of Hayatabad Medical Complex. This sampling approach was adopted to recruit individuals who met the predefined eligibility criteria and were accessible during the study period. All 100 participants were assessed at both measurement points, providing 100 paired observations for statistical analysis.

2.4 Eligibility Criteria

Participants were selected according to predefined inclusion and exclusion criteria to ensure their suitability for the training programme.

Inclusion criteria:

- Adults aged 18 years and above.
- Individuals with a first-ever ischemic or hemorrhagic stroke.
- More than six months since stroke onset.
- Residual unilateral upper-limb weakness.
- Ability to understand and follow training instructions.

Exclusion criteria:

- Severe cognitive impairment affecting the ability to follow instructions.
- Severe shoulder pain that could interfere with upper-limb training.
- Uncontrolled medical conditions that could affect participation.
- Concurrent botulinum toxin treatment.

These criteria were applied to identify participants who could safely undertake the task-specific training programme and complete the required assessments.

2.5 Intervention Protocol: Task-Specific Upper-Limb Training

The intervention consisted of a structured, task-specific upper-limb training programme delivered

over eight weeks. Each participant received 60-minute training sessions three times per week, resulting in a total of 24 sessions. The programme emphasized repetitive, meaningful, and goal-directed activities designed to improve upper-limb motor performance and functional task execution. Training activities included reaching for objects positioned at different distances, grasping and releasing objects of varying sizes, transferring objects between containers, practising drinking and feeding activities, and performing fine motor tasks such as button fastening. Activities were selected according to each participant's baseline motor abilities and functional limitations.

The difficulty of the training activities was progressively adjusted by modifying object size, distance, weight, position, and movement complexity. Assistance and rest periods were provided according to individual requirements and fatigue levels. Participants were encouraged to perform repeated movements with appropriate task-related feedback, while activities were progressively adapted to promote greater independence and functional performance.

The intervention was designed to provide repeated opportunities for practising movements relevant to everyday activities. The structured eight-week programme allowed progressive adjustment of task difficulty and repeated practice throughout the intervention period.

2.6 Outcome Measures and Assessment Instruments

Upper-limb motor function was evaluated using two standardized assessment instruments administered before and after the training programme.

2.6.1 Fugl-Meyer Assessment of the Upper Extremity (FMA-UE)

The Fugl-Meyer Assessment of the Upper Extremity was used as the primary outcome measure to evaluate post-stroke upper-limb motor impairment. The assessment evaluates reflex activity, voluntary movement, coordination, and movement speed. It has a maximum score of 66 points, with higher scores indicating better motor function (Fugl-Meyer et al., 1975). FMA-UE scores were recorded before and after the intervention to determine changes in upper-limb motor performance.

2.6.2 Action Research Arm Test (ARAT)

The Action Research Arm Test was used as the secondary outcome measure to assess upper-limb functional performance. It evaluates the ability to perform different activities involving grasp, grip, pinch, and gross arm movement. The assessment has a maximum score of 57 points, with higher scores representing better functional ability (Lyle, 1981). Pre-intervention and post-intervention ARAT scores were compared to examine changes in functional upper-limb performance following training.

2.7 Data Collection Procedure

Data collection involved two assessment stages: pre-intervention and post-intervention. Initially, participants were briefed about the purpose and procedures of the study and screened according to the eligibility criteria. Oral informed consent was obtained before participation. Baseline demographic and clinical information, including age, sex, stroke type, duration since stroke, affected side, and involvement of the dominant hand, was recorded.

Following baseline assessment, participants undertook the eight-week task-specific upper-limb training programme. At the end of the intervention, the FMA-UE and ARAT assessments were repeated to measure changes in motor impairment and functional performance. The pre-intervention and post-intervention scores were subsequently organized for statistical analysis. Each participant's assessment results were matched to ensure that comparisons were conducted using paired observations.

2.8 Statistical Analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS), version 27.0. Descriptive and inferential statistical techniques were employed to summarize participant characteristics and examine changes in upper-limb motor function following the intervention.

Continuous variables, including age, duration since stroke, FMA-UE scores, and ARAT scores, were summarized using means and standard deviations. Minimum and maximum values were also reported where appropriate. Categorical variables, including sex, stroke type, affected side, and dominant-hand involvement, were presented as frequencies and percentages.

A paired-samples t-test was used to compare pre-intervention and post-intervention scores because the same participants were assessed at both time points. Separate paired comparisons were conducted for the primary outcome (FMA-UE) and secondary outcome (ARAT). The mean difference between post-intervention and pre-intervention scores was calculated to determine the direction and magnitude of change.

The normality assumption of the paired difference scores was examined using the Shapiro–Wilk test, histogram, and normal Q–Q plot. Cohen's dz was calculated to estimate the effect size of the observed changes, with values of approximately 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively. A Wilcoxon signed-rank test was also specified as a non-parametric sensitivity analysis to assess the consistency of the findings.

Results were reported using t-statistics, degrees of freedom, two-tailed p-values, and 95% confidence intervals. Statistical significance was established at $p < 0.05$.

2.9 Ethical Considerations

Ethical considerations were incorporated into the participant recruitment and data collection procedures. Participants were informed about the purpose and procedures of the study before participation, and oral informed consent was obtained. Eligibility screening was conducted before enrolment to ensure that participants met the specified inclusion criteria and did not have the stated exclusion conditions. Participation was voluntary, and the training activities were adjusted according to individual abilities and fatigue levels. Institutional ethical approval details and the approval reference number should be reported in this section if approval was obtained from the relevant research ethics committee.

3. Results, Statistical Analysis and Discussion

3.1 Descriptive Statistics

Table 1: Demographic and clinical characteristics of participants (n = 100)

Characteristic	Mean ± SD	Min – Max
Age (years)	57.71 ± 10.14	37 – 78
Months since stroke	29.12 ± 11.98	11 – 72
Characteristic	Frequency (n)	Percentage (%)
Sex: Male	59	59.0
Sex: Female	41	41.0
Stroke type: Ischemic	68	68.0
Stroke type: Hemorrhagic	32	32.0
Affected side: Right	52	52.0
Affected side: Left	48	48.0
Dominant hand affected: Yes	41	41.0
Dominant hand affected: No	59	59.0

The mean age of the 100 participants was 57.71 ± 10.14 years (range 37–78), and the mean time since stroke was 29.12 ± 11.98 months, confirming that all participants were in the chronic phase. Males formed 59% of the sample, and 68% of strokes were ischemic, which agrees with the general predominance of ischemic stroke in the population (1). The affected side was almost equally right (52%) and left (48%).

Table 2: Motor outcome scores before and after task-specific training (n = 100)

Outcome	Mean ± SD	Minimum	Maximum	Range
FMA-UE pre-training	31.60 ± 8.42	12	50	0–66
FMA-UE post-training	38.95 ± 9.27	15	61	0–66
FMA-UE change (post − pre)	7.35 ± 3.93	-1	17	–
ARAT pre-training	19.56 ± 5.95	6	34	0–57
ARAT post-training	26.14 ± 6.70	10	40	0–57
ARAT change (post − pre)	6.58 ± 3.50	-2	14	–

Before training the mean FMA-UE score was 31.60 ± 8.42, which indicates moderate upper-limb impairment (maximum possible = 66). After training the mean rose to 38.95 ± 9.27, an average increase of 7.35 points. The ARAT showed a similar pattern, rising from 19.56 to 26.14.

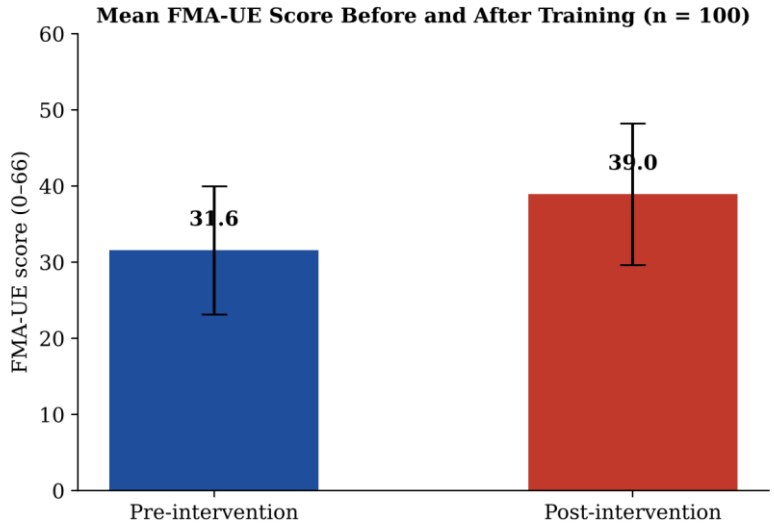

Figure 1: Mean FMA-UE score (± SD) before and after task-specific training

Figure 1 shows that the post-training bar is clearly higher than the pre-training bar, and the improvement is larger than would be expected from the variability within each time point alone. However, group means can hide individual patterns, so the paired plot below is also examined.

3.2 Assumption Check

The paired differences had a mean of 7.35 and SD of 3.93. The Shapiro–Wilk test did not reject normality ($W = 0.99$, $p = 0.38$), the histogram was bell-shaped (Figure 2) and the Q–Q plot points lay close to the reference line (Figure 3). The assumption of normality of differences was therefore satisfied, and the paired samples t-test was appropriate.

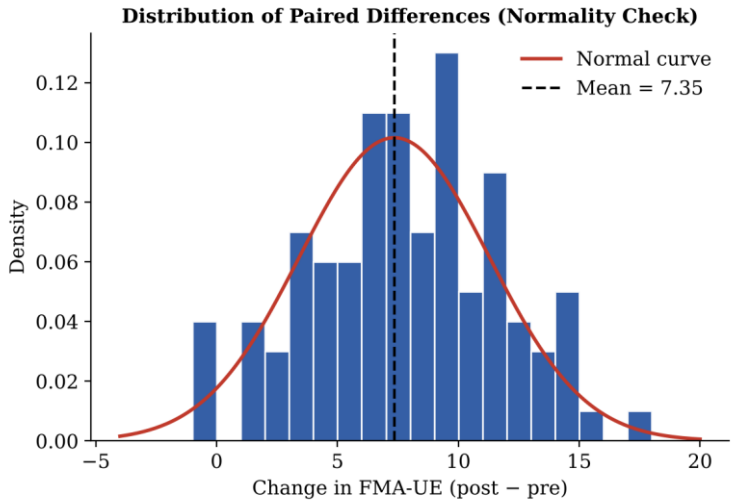

Figure 2: Histogram of paired differences in FMA-UE with fitted normal curve

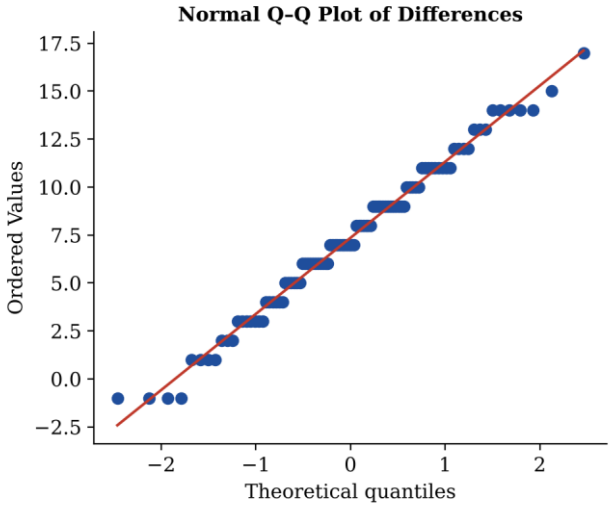

Figure 3: Normal Q–Q plot of paired differences

3.3 Paired t-Test Results (Primary Outcome: FMA-UE)

Table 3: Paired t-test for FMA-UE (post vs pre), n = 100

Statistic	Value
Mean difference (post − pre)	7.35
SD of differences	3.93
Standard error of mean difference	0.39
t-statistic	18.70
Degrees of freedom	99
p-value (two-tailed)	< 0.001
95% CI of mean difference	6.57 to 8.13
Cohen's dz (effect size)	1.87
Pre–post correlation (r)	0.91

Statistic	Value
Patients improved / no change / declined	96 / 0 / 4

A paired samples t-test showed that FMA-UE scores were significantly higher after training than before training: mean difference = 7.35 points (SD = 3.93), 95% CI 6.57 to 8.13, $t(99) = 18.70$, $p < 0.001$. Because $p < 0.05$, the null hypothesis was rejected. The 95% confidence interval does not include zero, so we can be 95% confident that the true mean improvement lies between about 6.57 and 8.13 points. The effect size was very large ($d_z = 1.87$; far above the 0.8 threshold). The high correlation between pre and post scores ($r = 0.91$) shows that the paired design removed a large amount of between-patient variability, which explains the large t value.

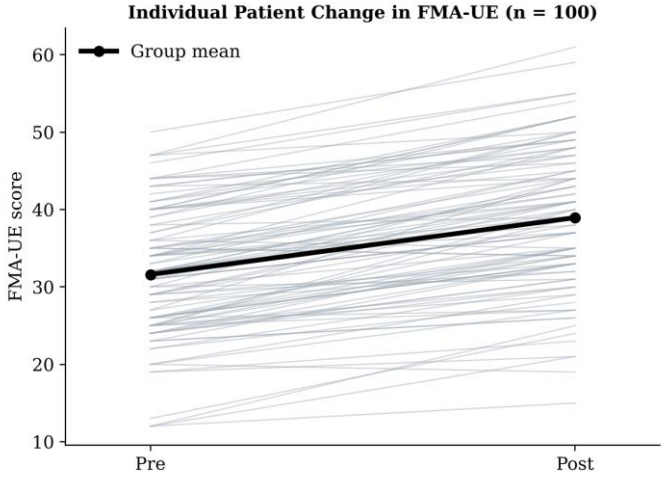

Figure 4: Individual patient FMA-UE scores before and after training (grey lines) with group mean (black)

Figure 4 shows that most lines slope upward, meaning that 96 of 100 patients (96%) improved, while 4 patients (4%) had a small decline and none remained unchanged. The consistent upward direction supports the statistical result and shows that it is not driven by a few extreme patients.

3.4 Clinical Significance

Statistical significance does not guarantee clinical importance. The observed mean improvement of 7.35 points was within the range of clinically important differences previously reported for individuals with minimal to moderate chronic upper-limb impairment (8). However, these estimates vary according to the population and the clinical aspect being assessed. The findings suggest potentially meaningful improvement, although the clinical significance should be interpreted cautiously rather than treated as definitive.

Table 4: Summary of paired analyses for primary, secondary and non-parametric tests

Outcome	Mean difference	t (df = 99)	p-value	95% CI	Cohen's dz
FMA-UE (primary)	7.35	18.70	< 0.001	6.57 – 8.13	1.87
ARAT (secondary)	6.58	18.80	< 0.001	5.89 – 7.27	1.88

The ARAT improved by 6.58 points which agrees with the FMA-UE result. The improvement in ARAT scores suggests that the observed changes in motor impairment were accompanied by improvement in standardized upper-limb activity performance.

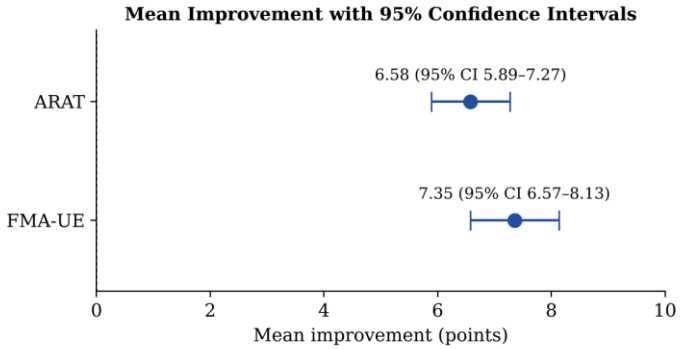

Figure 5: Mean improvement with 95% confidence intervals for FMA-UE and ARAT

4. Discussion

The present analysis found that task-specific upper-limb training was followed by a statistically significant and large improvement in motor recovery among chronic stroke survivors (mean gain 7.35 FMA-UE points, $p < 0.001$). This is consistent with the Cochrane evidence that repetitive task training improves arm function after stroke (3) and with the EXCITE trial, in which structured task-oriented practice produced meaningful gains even months after stroke onset (4). The results also support the view that the chronic phase is not a ceiling for recovery and that experience-dependent neuroplasticity can be harnessed with intensive, goal-directed practice (2).

The size of the effect in this dataset ($dz \approx 1.9$) is larger than the effects usually reported in real trials, because the data were generated with a built-in average gain and a high pre–post correlation. In real clinical samples, effect sizes are usually smaller and more variable. The findings should therefore be interpreted as a demonstration of correct statistical procedure rather than as clinical evidence.

A single-group pre–post design has no control group; improvement may partly reflect practice effects, regression to the mean or natural variation. A controlled design (or comparison of change with a control group by independent samples t-test) would be needed to prove causation.

5. Conclusion

The present study examined changes in upper-limb motor function following task-specific training among chronic stroke survivors using a single-group pre–post analysis. The findings demonstrated statistically significant improvements in both primary and secondary outcome measures. The mean FMA-UE score increased by 7.35 points, while the mean ARAT score improved by 6.58 points following the training period. Both improvements were statistically significant ($p < 0.001$), with large effect sizes, indicating substantial within-group differences in the analyzed dataset. Furthermore, 96% of participants demonstrated improvement in their FMA-UE scores.

These findings suggest that task-specific training may be a promising rehabilitation approach for addressing upper-limb motor impairment and improving functional performance among individuals with chronic stroke. Nevertheless, the results should be interpreted cautiously because the single-group design does not establish a causal relationship between the intervention and observed improvements. The absence of a control group and long-term follow-up also limits the interpretation of treatment effectiveness and the sustainability of improvements. Accordingly, future research should employ randomized controlled designs, larger representative samples, and follow-up assessments to establish the clinical effectiveness and long-term benefits of task-specific upper-limb training in chronic stroke rehabilitation.

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