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HEALTH AND REHABILITATION

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COMPARISON OF TAI CHI AND FRENKEL'S EXERCISES TO IMPROVE BALANCE, FALL RISK AND ACTIVITIES OF DAILY LIVING IN PATIENTS WITH STROKE

Original Research

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Acknowledgement: The authors express their gratitude to all participants and the staff of Islam Central Hospital, Sialkot, for their valuable support throughout the study.

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Stroke is a leading cause of adult disability, often resulting in impaired balance, increased fall risk, and reduced ability to perform activities of daily living (ADLs). Recovery depends on early and effective rehabilitation strategies that enhance motor control and coordination. Tai Chi, a traditional Chinese movement practice, and Frenkel's exercises, a proprioceptive training regimen, are both used to address these deficits in neurological populations. However, limited evidence exists comparing their effectiveness in stroke rehabilitation.

Objective: To compare the effects of Tai Chi and Frenkel's exercises on improving balance, fall risk, and ADLs in stroke survivors.

Methods: This randomized clinical trial was conducted at the Outpatient Physiotherapy Department of Islam Central Hospital, Sialkot, from November 2023 to June 2024. A total of 36 stroke patients were recruited through non-probability convenience sampling and randomly assigned into two groups (n=18 each). Group A received modified Tai Chi training along with conventional physiotherapy, while Group B received Frenkel's exercises with conventional therapy. Outcome measures included the Berg Balance Scale (BBS) for balance, the Barthel Index (BI) for ADLs, and the STRATIFY tool for fall risk. Assessments were conducted at baseline and after 8 weeks. Data were analyzed using SPSS version 26, applying independent sample t-tests.

Results: Post-intervention scores showed significant improvements in all outcome measures in both groups ($p < 0.05$). However, Group A (Tai Chi) demonstrated superior outcomes with BI improving from 58.13 ± 9.81 to 85.63 ± 7.93, BBS from 35.81 ± 4.34 to 45.38 ± 3.32, and STRATIFY scores decreasing from 2.62 ± 0.957 to 0.94 ± 0.680. In contrast, Group B (Frenkel's) showed less pronounced gains (BI: 56.88 ± 10.94 to 69.38 ± 9.81; BBS: 35.50 ± 4.38 to 41.94 ± 2.64; STRATIFY: 2.56 ± 0.892 to 1.68 ± 0.602), with significant between-group differences ($p < 0.05$).

Conclusion: Both Tai Chi and Frenkel's exercises contributed positively to stroke rehabilitation; however, Tai Chi demonstrated superior efficacy in improving balance, reducing fall risk, and enhancing ADL performance in stroke patients.

Keywords: Activities of Daily Living, Exercise Therapy, Postural Balance, Rehabilitation, Risk Assessment, Stroke, Tai Chi.

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INTRODUCTION

Stroke remains one of the most significant global health challenges, ranking among the top five causes of mortality in the United States and serving as the leading cause of hospitalization due to neurological conditions (1). The condition encompasses three primary subtypes: hemorrhagic stroke, transient ischemic attack, and ischemic stroke (2). While the past three decades have seen a noticeable decline in overall stroke incidence, particularly intracerebral hemorrhage due to improved management of hypertension, the burden of stroke continues to rise owing to population aging and the increasing number of survivors living with long-term disability (3,4). Despite advances in acute care, many stroke survivors experience persistent impairments in body structure, function, and participation, often requiring long-term support (5). The degree of recovery and residual impairment after a stroke is closely linked to the type and timing of intervention, with cerebral hemorrhage still associated with higher mortality, even after adjusting for age (6). Improvements in diagnostic sensitivity, particularly with computed tomography (CT) imaging, have contributed to more accurate assessments of small hemorrhagic strokes and better-informed treatment approaches (7). Post-stroke disability is often characterized by impaired motor function, muscle weakness, spasticity, and reduced balance, all of which are compounded by neurodegenerative changes and disuse over time (8). These challenges highlight the importance of targeted rehabilitation strategies that promote neural plasticity and motor control recovery, especially in the lower limbs where nearly 80% of patients report significant functional deficits affecting quality of life and mobility (9). Conventional rehabilitation focuses on central nervous system reorganization and compensation, yet optimal outcomes are contingent upon integrating diverse and patient-centered interventions (10).

Complementary therapies such as Tai Chi have shown promise in enhancing motor coordination, balance, and proprioception in individuals with neurological conditions, including stroke (11). Tai Chi's emphasis on controlled movement, deep breathing, and relaxation aligns well with rehabilitation principles, offering both physical and psychological benefits that support recovery and stress regulation (12). Moreover, recent studies have expanded the scope of neurorehabilitation by incorporating Frenkel's exercises—a series of purposeful, repetitive, and visually guided limb movements originally developed to improve coordination in patients with ataxia (13). Emerging evidence suggests these exercises may have utility in improving functional mobility and reducing fall risk in stroke survivors, though findings are mixed. For example, a study reported significant improvements in mobility as measured by the Timed Up and Go (TUG) test, changes in the Berg Balance Scale (BBS) and Functional Independence Measure (FIM) were not statistically significant (4,10). Similarly, a study demonstrated that both Frenkel's and Otago exercises led to better TUG scores, though the Otago program was more effective in reducing fall-related anxiety (14). A study further explored Frenkel's exercises in a different neurological context—Wernicke-Korsakoff syndrome—finding cognitive and motor improvements that underscore the broader rehabilitative potential of coordination-focused exercises (15). Given the high prevalence of lower limb dysfunction after stroke and the associated risk of falls and reduced independence, there is a pressing need for effective, evidence-based interventions. While Tai Chi and Frenkel's exercises have demonstrated individual benefits in balance and coordination, comparative research is lacking in determining their combined or relative efficacy in stroke rehabilitation. Therefore, this study aims to evaluate and compare the effects of Tai Chi and Frenkel's exercises on balance and lower limb motor function in individuals recovering from stroke, with the objective of identifying therapeutic approaches that can better support functional recovery and reduce long-term disability.

METHODS

This randomized clinical trial was conducted to evaluate and compare the effectiveness of Tai Chi and Frenkel's exercises in enhancing balance, lower limb motor function, and daily functional independence among stroke survivors. A total of 36 participants were recruited and randomly allocated into two groups (n=18 per group), with the sample size calculated using G*Power software based on previously reported mean and standard deviation values of the Berg Balance Scale (BBS) (experimental group: 48.03 ± 9.59; control group: 39.64 ± 12.39), accounting for a 10% attrition rate to ensure sufficient power. The study followed a parallel-group, single-blinded design and was conducted at the physiotherapy outpatient department of Islam Central Hospital, Sialkot, between November 25, 2023, and June 10, 2024. Participants were selected through a non-probability convenience sampling technique. Inclusion criteria consisted of male and female stroke survivors aged above 50 years, with a history of ischemic or hemorrhagic stroke occurring at least three months prior. Participants were required to have stable vital signs, a Modified Rankin Scale (mRS) score below 3, moderate physical limitations as

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defined by a Short Physical Performance Battery (SPPB) score of 3–9, and a Mini-Mental State Examination (MMSE) score greater than 18, indicating mild or no cognitive impairment.

Exclusion criteria included individuals unable to participate in exercise therapy due to physical or medical restrictions, those diagnosed with vestibular disorders or dyskinesias that would impair Tai Chi participation, patients undergoing active cancer treatment, those with disabilities interfering with engagement in rehabilitation, individuals taking medications that significantly increased fall risk, and stroke survivors who had participated in strength or balance training within the last three months (2,3). Ethical approval for the study was obtained from the Institutional Review Board of Riphah International University, Lahore, Pakistan. All participants provided written informed consent after being fully briefed on the study's purpose, procedures, potential risks, and their right to withdraw at any time without penalty. Pre-intervention assessments were conducted to establish baseline measurements prior to group allocation.

Randomization was performed using a computer-generated number list, assigning participants to Group A (Tai Chi exercises) or Group B (Frenkel's exercises). Both interventions were administered alongside conventional physiotherapy. The study-maintained assessor blinding, with all outcome evaluations conducted by licensed neuromuscular physiotherapists possessing over five years of clinical experience, who were unaware of group assignments to minimize observer bias. The intervention spanned eight weeks, and outcome measures were assessed at baseline and post-intervention using three validated tools: the Barthel Index (BI) for assessing independence in activities of daily living, the Berg Balance Scale (BBS) for functional balance assessment, and the STRATIFY Fall Risk Assessment Tool for evaluating fall risk. All data were securely recorded and managed to ensure participant confidentiality. For statistical analysis, a parametric test—specifically, the independent sample t-test—was used to compare post-intervention outcomes between the Tai Chi and Frenkel's exercise groups across all three outcome measures (BI, BBS, and STRATIFY). Statistical significance was determined at a p-value < 0.05. This approach ensured that the effectiveness of the two rehabilitation interventions could be reliably compared using robust inferential statistics.

RESULTS

The results of this randomized clinical trial demonstrated statistically significant improvements in all measured outcomes, with greater efficacy observed in the Tai Chi group compared to the Frenkel's exercises group. An independent sample t-test was employed to compare post-intervention scores between groups using three standardized assessment tools: the Barthel Index (BI), the Berg Balance Scale (BBS), and the Fall Risk Assessment Tool (STRATIFY). In terms of functional independence as measured by the Barthel Index, the Tai Chi group showed a marked improvement from a pre-intervention mean of 58.13 ± 9.81 to a post-intervention mean of 85.63 ± 7.93. In comparison, the Frenkel's group improved from 56.88 ± 10.94 to 69.38 ± 9.81. The between-group comparison yielded a statistically significant difference in post-intervention scores ($p < 0.001$), indicating superior gains in daily functional independence in the Tai Chi group. For balance assessment using the Berg Balance Scale, the Tai Chi group improved from a baseline score of 35.81 ± 4.34 to 45.38 ± 3.32 following the intervention. The Frenkel's group also demonstrated improvement, with scores increasing from 35.50 ± 4.38 to 41.94 ± 2.64. The difference in post-intervention scores was statistically significant ($p = 0.003$), again favoring the Tai Chi group in terms of enhancing postural stability and balance.

In the evaluation of fall risk reduction using the STRATIFY tool, the Tai Chi group exhibited a substantial reduction in fall risk, with mean scores decreasing from 2.62 ± 0.957 to 0.94 ± 0.680. The Frenkel's group showed a smaller reduction from 2.56 ± 0.892 to 1.68 ± 0.602. The post-intervention comparison revealed a statistically significant difference ($p = 0.003$), confirming that Tai Chi was more effective in reducing fall risk among stroke survivors. These findings indicate that although both Tai Chi and Frenkel's exercises led improvements in function, balance, and fall risk, Tai Chi resulted in more pronounced gains across all domains. The data strongly support the integration of Tai Chi into post-stroke rehabilitation protocols, especially for targeting lower limb motor function and fall prevention.

Post-intervention analysis revealed that the Tai Chi group demonstrated consistently superior outcomes compared to the Frenkel's exercises group across all three measured domains. Functional independence, as measured by the Barthel Index, showed a significant increase in the Tai Chi group (from 58.13 ± 9.81 to 85.63 ± 7.93) compared to the Frenkel's group (from 56.88 ± 10.94 to 69.38 ± 9.81), with a highly significant p-value of < 0.001. Similarly, the Berg Balance Scale scores increased more in the Tai Chi group (from 35.81 ± 4.34 to 45.38 ± 3.32) than in the Frenkel's group (from 35.50 ± 4.38 to 41.94 ± 2.64), with a statistically significant p-value of 0.003. A notable reduction in fall risk was also observed through the STRATIFY scores, where Tai Chi participants improved from 2.62 ± 0.957 to 0.94 ± 0.680, in contrast to the Frenkel's group which improved from 2.56 ± 0.892 to 1.68 ± 0.602, again with a significant p-value of 0.003. These findings clearly suggest that Tai Chi had a more profound effect on post-stroke recovery than Frenkel's exercises.

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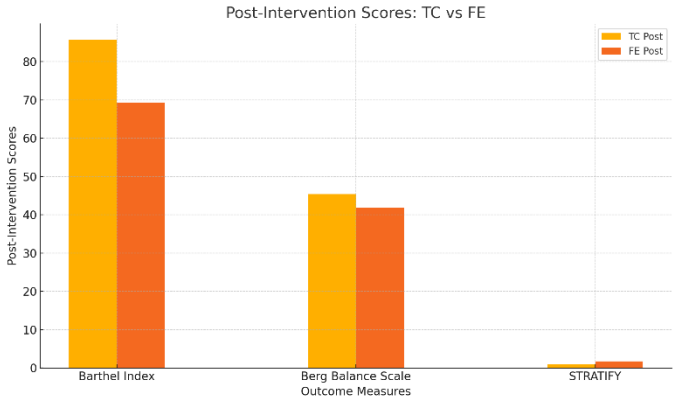


Figure 1 Post-Intervention Scores: TC vs FE

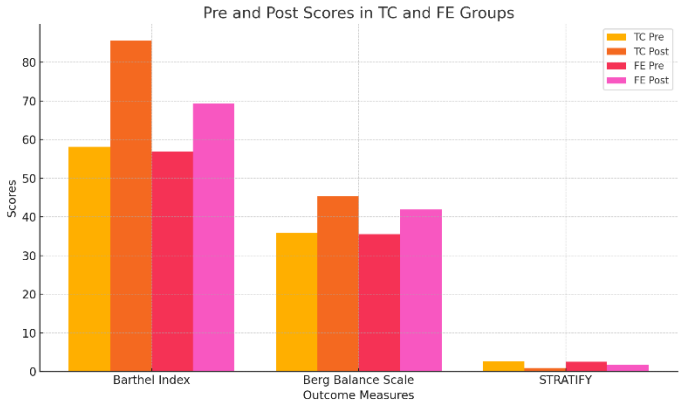


Figure 2 Pre and Post Scores in TC and FE Groups

Table 1 Between Group Studies of The Barthel Index Assessment

Variables	TC Group Mean ±S.D	FE Group Mean ±S. D	Sig.
Pre-intervention score	58.13 ±9.81	56.88 ±10.94	.736
Post-intervention score	85.63 ±7.93	69.38 ±9.81	.000

Table 2 Between Group Studies of Berg Balance Scale

Variables	TC Group Mean ±S. D	FE Group Mean ±S. D	Sig.
Pre-intervention score	35.81 ±4.34	35.50 ±4.38	.841
Post-intervention score	45.38 ±3.32	41.94±2.64	.003

Table 3 Between Group Studies of Fall Risk Assessment Tool (STRATIFY)

Variables	TC Group Mean ±S. D	FE Group Mean ±S. D	Sig.
Pre-intervention score	2.62± .957	2.56± .892	0.850
Post-intervention score	0.94± .680	1.68± .602	0.003

Table 4 ***Group-wise Outcome Comparison Table: Tai Chi vs. Frenkel's Exercises (Pre and Post Intervention)***

Measure	TC_ Pre	TC_ Post	FE_ Pre	FE_ Post	p_ value	p_ value_ post
Barthel Index	58.13	85.63	56.88	69.38	0.736	0
Berg Balance Scale	35.81	45.38	35.5	41.94	0.841	0.003
STRATIFY	2.62	0.94	2.56	1.68	0.85	0.003

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DISCUSSION

The current study demonstrated that stroke survivors who participated in Tai Chi exercises experienced significantly greater improvements in balance, fall risk reduction, and functional independence when compared to those who engaged in Frenkel's exercises. These findings contribute to the growing body of evidence supporting Tai Chi as an effective rehabilitative intervention for individuals recovering from stroke (6,8). Improvements observed in the Barthel Index, Berg Balance Scale, and STRATIFY scores reinforce the utility of incorporating balance-oriented, integrative movement therapies into stroke rehabilitation programs. While both groups showed within-group improvements over 12 weeks ($p < 0.05$), the post-intervention differences favored Tai Chi with strong statistical significance ($p < 0.001$), indicating a more robust impact on patient recovery outcomes (16). Previous research has emphasized the benefits of Frenkel's exercises, particularly in enhancing proprioceptive feedback and motor control, which are essential for restoring coordination post-stroke (17). These exercises rely on repetitive and visually guided limb movements, which are beneficial but may not fully address the multidimensional impairments seen in stroke survivors. In contrast, Tai Chi integrates controlled movement, body awareness, breathing regulation, and postural alignment. It offers a holistic intervention that not only targets neuromuscular coordination but also enhances lower limb strength, cognitive focus, and psychological well-being. Evidence from prior randomized trials has consistently shown that Tai Chi improves gait, balance, and overall quality of life in stroke patients, which aligns with the results of the present study (18).

The superiority of Tai Chi over Frenkel's exercises observed in this trial may be attributed to its dynamic nature, which challenges both static and reactive balance components (19). While Frenkel's exercises primarily involve seated or supported movements, Tai Chi includes a wider variety of functional, weight-shifting, and transitional postures, potentially providing a more comprehensive stimulus for neuromuscular recovery. The ability of Tai Chi to engage both the mind and body may also contribute to improved adherence, motivation, and psychosocial outcomes, although these factors were not measured in the current trial (20). This study's strengths include a well-defined sample, use of validated outcome measures, and a randomized design with blinded assessors, which collectively strengthen the internal validity of the findings. However, certain limitations must be acknowledged. The sample size, while adequately powered for primary outcome analysis, was relatively small and recruited using a non-probability sampling method, potentially limiting generalizability. Moreover, the absence of subgroup analyses by stroke type, gender, or age restricted the ability to determine whether specific subpopulations may have responded differently to the interventions. The short follow-up period of eight weeks also limited the assessment of long-term sustainability of functional gains.

Future research should consider larger multicenter trials with stratified randomization to capture subgroup variations. Incorporating follow-up assessments at 3, 6, and 12-months post-intervention could provide insights into the durability of treatment effects. Additionally, integrating qualitative feedback from participants may offer valuable perspectives on intervention feasibility, acceptability, and adherence. Exploring the neurophysiological mechanisms underlying Tai Chi's benefits through neuroimaging or electromyographic studies could further elucidate its role in neuroplasticity and motor re-learning post-stroke. In conclusion, while both Tai Chi and Frenkel's exercises contributed positively to stroke rehabilitation outcomes, Tai Chi demonstrated superior efficacy in enhancing functional independence, balance, and reducing fall risk. These findings support its inclusion as a recommended therapeutic modality in post-stroke rehabilitation protocols, with the potential to optimize recovery trajectories and improve quality of life for stroke survivors.

CONCLUSION

This study concluded that while both Tai Chi and Frenkel's exercises contributed positively to stroke rehabilitation, Tai Chi demonstrated more pronounced benefits in enhancing balance, reducing fall risk, and improving the ability to perform activities of daily living. These findings highlight the practical value of integrating Tai Chi into conventional rehabilitation programs for stroke survivors, offering a more holistic and functionally effective approach to restoring independence and mobility. The superior outcomes associated with Tai Chi support its application as a preferred therapeutic option in clinical practice, emphasizing its potential to positively impact recovery and quality of life in this population.

Author Contribution

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Author	Contribution
Faraha Naveed*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Syeda Pakeeza Bukhari	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Habiba Basit	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Asma Ghafoor	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Shamsa Tariq	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Aqsa Arif	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Hafiza Laraib Ijaz	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Ayesha Yousaf	Writing - Review & Editing, Assistance with Data Curation

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