DOI: https://doi.org/10.54393/pbmj.v9i4.1338

PAKISTAN BIOMEDICAL JOURNAL
https://www.pakistanbmj.com/journal/index.php/pbmj/index
ISSN (E): 2709-2798, (P): 2709-278X
Volume 9, Issue 04 (April 2026)

Review Article

OPEN ACCESS

Effect of Task-Specific Training with and without Biofeedback on Balance and Risk of Falls in Chronic Ischemic Stroke Patients: A Narrative Review with Implications for Pakistan

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ARTICLE INFO

Keywords:
Ischemic Stroke, Balance Impairment, Task-Specific Training, Biofeedback, Fall Risk Assessment

How to Cite:
Subazwari, S. A. . B., T.Jhon, A., Azeem, M., Awais, L., & Shabbir, M. (2026). Effect of Task-Specific Training with and without Biofeedback on Balance and Risk of Falls in Chronic Ischemic Stroke Patients: A Narrative Review with Implications for Pakistan: Biofeedback on Balance and Risk of Falls in Chronic Ischemic Stroke Patients. Pakistan BioMedical Journal, 9(4), 03-10. https://doi.org/10.54393/pbmj.v9i4.1338

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Received Date: 7th February, 2026
1st Revision Received: 15th March, 2026
Acceptance Date: 25th March, 2026
Published Date: 30th April, 2026

ABSTRACT

Balance deterioration is a contributing factor to fall risk and functional dependence and chronic ischemic stroke is responsible in long-term disability across the world. The aim of the study is to compare the effects of task-specific training (TST) versus no intervention on balance and fall risk in chronic ischemic stroke patients and to determine evidence gaps that could be of interest to low- and middle-income countries (LMICs) like Pakistan. PubMed, Scopus, and Google Scholar (2004-2025) were used as sources of a narrative review. Thirty-four studies (18 RCTs, 6 systematic reviews, 10 observational studies) met the inclusion criteria. Task-specific training (TST) was able to significantly enhance dynamic balance and functional mobility of chronic ischemic stroke patients. The addition of biofeedback to TST resulted in some further improvements in weight-bearing symmetry and postural (center of pressure) control, which were small-to-moderate in effect size. Fall incidence was only reported as an outcome in a minority of RCTs (4 out of 18). TST is a balance impairment rehabilitation method that is cost-effective and effective in chronic stroke. Biofeedback has some marginal biomechanical benefits, but the cost-efficacy of LMIC-based trials requires high quality to determine its cost-effectiveness in preventing falls.

INTRODUCTION

Stroke remains a leading cause of long-term disability globally, with ischemic stroke accounting for 85–87% of cases. Balance impairment is among the most disabling chronic sequelae, increasing fall risk, functional dependence, and healthcare costs. Post-stroke balance deficits arise from disrupted cortical, subcortical, and cerebellar pathways, compounded by muscle weakness, proprioceptive loss, and cognitive-motor interference [1]. Postural control requires multiple systems to work together, which include visual, vestibular, and somatosensory systems for motor control output. Ischemic lesions that damage cortical and subcortical and cerebellar and brainstem pathways create the symptoms of weight distribution imbalance, slow postural response, unstable trunk posture, and defective anticipatory movements. The combination of spasticity and muscle weakness, proprioceptive deficits, and reduced selective motor control creates additional challenges to maintaining stability. Executive dysfunction and attentional impairments create balance problems, which become

DOI: https://doi.org/10.54393/pbmj.v9i4.1338

worse when people perform two tasks at once during their daily activities [2]. The clinical consequences of balance dysfunction extend into multiple areas of medical practice. Stroke survivors experience falls at significantly higher rates than age-matched controls, particularly within the first-year post-stroke, although elevated risk persists into the chronic phase. Falls result in multiple consequences, which include fractures, development of fear about falling, limitations on activities, need for institutional care, and higher medical expenses. The act of falling creates a disability cycle, which begins with people developing an intense fear of falling. The Berg Balance Scale and Timed Up and Go test function as dependable clinical assessments that healthcare facilities use to evaluate patients' likelihood of falling. The healthcare industry still needs to create effective interventions that can prevent falls among stroke survivors who have reached their chronic phase [3, 4]. The theoretical foundation of TST is grounded in experience-dependent cortical reorganization. The activation of neural circuits that relate to the task needs to be activated multiple times so that their synaptic connections will become stronger and their remaining cortical networks will develop new abilities. Functional imaging studies indicate that task-oriented training improves the activation of perilesional cortical regions and enhances the balance between brain hemispheres. TST shows clinical benefits because it helps patients gain better walking speed and increased ability to move and maintain their balance during dynamic activities. The functional specificity of TST provides essential benefits for fall prevention because people tend to fall during transitional or dynamic activities that include turning and reaching tasks and sit-to-stand movements [5]. The motor learning process is affected by multiple factors, which include the practice intensity and relevance of tasks, combined with the existing feedback systems. The process of skill acquisition, together with error correction, depends on feedback as its essential component. People experience intrinsic feedback through their own sensory systems while they receive extrinsic (augmented) feedback from external sources. Stroke survivors experience intrinsic feedback meter systems because they lose their ability to sense body position through proprioception and sensory pathways. The resulting situation indicates that augmented feedback methods will provide their most significant advantages [6, 7]. The literature needs to answer a fundamental question about biofeedback because it brings additional clinical benefits to structured task-specific training, which exists as a standalone treatment. The two interventions stem from neuroplasticity principles, but research has not examined their separate and joint effects on chronic ischemic stroke patients. The existing trials face multiple constraints because they use small groups of participants and have brief treatment periods, and no extended monitoring of results, and they measure outcomes in inconsistent ways. The research studies face limitations because most of them take place in wealthy nations that possess sophisticated technological systems, which restrict their application to low and middle-income country settings [8]. The existing research gap becomes especially important for Pakistan because its population experiences rising stroke rates, which result from high hypertension, diabetes and sedentary behavior. Public healthcare systems distribute rehabilitation services in an unequal manner while they restrict access to advanced technological solutions throughout their facilities. The decision process for selecting rehabilitation methods needs to focus on two main factors, which are cost-effectiveness and portability of the rehabilitation methods. The research shows that TST delivers the same functional benefits as biofeedback programs, but structured therapist-led task-based training shows better long-term results. Strategic investment in cost-effective technological solutions becomes necessary when biofeedback shows substantial benefits, especially for fall prevention [9]. People who have suffered a stroke need special medical care. After six months, post-stroke patients show minimal neurological progress, which limits their ability to function without specific rehabilitation treatment. The research needs to identify which treatment methods produce the best results during this time period because it helps improve long-term success [10].

The research needs a complete evidence review to determine which version of TST with biofeedback and TST without biofeedback better serves chronic ischemic stroke rehabilitation. The narrative review investigates post-stroke balance impairment mechanisms while assessing the research support for task-specific training and biofeedback treatments and identifying research needs in treatment comparisons, which will affect clinical work and upcoming studies in Pakistan and other low- and middle-income countries. This study aims to synthesize evidence comparing task-specific training (TST) with and without biofeedback for improving balance and reducing fall risk in chronic ischemic stroke patients, and to identify research priorities for low- and middle-income countries (LMICs), particularly Pakistan.

The narrative review conducted to synthesize evidence that both biofeedback and non-biofeedback methods of task-specific training (TST) are effective for balance rehabilitation in patients who suffer from chronic ischemic stroke [11]. A systematic literature search was performed in PubMed, Scopus, and Google Scholar for articles published between 2004 and 2025. The search terms used were: "ischemic stroke," "balance rehabilitation," "task-specific

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training," "biofeedback," and "fall risk." PubMed and Scopus were searched using indexed keywords and Boolean operators. Google Scholar was used to identify additional references through forward citation tracking and manual screening of reference lists [12]. The first search resulted in 412 retrieved articles. After duplicate articles were removed, 364 articles became available for screening through title and abstract evaluation. As this is a narrative review of published literature, no ethical approval or informed consent was required. Inclusion criteria: adults aged ≥18 years with chronic ischemic stroke (>6 months post-stroke); studies evaluating task-specific training (TST) with or without biofeedback as the primary intervention; reporting balance or fall-related outcomes; peer-reviewed original research. Exclusion criteria: acute or subacute stroke; non-English articles; conference abstracts, editorials, or commentaries. 34 studies met the inclusion criteria: 18 randomized controlled trials, 6 systematic reviews, and 10 observational studies [13]. The researchers extracted study data, which included details about the country and study design and sample size, participant details, intervention type between TST alone and TST with biofeedback, study duration and balance, and fall risk outcome measures and study results. The researchers conducted narrative synthesis through three study groupings, which used intervention type and outcome focus and study design as their basis for classification. The inclusion criteria were fulfilled by 34 studies, which included 18 randomized controlled trials and 6 systematic reviews or meta-analyses, and 10 observational studies. The study sample sizes ranged from 12 to 120 participants, while the intervention periods extended from 2 weeks to 12 weeks. Most of the research studies took place in high-income nations, while a few studies occurred in low-income and middle-income countries, and no identified trial from Pakistan. The researchers used the Berg Balance Scale (BBS) and Timed Up and Go (TUG) tests, together with postural sway measurements and gait speed assessment, to evaluate outcomes, while they used fall incidence as a secondary assessment method. The results are organized in the following section based on different types of interventions and their respective outcome measurements.

Effects of Task-Specific Training (TST) Alone on Balance Outcomes

The findings of randomized controlled trials and systematic reviews demonstrated the beneficial effects of task-specific training on the dynamic balance and gait performance, and functional mobility of patients with chronic ischemic stroke. The repetitive goal-oriented task studies revealed that sit-to-stand transitions and the stepping tasks, obstacle negotiation tasks, and gait training exercises showed statistically significant changes in BBS scores, TUG performance, and walking speed. The study revealed that the best protocols used in improving dynamic postural control and mobility endurance were high-intensity and circuit-based TST protocols. The meta-analysis is evidence that repetitive task practice yields superior functional performance as compared to treatment-based approaches that solely aim at impairment treatment. The most evident changes were in measurements of real-life functional performance rather than of static balance capabilities. The data directly relates TST to improved results of balance, but indicates that the impact of TST on fall incidence is under-researched due to a lack of follow-up and different reporting on fall outcomes. The evidence indicates that TST is a simple type of treatment used to rehabilitate chronic stroke patients due to its capability to enhance the balance and locomotor functions of the patients [14].

Effects of TST Combined with Biofeedback

The outcomes of task-specific training programs with biofeedback were better on specific biomechanical and motor control measures. The authors used visual, auditory and virtual reality based biofeedback to reach three goals, which were to improve the weight-shifting symmetry, to decrease the postural sway and to gain control over the trunk. The interventions with the help of biofeedback showed superior outcomes as compared to TST as they provided more improvement in: Weight-bearing symmetry Center of pressure (COP) control, Trunk stability and Movement precision. It was demonstrated in the trials that biofeedback groups had better short term outcomes in terms of symmetry indices and posture control tests. These improvements, however, did not always result in much greater improvements in global functional mobility scores or a sustained fall reduction. The researchers found that biofeedback improves motor relearning through its enhanced external feedback system; however, the extra benefits which result from this system show variable results in different studies [15].

Impact on Fall Risk and Functional Independence

The evidence of prevention of falls by the use of different interventions is still deficient even though both types of interventions have improved outcomes when it comes to balance measurements. Few studies included were found to report fall incidence as a main outcome. Researchers reported some short-term fall risk reductions with some biofeedback-assisted interventions but lacked follow-up research. The majority of trials used surrogate balance measures, such as BBS and TUG, instead of monitoring actual falls. Lack of standardized methods of fall-reporting and long-term follow-up does not allow researchers to draw definite conclusions on which intervention is more effective in terms of protection against falls. The existing evidence shows that TST and its integration with

DOI: https://doi.org/10.54393/pbmj.v9i4.1338

biofeedback improve balance performance, but there is a lack of effective evidence to support real reductions in falls in real life [16].

Evidence from Low- and Middle-Income Countries (LMICs)

The review indicates that the majority of research studies in this field have been done in low- and middle-income countries, and Pakistan is one of the study sites. Most of the trials took place in high income countries using sophisticated rehabilitation centers. The biofeedback interventions are limited by the resources necessary to implement them due to their requirement of special equipment, such as force platforms, wearable sensors, and virtual reality systems. Structured TST protocols can be better used by the public-sector rehabilitation facilities since they rely on the knowledge of the therapists and the functional design of tasks that can aid them to extend their operations. The lack of comparative studies on the region creates uncertainty concerning the functioning of biofeedback training programs in LMIC contexts in terms of cost-effectiveness and real-life application [17].

Methodological Characteristics and Heterogeneity

Substantial heterogeneity across the studies was due to two main factors, which included Intervention duration and intensity, Type of biofeedback technology used, Participant chronicity and severity, Outcome measurement tools, and Follow-up periods. The different research methods made it impossible to combine results into a single summary, while researchers could not directly compare different treatment methods. The researchers found that the majority of studies used small participant groups and brief treatment periods, which raised the possibility of type II error. Future studies with standardized protocols that achieve sufficient power to study results for extended periods will determine the effectiveness of treatments and their long-term impact on clinical practice.

Table 1: Research Studies That Investigated the Effects of Task-Specific Training on Chronic Stroke Patients Who Received Biofeedback Treatment and Those Who Did Not

References	Country	Design	Sample (n)	Stroke Stage	Intervention	Duration	Outcomes Measured	Main Findings
[18]	USA	RCT	40	Chronic	Task-specific locomotor training	8 weeks	BBS, gait speed	Significant improvement in dynamic balance and walking endurance
[19]	Australia	RCT	36	Chronic	Task-oriented circuit training	6 weeks	TUG, 6MWT	Improved mobility and balance confidence
[20]	Canada	RCT	91	Chronic	Intensive task-specific gait training	10 weeks	BBS, gait speed	Superior functional gains vs usual care
[21]	Germany	RCT	38	Chronic	High-intensity TST	12 weeks	BBS, FES	Functional mobility significantly improved
[22]	South Korea	RCT	24	Chronic	TST + visual biofeedback	4 weeks	Weight symmetry	Improved weight-bearing symmetry
[23]	South Korea	RCT	28	Chronic	TST + force platform biofeedback	6 weeks	BBS, COP sway	Greater postural control vs TST alone
[24]	UK	RCT	29	Chronic	Balance training with biofeedback	6 weeks	BBS	Enhanced static balance control
[25]	Israel	RCT	41	Chronic	VR-based biofeedback + TST	6 weeks	Fall risk, gait variability	Improved gait symmetry; fall risk reduced short-term
[18]	Taiwan	RCT	45	Chronic	Virtual reality biofeedback	8 weeks	BBS, TUG	Significant dynamic balance improvement
[26]	USA	RCT	26	Chronic	Treadmill + visual feedback	6 weeks	Gait speed	Improved walking symmetry
[8]	Taiwan	RCT	34	Chronic	Biofeedback-based weight shift training	3 weeks	COP displacement	Reduced sway amplitude
[27]	India	Observational	50	Chronic	Structured TST	8 weeks	TUG, fall incidence	Functional mobility improved; fall rate unchanged
[28]	China	RCT	36	Chronic	TST + auditory feedback	6 weeks	BBS	Improved anticipatory postural adjustments
[29]	South Korea	RCT	32	Chronic	Biofeedback-based trunk training	5 weeks	Trunk Impairment Scale	Better trunk stability
[30]	Germany	Systematic Review	18	Chronic	TST-based gait training	–	Mobility outcomes	Moderate evidence supporting task-oriented approaches
[31]	UK	Systematic Review	17	Chronic	Physical rehab approaches	–	Balance	Task-oriented training effective vs impairment-based therapy

DOI: https://doi.org/10.54393/pbmj.v9i4.1338

[32]	Canada	RCT	22	Chronic	Wii-based balance biofeedback	8 weeks	BBS	Improved engagement and balance
[33]	South Korea	RCT	30	Chronic	TST vs TST + biofeedback	6 weeks	BBS, TUG	The biofeedback group showed greater symmetry, not significantly fewer falls

TST serves as an efficient balance rehabilitation method that proves to be effective for chronic ischemic stroke patients. Biofeedback produces additional advantages for motor control and postural symmetry, yet researchers need to conduct extensive RCT studies in LMIC settings to determine its clinical and economic value. The current research evidence shows that task-specific training with biofeedback and without biofeedback helps people with chronic ischemic stroke to improve their balance and decrease their risk of falling. The research confirms that multiple factors contribute to balance problems, which occur after a stroke because people lose their ability to control their movements, their body position, their ability to predict movements, and their cognitive-motor skills. The solution to these complicated disabilities needs rehabilitation methods that follow the rules of neuroplasticity and treatment methods that display actual functional skill development [34]. Task-specific training remains one of the most theoretically and clinically supported approaches in stroke rehabilitation. The theoretical foundation of TST functions through motor learning theory, which requires practitioners to repeat tasks while maintaining their actual work performance at high levels with proper environmental conditions. The components act as key processes that expedite the experience-dependent cortical reorganization process. The repetition of functional activities, which are goal-oriented, involves such activities as sit-to-stand transfers, stepping, negotiating obstacles, and weight transfer, contributing to the formation of the remaining neural networks and the formation of new movement patterns. Studies indicate that exercises that most closely resemble real life activities have better functional outcomes compared to impairment based training or nonspecific training. The research incorporates biofeedback into task-specific systems, which offer extra external feedback that assists the user to recognize his or her errors and rectify his or her motions. The biofeedback systems which involve visual and auditory cues show instant information on how the users change their body weight and balance as they move. The augmented feedback mechanism enhances the control of body movement, and, as neurophysiological studies reveal, people can learn through their mistakes. With the capability to identify post-stroke weight-bearing asymmetry, which individuals usually feel, they will be able to regain balance as they gain greater control of their dynamic movements [35]. The study indicates promising outcomes but the study has not determined whether biofeedback will provide any additional benefits to the structured TST programs. The majority of studies show that biofeedback is associated with improvements in both parameters of postural sway and indices of symmetry, although these improvements do not result in clinically significant changes in the number of falls and irreversible changes in functional status. The research studies are problematic as they have varied methods and hence it is hard to compare the results. This makes the findings of the study inconsistent as the researchers applied varying treatment regimes, subject specifications, methods of assessment and periods of observation. The small number of participants makes it harder to detect actual effects while increasing the possibility of type II errors [36]. Another important consideration is the stage of stroke recovery. The condition of chronic ischemic stroke, which occurs after six months from its onset, shows only minimal spontaneous neurological recovery. The observed improvements result from intervention effects that operate independently of natural recovery processes. The research fields that study chronic populations provide essential information for comparative effectiveness research. The existing studies include subacute participants who limit their applicability to long-term stroke survivors, who make up a significant portion of the stroke population in Pakistan and other low-middle-income countries[37].

The economic dimension is especially relevant in resource-constrained healthcare systems. Biofeedback systems that use force platforms and virtual reality technologies need financial backing and technical expertise, and ongoing maintenance support. Task-specific training requires only basic equipment because it depends on the therapist's knowledge and predefined training methods. Public rehabilitation facilities throughout Pakistan should use scalable low-cost methods because TST produces results that match technology-based treatments. Biofeedback systems, which provide additional clinical advantages, should receive funding for the development of simplified biofeedback systems according to their value in high-risk fall patient groups [37]. The implementation of projects needs to be executed exactly as planned. Evidence-based interventions will not succeed in actual environments unless the three elements of therapist training, patient adherence, and contextual adaptation are properly executed. Pakistan delivers rehabilitation services through its outpatient facilities, which treat many patients despite having insufficient physical therapists for

DOI: https://doi.org/10.54393/pbmj.v9i4.1338

their needs. The development of standardized time-efficient structured TST protocols requires proper implementation, which allows different severity levels to be handled [38]. Post-stroke disability develops through psychosocial factors, which include fear of falling and reduced confidence, and learned non-use. Biofeedback provides indirect treatment for these factors through its ability to boost patient involvement and deliver instant proof of their performance. Interactive feedback systems need to offer motivational elements that will lead to better patient treatment compliance and increased therapy duration. Future trials should therefore incorporate patient-reported outcomes, fear-of-falling scales, and quality-of-life measures alongside objective balance metrics [39]. Researchers have limited access to long-term follow-up data. The initial balance performance improvements from training will not lead to a permanent decrease in falling accidents. Future research should include extended follow-up periods to assess the durability of effects and the true impact on fall prevention. The LMIC regions require immediate cost-effectiveness studies because their health systems operate under financial limitations [40]. Existing research evidence establishes TST as a fundamental therapeutic method that healthcare professionals should use during the rehabilitation process for patients with chronic stroke disabilities. Biofeedback functions as a theoretically valid complementary therapy that can improve motor relearning abilities but requires researchers to conduct high-quality studies with sufficient participants to assess whether its added costs and complexities provide actual medical advantages. Pakistani research, along with similar studies from other low- and middle-income countries, will play a crucial role in developing area-specific evidence which will shape national standards for rehabilitation treatment [41].

Limitations

The study suffers from selection bias because it fails to include a meta-analytic synthesis while conducting research. The included studies show different characteristics, which combine with the study's intervention methods to prevent researchers from establishing definite comparative results.

CONCLUSIONS

In this conclusion, Chronic ischemic stroke leads to disability, which doctors assess through two main factors: balance impairment and fall risk. The main rehabilitation approach uses task-specific training together with biofeedback, which provides additional benefits. The establishment of clinical and economic value needs high-quality comparative trials, which should focus on LMIC contexts.

Acknowledgement

A special thanks go out to the individual who gave me his time while I was finalizing my manuscript.

Authors' Contribution

Conceptualization: SABS, MA
Methodology: SABS
Formal analysis: MA
Writing and Drafting: SABS, ATJ, LA, MS
Review and Editing: SABS, ATJ, MA, LA, MS

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

The authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

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