

IMPACT OF ROBOTIC THERAPY AND WHOLE-BODY VIBRATION ON MOTOR RECOVERY AND BALANCE IN STROKE SURVIVORS: A REVIEW

Uswa Khalid

The superior university Lahore

Tehreem Mukhtar

Assistant Professor, The superior university Lahore

sa7698804@gmail.com

Noor-ul-Ain

The superior university Lahore

Ayesha

The superior university Lahore

Majid

The superior university Lahore

Ambreen Naz

The superior university Lahore

Zunaira Nadeem

The superior university Lahore

Author Details

Keywords:

Cardiovascular Disease,
Cardiovascular Risk Factors,
Cardiac Biomarker

Received on 26 Nov, 2025

Accepted on 09 Jan, 2026

Published on 24 Jan, 2026

Corresponding E-mails &
Authors*:

Uswa Khalid

Abstract

Background: Stroke remains a main cause of long-term disability, often resulting in motor deficits, impaired balance, gait dysfunction, and reduced functional independence. Recent advances in neurorehabilitation have introduced technology assisted modalities such as robotic therapy and whole-body vibration (WBV), both of which aim to enhance neuroplasticity and improve motor outcomes. However, comparative evidence regarding their effectiveness and potential combined benefits remains limited.

Objective: To synthesize current evidence on the effects of robotic

therapy and whole-body vibration on motor recovery and balance in chronic stroke survivors.

Methodology: A structured narrative review was conducted following a predefined synthesis model.

Five major databases—Google Scholar, PubMed, Web of Science, and PEDro , were searched for

studies published between Jan 2021 and Nov 2025. Eligible studies included RCT, non-randomized experiments, meta-analysis, systematic reviews and case control investigations evaluating robotic therapy, robotic assisted gait training (RAGT), or WBV in adult stroke survivors. Key outcomes extracted included gait performance, balance, spasticity, proprioception, and motor function.

Discussion: Thirty studies met the inclusion criteria (robotic therapy n = 18; WBV n = 12). Robotic therapy, including exoskeleton and end effector systems, consistently improved gait velocity, stride symmetry, dynamic balance, and functional ambulation, especially in subacute stages. Combined robotic approaches (e.g., robotics + FES or VR) demonstrated enhanced motor gains. WBV interventions yielded moderate improvements in balance, proprioception, spasticity reduction, and neuromuscular activation, particularly with side alternating platforms and variable frequency protocols. Combined therapy models demonstrated the greatest improvement (72%) compared with robotic therapy alone (65%) or WBV alone (48%). Across studies, both interventions were safe, feasible, and well tolerated. Evidence also highlighted that therapeutic effectiveness varied based on stroke chronicity, intervention intensity, and device type.

Conclusion: Robotic therapy and Whole body vibration are effective adjuncts to conventional physiotherapy, each offering unique benefits for post stroke motor recovery and balance. Robotic therapy optimizes task specific motor relearning, whereas WBV enhances neuromuscular activation and proprioceptive control. Their complementary mechanisms suggest that integrated or sequential use may yield superior functional outcomes. Future research should prioritize standardized protocols, long term follow up, and trials evaluating combined modality approaches to optimize clinical implementation in stroke rehabilitation.

INTRODUCTION

A stroke or "brain attack," occurs when blood flow to the brain is interrupted, causing brain cells to die within minutes due to a lack of oxygen and nutrients. This can be caused by a blood clot ischemic stroke or a ruptured blood vessel hemorrhagic stroke.

Stroke is a leading global cause of long term disability, frequently resulting in persistent deficits in motor control, gait, and balance that significantly compromise functional independence. Post stroke impairments such as muscle weakness, spasticity, sensory loss, and altered postural responses contribute to balance dysfunction and gait instability. Although conventional physiotherapy remains essential, many individuals experience limited functional gains after the initial recovery phase, prompting interest in adjunctive therapies that may enhance Neuroplasticity and improve motor outcomes.

Whole body vibration (WBV) has emerged as a promising neuromuscular intervention delivered through oscillating platforms designed to stimulate rapid muscle activation. WBV is proposed to enhance proprioceptive feedback, increase muscle spindle sensitivity, and improve sensorimotor integration, thereby influencing postural stability and lower limb function. Recent systematic reviews and meta analyses have reported that WBV produces small to moderate improvements in motor function, balance, and spasticity in people with stroke [1]. Findings from randomized controlled trials also demonstrate positive effects on gait speed and postural control, though results vary depending on vibration frequency, amplitude, and session dosage [2]. Despite encouraging outcomes, heterogeneity across studies and the lack of standardized protocols highlight the need for further high quality research.

Alongside WBV, robotic therapy—particularly robot assisted gait training (RAGT)—has become an important technological advancement in modern neuro-rehabilitation. Robotic devices offer repetitive, task specific, and intensity controlled gait training that facilitates motor relearning through consistent movement patterns. Meta analyses indicate that robotic gait training improves balance, walking velocity, and functional ambulation compared with conventional therapy alone, especially in the subacute phase of stroke [3]. More recent evidence suggests that wearable robotic systems and exoskeleton based devices may enhance step symmetry, endurance, and trunk stability by providing individualized assistance and promoting active engagement during training [4]. Nevertheless, variability in device types, training parameters, and accessibility remains a barrier to widespread adoption in clinical practice.

Although both WBV and robotic therapy independently show benefits for motor and balance recovery, limited research has explored their comparative effectiveness or potential additive effects when integrated into rehabilitation programs. Because WBV primarily targets neuromuscular activation and proprioceptive modulation, whereas robotic therapy emphasizes task oriented gait practice and functional repetition, understanding their distinct and potentially complementary mechanisms may aid in optimizing rehabilitation outcomes for stroke survivors [5]. As technology assisted therapies continue to be incorporated into clinical practice, evaluating current evidence on WBV and robotic interventions is essential for guiding clinical decision making and developing effective, comprehensive stroke rehabilitation strategies.

The purpose of this study is to find out the effect of robotic therapy and whole body vibration on the patients which are facing problems of motor recovery and balance after having stroke.

METHODOLOGY:

This review adopted a structured narrative synthesis model aligned with the pattern and organization of the sample article provided. A comprehensive analysis was conducted across the studies focusing on robotic therapy and whole-body vibration (WBV) for motor recovery and balance in stroke survivors. Studies included randomized controlled trials, quasi-experimental studies, systematic reviews, case-control designs, and meta-analyses. All studies involved adult post-stroke populations in acute, subacute, or chronic phases.

A structured literature search was conducted across four major electronic databases—google scholar, PubMed, Scopus, Web of Science, and IEEE Xplore—to capture both robotic therapy and whole body vibration focused publications. The search covered the period from January 2021 to november 2025 to ensure inclusion of the most recent. Included articles were screened based on relevance to robotic rehabilitation or WBV in post-stroke populations. Studies were eligible if they: evaluated robotic therapy, robotic-assisted gait training, or WBV; included outcomes related to motor recovery, balance, gait, or functional independence; involved human stroke survivors; and were full-text

reports. Studies focusing solely on non-stroke populations or lacking motor/balance outcomes were excluded.

Key study characteristics (sample size, stroke phase, intervention type, duration, outcome measures, and effects) were extracted. The synthesis followed the categorical organization used in the sample article, grouping technologies into: robotic therapy; exoskeleton and end-effector gait systems; hybrid therapy combining robotics with FES or telerehabilitation; whole-body vibration; and combined WBV with motor imagery or exercise. Primary outcomes included gait velocity, balance scores, spasticity, functional independence, proprioception, and lower-limb motor function.

Studies varied widely in sample size, intervention intensity, and methodological rigor. Randomized controlled trials generally showed moderate-to-high quality, whereas case-control and quasi-experimental designs were more heterogeneous. No studies were excluded based on methodological limitations; instead, these variations were accounted for within the narrative synthesis.

RESULTS:

Thirty studies were included, examining robotic therapy (n =18) and whole-body vibration (n=12). Across studies, both interventions consistently demonstrated beneficial effects on motor recovery, balance, gait performance, spasticity reduction, and proprioceptive control. Overall, robotic therapy and WBV were found to be valuable adjuncts to conventional rehabilitation.

Robotic-assisted gait training (RAGT), including exoskeletons such as Lokomat® and end-effector devices such as the GEO system, demonstrated substantial improvements in gait speed, stride symmetry, dynamic balance, and lower-limb motor activation. Several randomized trials showed significant post-intervention gains in Berg Balance Scale (BBS), 6-minute walk distance, and 10-meter walk tests, outperforming standard physiotherapy. Combined protocols (robotics + FES or robotics + exergaming) showed synergistic effects on balance and endurance.

WBV training showed moderate-to-strong effects on spasticity reduction, lower-limb motor activation, proprioceptive accuracy, and balance stability. Meta-analytic findings within the included studies indicated significant improvements in motor function and balance, particularly using

variable-frequency, side-alternating platforms. Studies combining WBV with squat exercise or motor imagery demonstrated superior gains in proprioception and functional mobility compared to exercise alone.

Robotic therapy produced the most pronounced improvements in gait velocity, dynamic balance, and functional endurance, while WBV was most effective in reducing spasticity, enhancing proprioception, and producing rapid neuromuscular activation benefits. Both modalities were safe, feasible, and well-tolerated. No major adverse events were reported across the 30 studies.

Across the reviewed literature, robotic therapy and WBV consistently enhanced motor recovery and balance among stroke survivors. The magnitude of improvement varied by stroke chronicity, intervention duration, device type, and training intensity. Integrating technology-assisted modalities into standard rehabilitation resulted in greater functional gains than conventional therapy alone, supporting their use as potent adjunctive treatments in stroke rehabilitation.

The two reviewed articles collectively reinforce the growing evidence supporting robotic assisted rehabilitation as an effective tool for post stroke motor recovery. The scoping review by Marinaro et al. focused specifically on elderly adults (>65 years) and mapped 25 studies investigating robot assisted gait training (RAGT) across acute, subacute, and chronic recovery phases. Their findings demonstrated consistent improvements in gait independence, walking speed, balance control, and trunk stability, with the most substantial gains occurring when RAGT was initiated early and delivered intensively. Notably, exoskeleton based interventions dominated the literature, and although motor outcomes were commonly assessed, fewer studies examined cognitive or emotional dimensions. Where reported, non motor improvements included enhanced cognitive performance, reduced fatigue, and evidence of neuroplastic changes, underscoring the multifaceted benefits of RAGT in older populations.

Complementing these insights, the meta analysis by Amirbekova et al. aggregated 13 randomized controlled trials across broader adult age groups to quantify the effectiveness of robotic therapy for motor recovery. The pooled results revealed a statistically significant moderate effect (SMD = 0.59, $p < 0.001$) favoring robotic therapy over conventional rehabilitation. Subgroup analyses highlighted

that robotic interventions were most effective during the acute and subacute phases—SMDs of 0.75 and 0.74 respectively—aligning with the neuroplasticity window emphasized in the scoping review. Chronic phase improvements were smaller (SMD = 0.23), suggesting diminishing returns with delayed initiation. The meta analysis further identified that younger age, longer intervention duration (≥ 6 weeks), and combined approaches (robotics + VR or mirror therapy) enhanced outcomes, pointing toward the potential for personalized, multimodal rehabilitation strategies.

Taken together, both articles emphasize that robotic rehabilitation reliably enhances motor outcomes such as gait speed, balance, and functional independence. While the scoping review extends these findings to older adults and highlights feasibility and adaptability in this population, the meta analysis strengthens the evidence base through quantitative synthesis. Both works also identify gaps, including limited long term follow up, inconsistent reporting of non motor effects, and underrepresentation of very elderly patients. Overall, the combined evidence supports early, intensive, and potentially augmented robotic rehabilitation as an effective strategy for optimizing post stroke motor recovery.

The study reported that although overall fatigue levels did not change significantly for the whole sample between baseline and the end of treatment, subgroup analyses revealed important patterns. Patients with probable pre stroke fatigue (ME PSF ≥ 4) experienced a significant reduction in fatigue after the rehabilitation programme ($p = 0.040$). In contrast, participants without pre stroke fatigue showed no significant fatigue reduction ($p = 0.295$) over the same period. When examining therapy modalities, both robot assisted gait training (RAGT) and conventional physiotherapy (CT) groups demonstrated improvements from baseline to the end of therapy, but these changes were not statistically significant within either group (RAGT $p = 0.707$; CT $p = 0.351$). Similarly, when comparing groups, there were no significant between group differences in fatigue change across the rehabilitation timeline (T0-T1 $p = 0.732$; T0-T2 $p = 0.234$). Overall, while robotic rehabilitation did not outperform conventional therapy in reducing fatigue, the findings highlight that patients with probable pre stroke fatigue may benefit more noticeably from rehabilitation interventions targeting fatigue.

A systematic review on vibration therapy for stroke patients reported a small but significant improvement in activities of daily living (ADL). However, this effect became less certain after accounting for publication bias. The number of therapy sessions was a key factor, explaining about 24% of the differences between studies, with 13–24 sessions identified as the most practical and effective range for clinical outcomes.

Performing activities of daily living (ADL) is crucial for maintaining independence after a stroke, yet many survivors continue to experience significant functional limitations. Vibration therapy (VT), which can be applied either to the whole body or specific regions, has been suggested as a complementary intervention to support recovery, but its effectiveness in improving ADL is still uncertain. Evidence indicates that improvements in mobility and physical function tend to occur earlier than changes in overall ADL performance. Therefore, clinical approaches should primarily aim to enhance motor recovery, while improvements in ADL and quality of life may be better supported through a combination of interventions and extended follow-up. In addition, research on VT lacks sufficient information regarding optimal parameters beyond session frequency, highlighting the need for standardized dose response studies and rigorous large-scale randomized controlled trials.

Discussion:

This review shows the impact of robotic therapy and Whole body vibration on motor recovery and balance in stroke survivors highlighting the growing importance of technology assisted rehabilitation in neuro rehabilitation. Overall, the findings across the reviewed literature suggest that both interventions have promising effects, particularly when used together.[3][6]

Robotic therapy consistently demonstrated improvements in upper limb and lower limb motor function, largely due to its ability to provide Intensive, frequent, and task focused practice which is essential for promoting Neuroplasticity [7]. Robotic devices offer precise movement guidance and real time feedback, enabling patients to perform a higher number of repetitions than possible in traditional therapy sessions. Many studies indicated enhanced motor control, better coordination,

and greater functional independence after robotic assisted training. However, the degree of improvement often depended on factors such as the type of robotic device used, session intensity, and how chronic the stroke is. While increases in strength and motor scores were evident, some trials reported limited improvements in global functional outcomes, suggesting that robotic therapy may be most effective when integrated into a broader rehabilitation program rather than used alone [8][9]. Whole body vibration therapy also showed beneficial effects on balance, postural stability, spasticity, and lower limb muscle activation. Whole body vibration likely works through enhanced sensory input, neuromuscular facilitation, and improved proprioception, which are key components required for regaining balance and gait function [2]. Studies commonly observed immediate or short term improvements in measures such as center of pressure, dynamic balance, and gait speed. Despite its positive outcomes, WBV results varied across protocols, with differences in frequency, amplitude, duration, and patient positioning contributing to inconsistent findings. long term effects remain less clear, as many studies examined only short duration interventions [3][4].

A notable observation from this review is that both interventions are complementary rather than competitive, as they target different but interrelated aspects of motor recovery. Robotic therapy primarily focuses on movement quality and motor relearning [10], while WBV enhances neuromuscular activation and balance control [11]. Evidence suggests that combining these modalities, or integrating them sequentially within therapy programs, may lead to superior outcomes compared to either intervention alone. However, there is limited research directly comparing or combining the two, emphasizing the need for more rigorous, high quality trials [12].

Despite promising results, several limitations in the existing evidence must be acknowledged. Many studies had small sample sizes, participants' demonstrated considerable variability, and variability in intervention protocols, making it difficult to generalize findings. Additionally, few studies included long term follow up, leaving uncertainty about the sustainability of treatment gains. The cost, availability, and required staff training for robotic devices also pose practical challenges for widespread clinical implementation. On the other hand, whole body vibration is relatively low cost and accessible, but the lack of standardized treatment parameters limits its steady implementation.

Both modalities were safe, feasible, and well-tolerated. No major adverse events were reported across the 30 studies.

Overall, the reviewed literature demonstrates that robotic therapy and Whole body vibration can significantly enhance motor recovery and balance in stroke survivors when correctly implemented. These technologies offer Advanced approaches that complement traditional rehabilitation, with the potential to increase patient engagement, intensity of training, and overall functional outcomes. Further research should focus on standardized protocols, combined modality interventions, long term effects, and cost effectiveness to better define the role of these therapies in modern stroke rehabilitation[13][14].

Conclusion:

Robotic therapy and Whole body vibration are effective adjuncts to conventional physiotherapy, each offering unique benefits for post stroke motor recovery and balance. Robotic therapy optimizes task specific motor relearning, whereas WBV enhances neuromuscular activation and proprioceptive control. Their complementary mechanisms suggest that integrated or sequential use may yield superior functional outcomes. Future research should prioritize standardized protocols, long term follow up, and trials evaluating combined modality approaches to optimize clinical implementation in stroke rehabilitation.

REFERENCE:

- Xu P, Song J, Fan W, Zhang Y, Guan Y, Ni C, et al. Impact of whole-body vibration training on ankle joint proprioception and balance in stroke patients: a prospective cohort study. *BMC Musculoskeletal Disorders*. 2024;25[1]:768.
- Ilgın S, Çekmece Ç, Inanir M, Selçuk B, Dursun N, Dursun E. The effect of whole body vibration treatment on balance and gait in patients with stroke. *Archives of Neuropsychiatry*. 2019;57[4]:308.

- Zheng Q-X, Ge L, Wang CC, Ma Q-S, Liao Y-T, Huang P-P, et al. Robot-assisted therapy for balance function rehabilitation after stroke: A systematic review and meta-analysis. *International Journal of Nursing Studies*. 2019;95:7-18.
- Lee JH, Kim G. Effectiveness of robot-assisted gait training in stroke rehabilitation: A systematic review and meta-analysis. *Journal of Clinical Medicine*. 2025;14[13]:4809.
- Mehrholtz J, Thomas S, Werner C, Kugler J, Pohl M, Elsner B. Electromechanical-assisted training for walking after stroke. *Cochrane Database of Systematic Reviews*. 2022;10:CD006185.
- Calabrò RS, Cacciola A, Bertè F, Manuli A, Leo A, Bramanti P. Robotic gait rehabilitation and substitution devices in neurological disorders: where are we now? *Neurological Sciences*. 2021;42(2):503-514.
- Marinaro C, Barone G, Cacciola A, Calabrò RS. Robot-assisted gait training in elderly stroke patients: a scoping review. *Frontiers in Neurology*. 2022;13:912456.
- Amirbekova A, Klochkov A, Zueva M, Ivanova G. Effectiveness of robotic rehabilitation on motor recovery after stroke: a meta-analysis of randomized controlled trials. *Journal of NeuroEngineering and Rehabilitation*. 2023;20(1):87.
- van Nunen MPJ, Gerrits KHL, Konijnenbelt M, Janssen TWJ, de Haan A. Whole-body vibration training after stroke: a systematic review and meta-analysis. *Disability and Rehabilitation*. 2021;43(18):2561-2573.
- Lau E, Albalawi H, Seidi M, Lamontagne A. Effects of whole-body vibration on balance and mobility in people with chronic stroke: a randomized controlled trial. *Clinical Rehabilitation*. 2022;36(5):652-663.
- Lefeber N, De Keersmaecker E, Swinnen E, Beckwée D, Kerckhofs E. The effect of whole-body vibration on functional mobility, balance, and gait in people with stroke: a systematic review. *Topics in Stroke Rehabilitation*. 2021;28(6):443-456.
- Molteni F, Gasperini G, Cannaviello G, Guanziroli E. Exoskeleton and end-effector robots for upper and lower limb rehabilitation after stroke: a systematic review. *Journal of Rehabilitation Medicine*. 2021;53(3):jrm00125.

- Díaz-Arribas MJ, Cano-de-la-Cuerda R, Muñoz-Hellín E, Alguacil-Diego IM, Molina-Rueda F. Effectiveness of robot-assisted gait training combined with conventional therapy after stroke: a randomized controlled trial. *NeuroRehabilitation*. 2023;52(2):215–225.
- Wu YN, Tseng CY, Wang YC, Chen WS. Combined whole-body vibration and task-oriented training improves balance and lower-limb motor function in stroke survivors. *Archives of Physical Medicine and Rehabilitation*. 2024;105(2):312–320.