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Systematic Review

Weight-bearing asymmetry patterns in patients with stroke: a systematic review

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ABSTRACT

Stroke frequently results in weight-bearing asymmetry (WBA), a common motor impairment that negatively affects postural stability, gait, and increases fall risk. Identifying asymmetry patterns and reliable assessment methods is essential for individualized rehabilitation. This systematic review synthesized evidence on weight-bearing asymmetry patterns in stroke survivors and the tools used to assess and quantify them. The review followed PRISMA guidelines. A literature search of PubMed and Google Scholar identified randomized controlled trials published between 2015 and 2025 using keywords related to stroke, hemiplegia, weight bearing, postural control, postural sway, asymmetry patterns, and measurement methods. Eligible studies included individuals with stroke, objective evaluation of WBA, and reporting of asymmetry patterns and measurement tools. Data extraction focused on asymmetry types, assessment methods, and intervention approaches. 7 randomized controlled trials involving approximately 266 participants were included. Common WBA patterns included greater loading on the non-paretic limb, lateral weight shift, and reduced paretic limb loading during static and dynamic tasks. Measurement tools included force platforms, GAITRite systems, weight-bearing scales, and clinical balance measures. Interventions including insoles, weighted gait training, modified sit-to-stand training emphasizing symmetry, ankle–foot orthoses, shoe lifts on the non-paretic limb, tilt-based postural training, and weight-shift-triggered electrical stimulation improved symmetry indices and functional outcomes. Force platforms and symmetry indices were the most reliable methods for capturing static and dynamic asymmetries. Accurate assessment combined with targeted interventions can enhance postural control, gait symmetry, and functional recovery after stroke survivors during rehabilitation programs and clinical practice.

Keywords: Stroke, Weight-bearing asymmetry, Postural control

INTRODUCTION

Stroke often result in motor impairments, postural instability, and reduced weight-bearing symmetry when standing and walking, making them a major cause of long-term disability globally. Weight-bearing asymmetry (WBA), which is defined as an unequal distribution of body weight between the paretic and non-paretic limbs, is one of the most common motor deficits that occur after a stroke. Reduced mobility, poor balance control, and an elevated risk of falls are all further exacerbated by this imbalance.[2,3]

The pattern of hemiparesis, the extent of neurological impairment, and the stage of stroke recovery can all affect the kind and severity of WBA. Following a stroke, people have been found to exhibit patterns such lateral asymmetry (weight shift more toward one limb), antero-posterior asymmetry (unequal load on forefoot versus heel), and diagonal alterations in centre of pressure (COP).[1,3] These patterns of asymmetry have neurophysiological roots that are connected to sensorimotor dysfunction and compromised postural responses, in addition to being biomechanical results.

To better understand these weight shifts, researchers and clinicians use various measurement tools. Some rely on advanced equipment like force platforms and pressure-sensitive mats, while others use more accessible tools such as clinical balance tests or weight distribution scales.[5,7] These methods help track how much weight a person is placing on each leg and how well they are maintaining balance. Despite the variety of tools available, there's still no universal agreement on which method is best for assessing weight-bearing asymmetry. Furthermore, the way individuals compensate for their deficits varies greatly. That's why it's important to look closely at both the types of asymmetries that exist and the ways we can measure them effectively.[2,6]

This systematic review aims to bring clarity to this topic by exploring the different patterns of weight-bearing asymmetry seen in people after a stroke and the tools and methods used to assess and quantify these patterns. By understanding these aspects better, we can work towards more personalized and effective rehabilitation strategies for stroke survivors.

METHODS

This systematic review was done and detailed in compliance with the preferred reporting items for systematic reviews (PRISMA) guidelines, from May 2025- July 2025 at DVVPF's College of Physiotherapy, Ahilyanagar, Maharashtra, India. This systematic review included 7 RCTs with the combined count of 266 participants in all (Table 2).

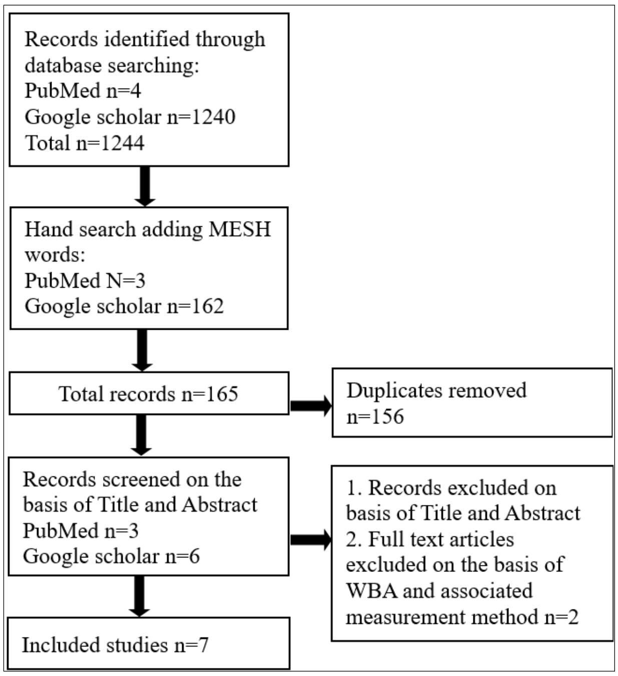

Figure 1: Flowchart of systematic review of weight bearing asymmetry patterns and measurement methods used.

Eligibility criteria

To be included studies had to meet the following eligibility criteria like publication type: the type of studies included in this review are the randomized control trials, participants: subjects had to have sustained a stroke, regardless of stroke type or post-stroke duration, outcome measures: the study contained data on the association between WBA patterns and the methods used to measure them.

Intervention studies aimed at restoring weight-bearing symmetry were only considered for inclusion if they reported on the association between WBA and postural control. Measures for WBA were accepted if they quantified the differences in weight borne on either leg, and language: the study was written in the English language.

Information sources

A literature search was performed to recognize all qualified randomized controlled trials. An electronic search of the literature was conducted to identify relevant studies from the databases like: PubMed and Google scholar. The retrieving of the studies was set from 2015 to 2025 for the published articles.

Search strategy

The following MESH terms were used for the search; "Stroke," "Cerebral", "Cerebrovascular", "Hemiplegia", "Weight-Bearing", "Postural control", "Postural sway", "weight bearing asymmetry", "Asymmetry in standing", "Asymmetry patterns", "measurement methods" and "Randomized control trials"

Study selection

First, the titles and abstracts of the publications retrieved by electronic searching were screened. Second, potentially eligible studies were retrieved full text before definitive inclusion. Only RCTs from 2015-2025 are included.

Data extraction

Data were extracted from the studies and then checked. The extracted data were discussed until consensus was reached. No specific form was used for data extraction; however, the outcomes to be extracted were defined a priori.

The following information was extracted from each study; author and year of publication, study design, study population with number of participants, interventions provided for experimental and control groups, asymmetry measurement tools and parameters used, results in the form of: symmetry pattern quantification and asymmetry pattern observed.

RESULTS

Study selection

A total of 7 randomized controlled trials (RCTs) published between 2015 and 2025 were included based on their relevance to WBA in individuals with stroke. Studies were selected if they involved stroke survivors (acute, subacute, or chronic phase) with the ability to stand independently, investigated interventions targeting WBA, used objective tools to quantify asymmetry and reported outcomes on symmetry patterns, load distribution, and postural control.

Study characteristics

The included studies involved a cumulative sample of approximately 260 participants with either hemiplegia or hemiparesis, primarily in the chronic or subacute stroke phases. Interventions included insoles for non-paretic lower limb, weighted gait training, modified sit-to-stand training, ankle foot orthosis, shoe lifts for non-paretic lower limb, tilt-based postural training and weight-shift-triggered electrical stimulation.[1-3,5-7]

Quality of reporting in individual studies

Every study used an RCT design with thorough details of the methodology and interventions. The majority made use of trustworthy and validated measurement instruments such balance tests (BBS, FMA), force plates, weight-bearing scales, and GAIT Rite systems. In order to ensure objective reporting of results, symmetry indices were employed in a number of research to measure load distribution and asymmetry patterns.

Methodological quality assessment using PEDro scale

The methodological quality of the included RCTs was assessed using the PEDro (physiotherapy evidence database) scale, which evaluates internal validity and the interpretability of trial results. The scale comprises 11 items, of which 10 contribute to the total score (maximum score: 10). These items assess key methodological aspects such as random allocation, allocation concealment, baseline comparability, blinding, follow-up adequacy, intention-to-treat analysis, and statistical reporting.

Overall, the methodological quality of the included studies ranged from moderate to good. Most studies adequately reported randomization, baseline comparability, and outcome measures. However, frequent limitations included the absence of therapist and participant blinding, and unclear reporting on allocation concealment and intention-to-treat analysis. These limitations reflect the practical challenges of conducting rehabilitation trials but underscore the need for improved methodological transparency in future research (Table 1).

The analysed RCTs consistently show that patients with Stroke have asymmetric weight-bearing, which is usually characterized by a greater dependence on the non-paretic limb. Both static (standing) and dynamic (gait, sit-to-stand) situations exhibit this asymmetry. Key patterns identified as reduced load on paretic limb, increased sway and CoP displacement and lateralized postural control deviations.

Summary of all the included study was presented in Table 2.

Although there were many other measurement instruments, the most commonly used techniques for measuring asymmetry patterns were force plates and symmetry indices. While their effects on postural control and long-term results vary, interventions like gait retraining, neuromuscular stimulation, and orthotic devices (AFO, insoles, shoe lifts) have shown promise in enhancing symmetry. Overall, addressing weight-bearing asymmetry with targeted rehabilitation strategies is crucial for enhancing post-stroke mobility and balance (Table 3).

Table 1: Quality of included studies based on PEDro scale.

Study	PEDro score	Strengths and weaknesses
Kim et al, 2015[21]	5–6/10	Reported randomization and outcome measures; lacked therapist/subject blinding
Sheikh et al, 2017[7]	5–6/10	Used force plates; unclear on allocation concealment and blinding procedures
Park et al, 2024[3]	6–7/10	Good outcome reporting with GAIT Rite; blinding not clearly stated
Liu et al, 2016[1]	6–7/10	Symmetry index calculation; intention-to-treat analysis not specified
Lee et al, 2023[5]	7–8/10	Reported use of validated scales (BBS, FMA); assessor blinding likely; good statistical reporting
Ribeiro et al, 2020[2]	6–7/10	Time-based asymmetry assessment; adequate reporting, but blinding unclear
An et al, 2021[6]	6–7/10	Used tilt-feedback and CoP analysis; therapist/subject blinding not described

Table 2: Summary of included studies.

Study	Design	Population	Intervention	Control	Tools/method	Parameters measured	Symmetry pattern quantification	Asymmetry distribution	Conclusion
Park et al, 2024	RCT	Patients with chronic hemiplegia	Application of insoles to the sound-side lower extremity during walking	Walking without insoles	GAITRite system and pressure sensors	Stance time, step length, weight distribution	Load distribution ratio, gait symmetry	Asymmetric stance and gait patterns; 1 weight-bearing on hemiplegic side; 1 stance time on sound side	Immediate improvements in gait symmetry and weight distribution observed with insole application, suggesting potential for enhancing walking function in chronic hemiplegic patients.
Lee et al, 2023	RCT	Chronic stroke patients	Weight-shift-triggered electrical stimulation	Balance training only	Force plates, Berg balance scale (BBS), Fugl- Meyer assessment (FMA)	Static/dynamic balance, lower-limb motor recovery	Balance symmetry index, center of pressure (CoP) weight distribution	Less weight borne on the paretic limb during standing tasks	Weight-shift-triggered stimulation improved symmetry and functional outcomes more effectively than conventional balance training.
An et al, 2021	RCT	Subacute stroke patients with lateropulsion	Tilt-based postural training	Conventional therapy	Force platform and clinical balance tests	Weight-bearing asymmetry (WBA), functional postural control	Limb load symmetry assessed during weight-shift training	Decreased dynamic loading on the paretic side during functional tasks	Tilt-device training significantly reduced weight-bearing asymmetry compared with the control group.
Ribeiro et al, 2020	RCT	30 post-stroke patients with hemiparesis	Gait training with additional load on the non-paretic limb	Gait training without additional load	Force platforms	Ground reaction force (GRF), stance and swing times	Symmetry index (SI) for WBA and gait	Lateral weight-shift bias toward the non-paretic side	Significant improvement in weight-bearing symmetry in the intervention group; however, no significant changes were observed in temporal gait asymmetry.
Sheikh et al, 2017	RCT	27 chronic stroke patients	Shoe lift on the non- paretic limb	No shoe lift	Force plates	Weight-bearing asymmetry (WBA), CoP velocity	WBA index, CoP sway area and velocity	1 Load on paretic side; T load on non-paretic side	Shoe lift intervention shifted weight toward the paretic side and improved symmetry, but resulted in minimal improvements in postural control.

Continued.

Study	Design	Population	Intervention	Control	Tools/method	Parameters measured	Symmetry pattern quantification	Asymmetry distribution	Conclusion
Liu et al, 2016	RCT	40 patients with chronic hemiplegic stroke	Modified sit-to-stand (STS) training focusing on weight-bearing symmetry	Conventional balance training	Force platforms measuring vertical ground reaction force (vGRF) during STS	vGRF of each limb; balance assessments using BBS	Symmetry Index (SI) calculated from affected and unaffected limb vGRF (lower SI indicates better symmetry)	Increased reliance on the non-paretic limb and asymmetric static stance	Significant improvements in weight-bearing symmetry and balance control were observed in the intervention group compared with controls.
Kim et al, 2015	RCT	16 chronic stroke patients	Ankle-foot orthosis (AFO) during functional standing tasks	No AFO	Weight-bearing scales	Weight distribution during standing	Percentage weight-bearing per limb	Weight-bearing asymmetry during sit-to-stand, with greater loading on the non-paretic limb	AFO use improved paretic-side weight-bearing during sit-to-stand and static standing tasks.

Table 3: Overview of weight bearing asymmetry in stroke: patterns, methods and findings.

Author	Asymmetry pattern	Measurement method	Key observations
Kim et al, 2015[21]	Reduced weight-bearing on paretic side during standing	Weight-bearing scales	Quantified percentage of body weight distribution; detected improvement with AFO use
Sheikh et al, 2017[7]; An et al, 2021[6]	Lateral shift of weight to non-paretic limb in static stance	Force plates + centre of pressure (CoP) analysis	Captured CoP displacement and WBA index; effective in measuring static asymmetry and postural control shifts
Park et al, 2024[3]	Increased stance time and step length on non-paretic limb during gait	GAIT rite system and pressure sensors	Gait analysis revealed improved symmetry with insoles; sensitive to dynamic gait asymmetry
Liu et al, 2016[1]	Greater vertical ground reaction force (vGRF) on non-paretic limb during sit-to-stand	Dual force platforms	Allowed calculation of symmetry index (SI); showed direct improvement in weight distribution post-intervention
Lee et al, 2023[5]	Dynamic underloading of paretic limb during functional tasks	Force plates with CoP distribution and balance tests (BBS, FMA)	Detected symmetry improvement with stimulation-based intervention; sensitive to both static and dynamic shifts
Ribeiro et al, 2020[2]	Temporal asymmetry in gait cycles (e.g., altered swing/stance time)	Force platforms with symmetry index calculation	Effective in measuring time-based asymmetry and load response during walking
An et al, 2021[6]	Postural asymmetry due to lateropulsion (weight-shift bias)	Tilt-based postural feedback with force platforms	Detected biased weight shift; tilt device helped recalibrate symmetry

DISCUSSION

All studies reported a consistent trend of asymmetrical weight bearing pattern, where stroke patients showed less loading on the paretic leg, according to a consistent trend of unequal weight distribution documented in all studies. Muscle weakening, altered proprioceptive signals, and motor deficits following a stroke are likely the causes of this pattern. This systematic review examined the different weight-bearing asymmetry (WBA) patterns in stroke patients, as well as the approaches to measurement and treatment. The results show that multiple methods are used to quantify and intervene in WBA, and that different studies have varied technology, asymmetry profiles, and outcomes.

Measurement tools

Several measurement tools were used across the reviewed RCTs, each offering specific strengths:

Force platforms/plates are highly accurate for capturing ground reaction forces (GRF), centre of pressure (CoP), and symmetry indices (vertical and lateral asymmetries).[1,2,5,6,7] They offer objective and quantitative data crucial for both dynamic and static balance evaluation.

GAIT rite system/pressure sensors provide detailed spatiotemporal parameters during gait, such as stance time and step length.[3] Particularly useful in detecting subtle gait asymmetries and responses to interventions like insole use. Weight-bearing scales are easy to use and allow quick assessment of limb loading in clinical settings, though they may not offer the granularity of force platforms.[3]

Clinical balance tools like the Berg balance scale (BBS) and Fugl-Meyer assessment (FMA) complement objective measures by evaluating functional improvements and motor recovery.[5,6]

Asymmetry patterns observed

The studies showed recurring asymmetry patterns, with most patients shifting weight toward the non-paretic (sound) limb.

Increased stance time and load on the non-paretic side

This pattern was consistently observed. This asymmetry is often a compensatory response to instability, weakness, or reduced proprioception on the affected side.

Reduced paretic-side weight-bearing in both static and dynamic tasks

Noted minimal loading on the paretic limb during standing and movement.[3,5] This pattern reinforces asymmetry and may hinder motor recovery over time.

Lateral weight shift or lateropulsion towards non-paretic side

Specifically observed in subacute patients with perceptual deficits like Pusher's syndrome or impaired midline orientation, leading to biased postural orientation toward the non-paretic side.

Sit-to-stand asymmetry

Where vertical ground reaction force data indicated offloading of the paretic side.[1] Specific tasks like sit-to-stand magnify asymmetry due to the high demand for lower limb coordination and strength.

Interventions to reduce WBA

A wide range of interventions were described in articles:

Insole application on sound side

By placing an insole on the non-paretic (sound) limb, the limb is slightly elevated, leading to a biomechanical shift that encourages greater weight transfer to the paretic limb. Immediate improvement in weight distribution and gait symmetry during walking.

This method is simple, low-cost, and provides instant feedback and adjustment.[3]

Shoe lift on sound side

Similar to the insole strategy, a shoe lift causes a limb-length discrepancy, prompting a shift of weight toward the shorter (paretic) side. Promotes midline alignment during standing. Statistically significant improvement in WBA, but minimal change in postural control (CoP sway metrics), suggesting it improves symmetry more than dynamic balance.[7]

Additional load on the sound side

During gait training, an extra weight (usually a cuff weight) is applied to the non-paretic limb, forcing the individual to rely more on the paretic limb for support and propulsion. This is based on the principle of constraint-induced movement therapy, adapted for the lower limbs. Significant improvement in WBA, though less impact was observed on temporal parameters like step timing.[2]

Modified sit-to-stand training

Patients practiced repeated sit-to-stand movements with emphasis on symmetrical loading, using cues or targets to promote equal weight-bearing. Force platforms measured vertical ground reaction force (vGRF) per limb to guide and evaluate training. Improved WBA and balance, as well as increased awareness of paretic limb use in functional transfers.[1]

Assistive orthotics for paretic side

The AFO provides external support and alignment to the ankle joint of the paretic limb, enhancing stability and confidence to bear weight. Static standing and sit-to-stand transitions were the targeted activities. Improved weight-bearing on the paretic limb; clinically useful for patients with ankle instability or foot drop.[3]

Tilt-based postural training

A tilt device was used to train lateral weight shifts and correct lateropulsion, a condition where patients actively push toward the paretic side. Training emphasized symmetrical postural control through guided tilting and proprioceptive feedback. Marked improvement in postural symmetry and weight distribution, particularly effective in subacute patients with lateral bias.[6]

Weight-shift-triggered electrical stimulation

Electrical stimulation was applied to the paretic limb only when a sufficient amount of weight shift was detected onto that limb. A feedback loop encourages symmetrical loading through a reward-based mechanism. Superior improvement in symmetry, dynamic balance (as measured by BBS), and lower limb motor recovery (FMA), compared to traditional balance training.[5]

Common parameters used and effects of interventions on them

Symmetry index and weight-bearing ratio

Parameter used

The symmetry index quantifies the proportional difference in weight-bearing or force output between paretic and non-paretic limbs. A lower symmetry index (SI) indicates improved symmetry.

Effect of interventions

Gait training with additional load on the non-paretic limb significantly reduced SI, indicating improved weight-bearing symmetry.[2]

Sit-to-stand (STS) training led to decreased SI values, reflecting enhanced symmetry in vertical ground reaction force (vGRF) distribution.[1] Weight-shift-triggered electrical stimulation further reduced SI during balance tasks, outperforming traditional balance training.[5]

Ground reaction force and centre of pressure

Parameter used

Ground reaction force (vGRF) reflects the force applied by each limb during movement or stance. Centre of pressure (CoP) measures (sway area, velocity) are indicators of balance control and postural stability.

Effect of interventions

STS training increased vGRF on the paretic side, promoting more even load sharing between limbs.[1]

Shoe lift corrected weight-bearing asymmetry but showed minimal change in CoP sway metrics, indicating limited effect on dynamic balance.[7]

Electrical stimulation improved CoP distribution and reduced sway velocity, suggesting better postural stability and control.[5]

Stance/swing time and step length (temporal gait parameters)

Parameter used

These temporal metrics assess the timing and symmetry of gait phases, providing insight into dynamic walking balance.

Effect of interventions

Insole application improved stance time and step length symmetry, promoting more balanced gait.[3]

Despite improvements in weight distribution, temporal gait asymmetry (e.g., swing time) showed minimal change, indicating that such parameters may be less responsive or slower to improve without specific gait retraining.[2]

Clinical scores: Berg balance scale and Fugl-Meyer assessment

Parameter used

Berg balance scale (BBS) evaluates functional balance through task performance. Fugl-Meyer assessment (FMA) measures lower limb motor recovery post-stroke.

Effect of interventions

Weight-shift-triggered stimulation significantly improved both BBS and FMA scores, reflecting enhanced functional balance and motor recovery.[5]

STS training also improved BBS scores, linking improved mechanical symmetry to better clinical performance.[1]

Clinical implications

Taken together, the evidence supports the use of individualized, task-specific rehabilitation strategies that target WBA. Clinicians should assess asymmetry using tools appropriate for the task (e.g., gait vs. standing) and consider interventions like orthotics, weight-shift training, or technology-assisted feedback depending on the nature and severity of asymmetry. While most interventions improved symmetry to some extent, combining sensory-motor retraining with biomechanical support appears to offer the most consistent functional gains.

Limitations

Some limitations were noted, including small sample sizes (e.g., Kim et al study had only 16 participants); lack of long-term follow-up in most studies; due to heterogenicity in the outcome measures and asymmetry indices, the meta-analysis cannot be conducted.

Future studies should adopt standardized outcome measures, ensure adequate sample sizes, and incorporate longitudinal follow-up to evaluate sustained effects on symmetry and fall risk.

CONCLUSION

Stroke survivors typically shift weight onto their non-paretic limb, but targeted interventions from orthotic aids to biofeedback devices can help restore balance, with effectiveness depending on the task and approach. Reliable measurement tools like symmetry indices and force platforms are vital for identifying asymmetries and tracking progress. Combining objective assessments with personalized interventions supports better weight-bearing symmetry and functional recovery.

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