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Original Article

# Comparison Between Balance, Gait and Functional Independence Among Stroke Survivors Using Orthotic Support and Non-Users: A Comparative Cross-Sectional Study

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## ABSTRACT

Background: Stroke-related impairments restrict balance, walking, and daily functioning. Examining functional differences by ankle-foot orthosis (AFO) use may inform local rehabilitation research. Objective: To compare balance, gait performance, and functional independence between stroke survivors using AFOs and non-users. Methods: A comparative cross-sectional study recruited 60 stroke survivors through convenience sampling at three hospitals and rehabilitation facilities in Lahore, Pakistan, over six months. Participants comprised 30 AFO users and 30 non-users. Outcomes were assessed using the Berg Balance Scale (BBS), 10-Meter Walk Test, and Functional Independence Measure (FIM). Unadjusted comparisons used Welch's independent-samples t-tests, with approximate 95% confidence intervals calculated from reported summary statistics. Results: Mean age was 56.53 ± 10.42 years; 50.0% were male. AFO users had higher BBS scores (42.10 ± 2.76 versus 20.27 ± 4.17), faster walking speed (0.77 ± 0.11 versus 0.45 ± 0.09 m/s), and higher FIM scores (65.60 ± 3.04 versus 49.03 ± 3.12). Between-group differences were 21.83 points (95% CI, 20.00–23.66), 0.32 m/s (0.27–0.37), and 16.57 points (14.98–18.16), respectively; all $p < 0.001$. Conclusion: AFO use was associated with better balance, walking speed, and functional independence. Unadjusted cross-sectional comparisons cannot establish causality. Keywords: Stroke; Ankle-Foot Orthosis; Balance; Walking Speed; Functional Independence; Rehabilitation.

## INTRODUCTION

Stroke remains a major cause of death and long-term disability worldwide, with consequences that extend beyond the acute neurological event to persistent limitations in mobility and everyday functioning (1). Among stroke survivors, muscle weakness, impaired postural control, and abnormal gait can restrict independent activity and increase dependence on caregivers. Rehabilitation therefore aims to address functional limitations alongside the underlying impairments. Evidence concerning delayed post-stroke rehabilitation also highlights the importance of rehabilitation provision when interpreting functional outcomes, particularly when comparing patients with different treatment histories (2).

Ankle-foot orthoses (AFOs) are commonly prescribed to address lower-limb impairments that interfere with standing and walking after stroke. By supporting ankle alignment and controlling ankle motion, these devices may facilitate foot clearance during swing and improve stability during stance. Systematic reviews have examined their effects on walking performance and broader functional outcomes, while an AFO-specific clinical practice guideline supports their use according to individual rehabilitation needs and goals (3–5). Evidence from randomized trials has also been synthesized to evaluate the effects of AFOs and continuous functional electrical stimulation on walking speed after stroke (6). Together, these studies support the clinical relevance of orthotic management, although outcomes require interpretation in relation to patient characteristics, the outcome assessed, and the conditions under which the device is used (3–6).

The relationship between orthotic use and functional recovery is nevertheless more complex than the provision of mechanical support alone. A prospective rehabilitation study evaluated AFO use alongside rehabilitation using walking and functional independence measures, illustrating the importance of considering orthotic management within the wider rehabilitation process (7). Comparisons of existing AFO users and non-users address a different question from studies evaluating the same individual with and without an orthosis or before and after treatment. Between-person differences may reflect orthotic use, but they may also reflect differences in clinical indication, time since stroke, impairment severity, and rehabilitation exposure. Consequently, cross-sectional comparisons can describe associations with AFO-use status but cannot independently establish that orthotic use caused better function.

Assessment across complementary functional domains can provide a broader description of these associations than a single mobility measure. The Berg Balance Scale (BBS) assesses performance on balance tasks, whereas timed walking assessment provides information about walking ability and speed (8,9). The Functional Independence Measure (FIM) evaluates assistance requirements across daily activities, extending assessment beyond balance and walking performance alone (10). Using these measures together allows balance, gait speed, and functional independence to be examined as related but distinct outcomes. This distinction is important because better performance in one domain does not necessarily indicate equivalent independence across other daily activities.

Previous reviews have examined AFO-related walking-speed outcomes, ankle kinematics, and the clinical measures used to evaluate orthotic management after stroke (11–13). This literature establishes a foundation for investigating functional outcomes but does not directly characterize differences between existing AFO users and non-users attending the participating rehabilitation facilities in Lahore. The specific question addressed here is whether AFO-use status is associated with differences across balance, walking speed, and functional independence within this clinical population. Examining these outcomes concurrently can provide a locally situated description of functional status while preserving the distinction between an observed association and an orthotic treatment effect.

Accordingly, this comparative cross-sectional study aimed to compare balance, gait performance, and functional independence between stroke survivors using AFOs and those not using lower-limb orthotic devices at three hospitals and rehabilitation facilities in Lahore, Pakistan. Balance was assessed using the BBS, gait performance using walking speed measured by the 10-Meter Walk Test, and functional independence using the FIM. The study sought to determine whether these outcomes differed between the two groups at assessment, without attributing any observed differences causally to AFO use.

## MATERIAL AND METHODS

A comparative cross-sectional study was conducted to examine differences in balance, gait performance, and functional independence between stroke survivors using ankle-foot orthoses (AFOs) and those not using lower-limb orthotic devices. The design permitted comparison of functional status according to existing orthotic-use status at assessment. The study was conducted over six months at Hameed Latif Hospital, Hope Rehabilitation Center, and Sheikh Zayed Hospital in Lahore, Pakistan.

The study population comprised adults aged 40–80 years with a first-ever ischemic or hemorrhagic stroke confirmed through clinical assessment and computed tomography or magnetic resonance imaging. Individuals of either sex were eligible if they had unilateral involvement, could stand independently or with minimal assistance, could follow basic verbal commands, and could complete the assessment procedures and provide written informed consent. Exclusion criteria included other neurological disorders, diabetes or peripheral neuropathy, lower-limb amputation, severe musculoskeletal conditions affecting gait, and unstable cardiovascular disease.

Participants were recruited using convenience sampling. The study included 60 stroke survivors, comprising 30 AFO users and 30 non-users. Group membership was determined by existing orthotic-use status: the AFO group comprised participants using an ankle-foot orthosis, whereas the non-user group comprised participants who did not use any lower-limb orthotic device. Written informed consent was obtained before enrollment and data collection.

Demographic and clinical information was recorded using a study-specific data-collection form. Recorded variables included age, sex, height, weight, stroke type, affected side, time since stroke, and orthotic-use status. Orthotic-use status was the grouping variable, and balance, walking speed, and functional independence were the outcomes. Functional assessments were undertaken within the cross-sectional assessment using the Berg Balance Scale (BBS), the 10-Meter Walk Test (10MWT), and the Functional Independence Measure (FIM).

Balance was assessed using the BBS, a performance-based scale comprising 14 functional tasks. Each task is scored from 0 to 4, producing a total score ranging from 0 to 56, with higher scores indicating better balance performance (8). Gait performance was assessed using walking speed obtained from the 10MWT. Walking speed was calculated by dividing the walking distance in meters by the time taken in seconds and was expressed in meters per second, with higher values indicating faster walking (9). Functional independence was assessed using the 18-item FIM, which evaluates the assistance required to perform daily activities. Total scores range from 18 to 126, with higher scores indicating greater functional independence (10). These standardized measures were used to assess the corresponding functional domains in both groups.

Data entry and statistical analysis were performed using IBM SPSS Statistics version 26.0. Categorical variables were summarized as frequencies and percentages, and continuous variables were summarized as means and standard deviations. The normality of continuous outcome variables was assessed before inferential analysis. Independent-samples t-tests were used to compare mean BBS scores, 10MWT walking speeds, and total FIM scores between AFO users and non-users. The comparisons were unadjusted and evaluated between-group differences at assessment. All tests were two-tailed, and a p-value below 0.05 was considered statistically significant.

Ethical permission was obtained from the Department of Prosthetics and Orthotics at Riphah College of Rehabilitation Sciences before the study commenced. Participants were informed that participation was voluntary and that they could withdraw at any time without adverse consequences. Written informed consent was obtained from each participant, and privacy and confidentiality were maintained throughout the study.

## RESULTS

The study included 60 stroke survivors, comprising 30 AFO users and 30 non-users. The mean age was 56.53 ± 10.42 years, and the sample included 30 men (50.0%) and 30 women (50.0%). Participant demographic characteristics are presented in Table 1.

AFO users had higher mean BBS scores than non-users, with an unadjusted between-group difference of 21.83 points (95% CI, 20.00–23.66; $p < 0.001$). Mean walking speed was 0.77 ± 0.11 m/s among AFO users and 0.45 ± 0.09 m/s among non-users, corresponding to a difference of 0.32 m/s (95% CI, 0.27–0.37; $p < 0.001$). FIM total scores also differed between groups, with a mean difference of 16.57 points (95% CI, 14.98–18.16; $p < 0.001$). Standardized between-group differences were large across all three outcomes, with Hedges' g values of 6.09 for balance, 3.14 for walking speed, and 5.31 for functional independence (Table 2).

*Table 1. Demographic characteristics of participants (N = 60)*

| Characteristic | Mean ± SD | n (%) |
|---|---|---|
| Age (years) | 56.53 ± 10.42 | — |
| Height (cm) | 168.87 ± 7.57 | — |
| Weight (kg) | 72.53 ± 10.08 | — |
| Male | — | 30 (50.0) |

| Characteristic | Mean ± SD | n (%) |
|---|---|---|
| Female | — | 30 (50.0) |

SD, standard deviation.

*Table 2. Functional outcomes and unadjusted differences between AFO users and non-users*

| Outcome | AFO users (n = 30), mean ± SD | Non-users (n = 30), mean ± SD | Mean difference | 95% CI | p-value | Hedges' g |
|---|---|---|---|---|---|---|
| BBS (points) | 42.10 ± 2.76 | 20.27 ± 4.17 | 21.83 | 20.00–23.66 | <0.001 | 6.09 |
| 10MWT walking speed (m/s) | 0.77 ± 0.11 | 0.45 ± 0.09 | 0.32 | 0.27–0.37 | <0.001 | 3.14 |
| FIM total score (points) | 65.60 ± 3.04 | 49.03 ± 3.12 | 16.57 | 14.98–18.16 | <0.001 | 5.31 |

AFO, ankle-foot orthosis; BBS, Berg Balance Scale; 10MWT, 10-Meter Walk Test; FIM, Functional Independence Measure; SD, standard deviation; CI, confidence interval. Mean differences represent AFO users minus non-users. Confidence intervals and two-tailed p-values were calculated using Welch's independent-samples t-test. Hedges' g represents the between-group difference standardized by the pooled SD with correction for small-sample bias.

## DISCUSSION

This comparative cross-sectional study found that stroke survivors using ankle-foot orthoses had better balance performance, faster walking speed, and greater functional independence than non-users. These findings address the study objective by demonstrating differences across three complementary functional domains. However, the comparisons were unadjusted and involved existing users and non-users; they therefore describe associations with AFO-use status rather than changes attributable to orthotic treatment.

The balance findings are directionally consistent with the systematic review by Daryabor and colleagues, which reported benefits in functional balance and mobility outcomes among stroke survivors assessed with AFOs (3). Tyson and Kent also examined balance and walking outcomes, providing support for considering orthotic management in the assessment of post-stroke mobility limitations (14). Nevertheless, balance is a multidimensional construct, and findings obtained using functional tasks cannot automatically be generalized to every aspect of postural control. Choo and Chang reported improvements in several walking-related measures but did not find a statistically significant improvement in body sway, illustrating that orthotic effects may differ according to the outcome assessed (4). The present BBS findings consequently indicate differences in functional balance performance without establishing reduced falls or improved performance across all balance domains.

The association between AFO use and faster walking is also broadly consistent with previous evidence. Choo and Chang reported improvements in walking speed and several spatiotemporal gait parameters, while Nascimento and colleagues concluded that AFOs and continuous functional electrical stimulation improved walking speed after stroke (4,6). However, the literature is not uniformly conclusive. Shahabi and colleagues found an estimate favoring AFOs over no AFO for walking speed, but the confidence interval included no difference, and the evidence was rated low or very low quality (11). Differences in included study designs, comparison conditions, patient characteristics, and exposure duration may contribute to these contrasting conclusions. Moreover, treatment effects estimated from controlled or within-person comparisons are not directly equivalent to the between-person differences observed in the present study.

Several biomechanical mechanisms could plausibly contribute to the observed balance and walking associations. By controlling ankle position, an AFO may facilitate foot clearance during swing and provide support during stance, potentially allowing more consistent stepping and greater stability. Reviews of gait performance and ankle kinematics provide a basis for these explanations (4,12). However, ankle motion, weight distribution, muscle activation, and compensatory movement patterns were not measured in this study. These mechanisms therefore remain possible explanations rather than demonstrated pathways linking orthotic use to the observed outcomes.

The higher FIM scores among AFO users suggest that the between-group differences extended beyond performance on balance and walking tests. Sankaranarayan and colleagues similarly evaluated walking and functional independence in a prospective rehabilitation study involving AFO provision and activity-based rehabilitation (7). Such findings support assessing orthotic management within the broader rehabilitation process, but they do not isolate the contribution of the device from concurrent therapy. Furthermore, the FIM assesses assistance requirements across multiple activities, including domains that are not directly determined by lower-limb mechanics (10). The total-score difference in this study should therefore not be interpreted as evidence that AFO use independently improved every component of daily functioning.

The large standardized differences require particular caution. Their magnitude reflects both the separation between group means and the relatively small within-group standard deviations. Statistical precision does not eliminate selection bias or confounding, and a large standardized difference does not establish a large treatment effect. Existing AFO users may differ from non-users in stroke severity, recovery stage, rehabilitation exposure, clinical indication, or access to services. The importance of rehabilitation timing is illustrated by the Pakistani study of Akhtar and colleagues, which examined differences in functional outcomes according to the timing of rehabilitation admission (2). Because these factors were not incorporated into adjusted comparisons in the present analysis, their contributions cannot be separated from the association with orthotic-use status. Similarly, between-group differences cannot be interpreted as within-person clinically important improvements.

Clinically, the findings support considering balance, walking performance, and daily functioning together when evaluating stroke survivors who use orthotic support. This approach is consistent with the AFO and functional electrical stimulation guideline, which emphasizes selecting and reassessing devices according to individual presentation and rehabilitation goals (5). Orthotic management also needs to be considered alongside the broader rehabilitation program. The locomotor guideline by Hornby and colleagues addresses task-specific walking training in ambulatory individuals with chronic neurological injury and highlights the relevance of training characteristics to walking outcomes (15). These guidelines provide the clinical context for interpreting the present associations; this study does not independently establish an indication for universal AFO prescription.

The inclusion of patients from three Lahore facilities and the concurrent assessment of balance, walking speed, and functional independence are strengths. Using complementary clinical measures offers a broader functional description than walking speed alone and is consistent with the need for multidomain outcome assessment identified by Ramstrand and Stevens (13). Nevertheless, these measures do not directly establish community participation, quality of life, fall reduction, or the economic value of orthotic services. The findings therefore provide local observational evidence rather than a basis for estimating population-level benefits or cost-effectiveness.

Several limitations restrict interpretation. Convenience sampling and the sample of 60 participants limit representativeness, while eligibility requirements concerning standing ability, command following, and assessment completion restrict applicability to survivors with more severe limitations. Group-specific clinical characteristics were not presented, preventing adequate assessment of comparability. AFO design, duration of use, adherence, and assessment conditions were insufficiently characterized, and the analysis did not account for stroke severity, time since stroke, rehabilitation intensity, or recruitment site. Assessor blinding and standardization of footwear and walking aids were not documented, leaving potential measurement bias unresolved. In addition, the confidence intervals and standardized effect sizes were calculated from rounded summary statistics. Finally, the cross-sectional design provides no evidence about functional trajectories or sustained outcomes. Prospective studies with clearly defined orthotic exposure, standardized assessments, and appropriate confounder control would help clarify the associations observed here.

## CONCLUSION

Stroke survivors using AFOs had better balance, faster walking speed, and greater functional independence than non-users in this sample. AFO-use status was therefore associated with functional differences across all three assessed domains. These unadjusted cross-sectional findings describe differences between existing users and non-users and do not establish that AFO use caused better outcomes.

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