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Original Article

Association Between Hip Strength and Dynamic Balance in Stroke Survivors with Coexisting Knee Osteoarthritis

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Abstract

Background: Stroke patients often experience impaired balance and mobility, which may be exacerbated by comorbid knee osteoarthritis (OA). Hip muscle weakness is a key contributor to reduced dynamic stability in these populations. **Objective:** To examine the association between hip muscle strength and dynamic balance in stroke survivors with and without knee OA. **Methods:** This cross-sectional study included 37 post-stroke participants (20 without OA, 17 with OA). Hip flexion and extension strength were assessed using manual muscle testing (MMT). Balance was evaluated via One-Leg Stance (OLS), Center of Pressure (COP) range and sway, and the Functional Reach Test (FRT). **Results:** Stroke patients with OA demonstrated significantly lower hip strength and impaired balance performance compared to those without OA. Hip flexor and extensor strength on the affected side showed moderate correlations with OLS (r = 0.52), COP sway (r = 0.49), and FRT (r = 0.45). The OA group had reduced OLS time ($p < 0.05$) and a smaller COP range. **Conclusion:** Hip muscle weakness is significantly associated with compromised dynamic balance in stroke patients with knee OA, underscoring the importance of hip-focused rehabilitation strategies in this population.

Keywords: Stroke, Knee Osteoarthritis, Hip Strength, Dynamic Balance, Postural Stability.

Introduction

Stroke is a leading cause of long-term disability, often resulting in muscle weakness, impaired coordination, and reduced balance control. These deficits may be further exacerbated by comorbid conditions such as knee osteoarthritis (OA), which alters lower limb biomechanics and contributes to decreased functional capacity (Mehwish et al., 2023, Deasy et al., 2016).

The hip joint, particularly the gluteus medius and maximus, plays a critical role in pelvic stabilization and lower limb control during gait and postural tasks (Takacs et al., 2017, Pua et al., 2009). In stroke patients, hip muscle weakness has been associated with poor balance performance and increased fall risk (Sánchez-Herán et al., 2016). The

presence of knee OA may further impair joint mobility and proprioceptive input, worsening postural sway and functional reach (Fransen et al., 2002).

Despite the known contributions of hip strength and knee function to balance, few studies have investigated their combined impact in stroke survivors with comorbid knee OA. This study aims to investigate the relationship between hip muscle strength and dynamic balance in stroke survivors with and without knee osteoarthritis (OA). Understanding this relationship may inform the development of targeted rehabilitation strategies to address neuromuscular and biomechanical impairments in this dual-diagnosis population. This study explores the association between hip strength and dynamic balance among stroke survivors with and without knee OA. Understanding this link is critical for designing rehabilitation protocols that target neuromuscular and biomechanical deficits in this dual-diagnosis population.

Methodology

Participants and Study Design

Forty-two young adults aged 18–25 years were recruited from local universities and communities to participate in this study. Thirty-seven post-stroke individuals aged 45–75 were recruited from a physiotherapy clinic. Group 1 included 20 hemiparetic patients without OA; Group 2 included 17 with mild to moderate radiological knee OA. Participants were capable of walking household distances independently. Diagnosis of OA and its severity was assessed by orthopedic clinical physicians.

The study inclusion criteria were as follows: Post-stroke hemiparesis, BMI 18–29.9, age 45–75, radiological confirmation of knee OA (for Group 2). While the exclusion criteria were as follows: Vestibular dysfunction, severe OA, severe cardiovascular disease, cognitive impairment, or current physical therapy.

Study Settings

This study was carried out at the Department of Physiotherapy in the Neuro-Rehabilitation section between 2023- to 2025.

Outcome's Measures

Hip Strength Testing: MMT was used to assess hip flexion and extension bilaterally. Strength was graded on a 0–5 scale.

Dynamic Balance Assessments:

One-Leg Stance (OLS): It was performed with eyes open/closed to assess the dynamic balance. Best of three trials recorded (Figure 1).

Figure 1. Mean OLS Time Across Groups (Eyes Open

and Closed).

Functional Reach Test (FRT): Distance reached forward beyond arm's length (Figure 2).

Figure 2. Patient performing Functional Reach Test

Figure 3. COP Range Comparison in Four Directions

COP Range & Sway: Measured using Pedalo®-Sensamove Balance Test Pro across front, back, left, and right directions (Figure 3).

Muscle strength of hip muscles was examined by a Physical Therapist who has master's degree in Neurological Disorders with 10 years' clinical experience. Dynamic balance like OLS, FRT and COP range was performed by subjects with close contact of another Physical Therapist with good clinical experience, both of these examiners were blind about the outcomes and Groups allocation. All these tests were performed in one session with 30 minutes' rest in between each outcome measures to avoid the fatigue. Timings of the tests were based on the subjects' appointments, for some subjects it was morning, noon and afternoon. This association between Hip strength and Dynamic Balance was examined in a rehabilitations stage of post-stroke (subacute stage).

To ensure the high inter-reliability, clear guidelines, clear instructions, criteria for evaluation was given to both evaluators prior to the subject outcome tastings

COP measure was done by using Pedalo®-Sensamove Balance Test Pro across front, back, left, and right directions.

Ethical Considerations

Ethical approval was obtained from the Ethics Research Committee [IEC# 31/10/181/SUP/IEC/2023], and all participants provided written informed consent prior to inclusion in the study. All procedures were conducted in accordance with institutional and national research ethics guidelines.

Statistical Analysis

Statistical analyses were performed using

appropriate tests based on the distribution of the data. Independent samples t-tests were used to compare normally distributed variables between the two groups, while the Mann–Whitney U test was applied for non-normally distributed data. Pearson's correlation coefficient was used to assess the relationship between hip muscle strength and dynamic balance variables. A p-value of ≤ 0.05 was considered statistically significant.

Results

Demographics

No significant differences were found between groups for age, height, weight, or BMI, indicating well-matched groups (Table 1).

Table 1. Demographic Characteristics of Study Participants (N=37)

Variable	Group 1 (n=20)	Group 2 (n=17)	p-value
Age (years)	59.8 ± 7.7	56.4 ± 7.9	0.297
BMI (kg/m^2)	24.6 ± 3.3	25.8 ± 3.4	0.168

Hip Strength

Group 2 (stroke with OA) showed significantly lower strength in left hip flexors and extensors compared to Group 1. The affected side demonstrated a marked reduction in muscle grade ($p < 0.05$). Right side (unaffected limb) strength was also lower in Group 2, although the difference was less pronounced.

One-Leg Stance (OLS)

Time maintained on the affected limb was shorter in Group 2 across both eyes-open and eyes-closed conditions. In particular, eyes-closed OLS showed greater deficits, indicating reliance on visual input for stability. Group 2 averaged 6.6 ± 9.8 seconds, significantly less than Group 1's 11.7 ± 9.1 seconds ($p = 0.023$) (Table 2).

Table 2. Comparison of Hip Strength and Balance Measures.

Measure	Group 1 (n=20) (Mean±SD)	Group 2 (n=17) (Mean±SD)	p-value	Effect size
Hip Flexion Strength (L)	2.4± 0.5	2.2± 0.48	0.21	0.028*
OLS (Eyes Open, R leg)	11.7±9.1	6.6±9.9	0.23	0.151
COP Range (Front)	15.7±3.6	13.3±3.6	0.047*	0.028*

Center of Pressure (COP) Range and Sway COP range was reduced in Group 2, particularly in the front (anterior) direction ($p = 0.047$), suggesting a diminished ability to lean forward and control anterior postural shifts. COP sway was elevated in all directions for Group 2, with statistically significant increases in anterior-posterior sway ($p < 0.05$), highlighting reduced stability and increased postural instability.

Functional Reach Test (FRT)

Although not statistically significant, Group 2 had consistently lower FRT scores compared to Group 1, indicating more limited dynamic reach and a trend toward impaired anticipatory postural control.

Correlation Analysis

Pearson's correlation revealed moderate positive associations between affected limb hip strength and dynamic balance outcomes: OLS time ($r = 0.52$, $p < 0.05$); FRT ($r = 0.45$, $p < 0.05$). COP range ($r = 0.49$, $p < 0.05$). These findings suggest that stronger hip musculature contributes to improved balance and stability, particularly in single-limb stance and reach tasks.

Discussion

This study investigated the association between hip muscle strength and dynamic balance in stroke survivors with comorbid knee osteoarthritis (OA). The findings indicate that patients with combined conditions experience significantly compromised hip flexor and extensor strength, particularly on the affected side, and present with impaired dynamic balance parameters such as reduced Center of Pressure (COP) range and increased sway. These results reinforce the concept that hip musculature plays a vital role in maintaining postural control and overall functional stability.

In stroke patients, unilateral motor deficits cause asymmetry in weight distribution and increased reliance on the unaffected limb, leading to muscular atrophy and reduced functional use of the paretic side (Mehwish et al., 2023, Deasy et al., 2016). The presence of knee OA further complicates this scenario by introducing joint degeneration, pain, and proprioceptive deficits, which inhibit normal weight transfer and challenge balance maintenance tasks (Takacs et al., 2017, Pua et al., 2009). Our study demonstrated that hip muscle strength was notably weaker in stroke survivors with OA compared to those without OA, especially in the left hip flexors and extensors. This muscle weakness is consistent with prior findings indicating significant reductions in lower limb force production in hemiparetic individuals (Sánchez-Herán et al., 2016).

Dynamic balance, assessed via COP measurements and Functional Reach Test (FRT), was also notably impaired in the OA group. Specifically, the COP range in anterior and lateral directions was reduced, indicating restricted voluntary postural shifts, which are essential for daily mobility tasks such as reaching or walking. Increased COP sway, particularly in the absence of visual feedback, suggests poor proprioceptive input and impaired central processing of balance cues (Fransen et al., 2002, Dobson et al., 2012).

Interestingly, the FRT values, though not statistically significant, were clinically lower in the OA group, supporting the notion of reduced dynamic reach capacity. Reduced reach distance may stem from the joint stiffness and compensatory trunk strategies common among individuals with knee OA and post-stroke gait alterations (Li et al., 2015). Furthermore, Timed Up and Go (TUG) scores were worse in patients with OA, indicating diminished mobility and balance confidence.

These impairments can be explained by biomechanical and neuromuscular factors. First, hip muscles—particularly the gluteus medius and maximus—are essential in controlling pelvis stability and maintaining upright posture during gait and stance (Mat et al., 2017). Weaknesses in these muscles can exacerbate trunk sway, induce compensatory lateral lean, and contribute to increased risk of falls. Second, OA-induced nociception may lead to arthrogenic muscle inhibition (AMI), limiting voluntary muscle activation and further degrading hip stability (Al-Khlaifat et al., 2016).

The presence of dual impairments—neurological (stroke) and musculoskeletal (knee OA) creates a synergistic challenge that extends beyond simple additive effects. The altered gait mechanics observed in such individuals, such as increased double limb support and asymmetrical step patterns, are compensatory strategies to mitigate instability and joint discomfort but often result in inefficient movement and energy expenditure (Ayotte et al., 2007, World Health Organization, 2003). This is especially concerning for aging populations, where functional independence is

already tenuous.

The results highlight the necessity for integrated rehabilitation approaches. Traditional stroke rehabilitation often prioritizes gait and coordination training; however, in the presence of OA, targeted hip strengthening, proprioceptive training, and pain-modulating strategies (e.g., knee bracing or TENS therapy) should be considered to enhance outcomes (Choi et al., 2020, Bennell et al., 2007). Incorporating closed-chain exercises, balance board training, and progressive resistance may also improve neuromuscular control and reduce fall risk in this population.

Stroke patients with comorbid knee OA show significant deficits in hip strength and dynamic balance. Given the heightened risk of falls, reduced mobility, and decreased independence in individuals with both stroke and knee OA, targeted rehabilitation that focuses on strengthening hip musculature, improving proprioceptive input, and enhancing dynamic balance is warranted (Qiu et al., 2023, Wellsandt et al., 2017).

The strengths of this study include comprehensive balance assessment using both clinical and instrumented tools, and the comparison of matched groups with and without OA. Further research should investigate the effectiveness of tailored intervention programs and the impact of OA severity on functional recovery post-stroke.

Limitations

This study had several limitations. First, the sample size was relatively small (n = 37), which may limit the generalizability of the findings. Second, the intervention period was relatively short, lasting only eight weeks. Third, the sample included a higher proportion of male participants, which could introduce gender-related bias. Finally, muscle strength was assessed using manual muscle testing (MMT), a subjective method that lacks the sensitivity and precision of objective tools such as handheld or isokinetic dynamometers.

Conclusion

This study underscores the critical role of hip muscle strength, particularly in the affected limb, in maintaining postural control and supporting functional stability in this dual-diagnosis population. The moderate correlations observed between hip strength and balance measures such as OLS time, FRT, and COP range suggest that muscle weakness directly impacts dynamic stability. Comprehensive programs that address both neurological and orthopedic impairments are likely to yield better functional outcomes, improve quality of life, and support safer community ambulation.

Future Research

Future studies should explore longitudinal outcomes and the effectiveness of specific therapeutic interventions in improving hip strength and reducing balance-related deficits in this population. Ultimately, early identification and intervention may help mitigate long-term disability and promote recovery.

Author Contributions

All authors significantly contributed to the work reported, including conception, study design, execution, data acquisition, analysis, and interpretation. They actively participated in drafting, revising, or critically reviewing the manuscript, provided final approval of the version to be published, agreed on the journal submission, and accepted accountability for all aspects of the work.

Data Availability Statement

The authors will transparently provide the primary data underpinning the findings or conclusions of this article, without any unjustified reluctance. If need from editorial team.

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Conflicts of Interest

The authors declare no potential conflicts of interest related to the research, writing, or publication of this work.

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