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Association Between Upper Limb Synergy Patterns and Functional Independence in Post-Stroke Patients: A Cross-Sectional Study

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ABSTRACT

Background: post-stroke motor impairment frequently presents as abnormal upper limb synergy patterns, limiting selective voluntary control and reducing functional use of the affected limb. These impairments significantly restrict activities of daily living (ADLs) and overall independence in stroke survivors.

Methods: This cross-sectional observational study aimed to evaluate upper limb synergy patterns and determine their association with functional independence in post-stroke patients. A total of 60 clinically diagnosed stroke patients (mean age: 58.4 ± 10.6 years) were included. Upper limb motor function and synergy patterns were assessed using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE), while functional independence was evaluated using the Barthel Index (BI). Statistical analysis was performed using Pearson's or Spearman's correlation tests based on data distribution.

Results: Flexor synergy predominance was observed in 68.3% of participants, indicating a higher prevalence of flexor-dominant movement patterns. The mean FMA-UE score was 38.6 ± 14.2, reflecting moderate motor impairment, and the mean BI score was 61.4 ± 18.7, indicating moderate functional independence. A statistically significant moderate-to-strong positive correlation was found between FMA-UE and BI scores ($r = 0.64$, $p < 0.001$), suggesting that improved upper limb motor control is associated with better performance in ADLs.

Conclusion: Upper limb synergy patterns are significantly associated with functional independence in post-stroke patients. Reduction of abnormal synergy patterns and improvement in selective motor control are crucial for enhancing ADL performance and promoting functional independence.

Keywords: Stroke; Motor Recovery; Activities of Daily Living; Upper Extremity; Rehabilitation

INTRODUCTION

Stroke is a leading cause of long-term disability worldwide, resulting in significant motor and functional impairments. In 2023, stroke continued to be the second leading cause of death worldwide, after ischemic heart disease, and ranked third in terms of disability-adjusted life years (DALYs) [1], [2]. Globally, there were approximately 93.8 million prevalent cases of stroke and 11.9 million new (incident) cases, of which 65.3% were ischemic strokes, 28.8% were intracerebral hemorrhages (ICH), and 5.8% were subarachnoid hemorrhages (SAH) [3].

Although age-standardized incidence and mortality rates have declined significantly over the past three decades—stroke-related deaths decreased from 144.3 per 100,000 population in 1990 to 87.4 per 100,000 in 2021 [3]—the overall number of stroke survivors has not reduced [4]. Stroke incidence increases markedly with age, doubling with each decade after 50 years and rising nearly 100-fold from individuals younger than 50 years to those older than 80 years. Consequently, due to population ageing and improved survival rates, the number of individuals surviving stroke at 3 months has increased by 90% over the past 30 years, as reported by the Dijon stroke registry [5].

Upper extremity (UE) motor dysfunction is a frequent outcome following stroke, affecting nearly two-thirds of survivors with lasting deficits. These impairments are commonly characterized by abnormal movement synergies, which interfere with the execution of everyday tasks, diminish functional independence and productivity, and restrict social participation. Such challenges emphasize the need for comprehensive evaluation of synergy patterns to guide effective rehabilitation planning. [6-9]

These synergies are thought to arise from damage to corticospinal pathways and increased reliance on brainstem-mediated motor control, particularly reticulospinal pathways [10]. As a result, patients exhibit stereotypical movement patterns, such as flexor and extensor synergies, which limit voluntary motor control and impair activities of daily living (ADL). The dominance of these abnormal movement patterns often leads to reduced coordination, decreased dexterity, and impaired functional use of the affected limb.

Upper limb dysfunction is particularly disabling, as it directly interferes with essential activities of daily living such as feeding, dressing, grooming, and object manipulation. Despite advances in rehabilitation approaches, recovery of upper limb function remains incomplete in a substantial proportion of stroke survivors, with many individuals not achieving full functional independence. This underscores the need to identify critical motor impairments that influence recovery outcomes and guide targeted rehabilitation interventions. [11-12]

The Fugl-Meyer Assessment for Upper Extremity (FMA-UE) is a widely used, valid, and reliable instrument for evaluating motor recovery after stroke, with particular emphasis on the assessment of movement synergies. It is based on the Brunnstrom stages of motor recovery and provides a structured, quantitative measure of motor impairment by assessing reflex activity, voluntary movement within and outside synergy patterns, coordination, and speed. The FMA-UE has demonstrated excellent inter-rater and intra-rater reliability, as well as strong construct validity, making it a gold standard outcome measure in both clinical and research settings. Additionally, it is sensitive to changes over time, allowing clinicians to monitor recovery progression and evaluate the effectiveness of rehabilitation interventions. [13-14].

Functional independence is commonly assessed using the Barthel Index (BI), a widely utilized and validated tool that evaluates a patient's ability to perform activities of daily living (ADLs). The BI measures performance across key domains such as feeding, bathing, grooming, dressing, bowel and bladder control, toileting, transfers, mobility, and stair use. It

provides a simple, objective score reflecting the level of independence, making it useful for clinical assessment, monitoring progress, and determining rehabilitation outcomes in stroke survivors. [15-16]. Both tools are widely used in clinical and research settings to quantify impairment and functional outcomes.

Previous studies have demonstrated that motor recovery is closely associated with functional independence;[17] however, the specific contribution of abnormal synergy patterns to functional limitations has not been extensively quantified. Understanding how synergy patterns influence ADL performance can provide valuable insights into the mechanisms underlying functional recovery and help clinicians design more targeted and effective rehabilitation interventions.

Furthermore, early identification and assessment of abnormal synergy patterns may allow clinicians to implement appropriate therapeutic strategies aimed at promoting selective motor control and reducing compensatory movement patterns. This can ultimately enhance functional recovery and improve quality of life in post-stroke patients.

Therefore, the present study aimed to assess upper limb synergy patterns using FMA-UE, evaluate functional independence using the Barthel Index, and determine the association between synergy patterns and functional independence in post-stroke patients.

MATERIALS & METHODS

This cross-sectional observational study was conducted in inpatient and outpatient physiotherapy departments. A total of 60 clinically diagnosed post-stroke patients were recruited using a convenience sampling technique, with the sample size determined based on feasibility and previous similar studies.

Participants aged between 40 and 75 years with a physician-confirmed diagnosis of ischemic or hemorrhagic stroke and a duration of ≥1 month were included. All participants had unilateral upper limb motor impairment with Fugl-Meyer Assessment for Upper Extremity (FMA-UE) scores ranging from 20 to 60, indicating mild to moderate impairment.[14] Participants were medically stable, able to follow simple verbal commands, and provided written informed consent. Patients with severe cognitive impairment, significant communication disorders, other neurological conditions, major upper limb musculoskeletal disorders, severe spasticity, or unstable medical conditions were excluded.

Upper limb motor function and synergy patterns were assessed using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE), a stroke-specific, performance-based scale evaluating motor recovery, including reflex activity, voluntary movement, and synergy patterns.[14] The motor domain has a maximum score of 66, with higher scores indicating better motor function. Functional independence was measured using the Barthel Index (BI), which assesses performance in activities of daily living such as feeding, bathing, dressing, mobility, and transfers, with scores ranging from 0 to 100, where higher scores indicate greater independence.[15]

All assessments were conducted in a single session by a trained physiotherapist. Demographic and clinical data, including age, gender, type of stroke, duration since stroke, and affected side, were recorded. Written informed consent was obtained from all participants prior to data collection.

Statistical Analysis

Statistical analysis was performed using appropriate statistical methods. Descriptive statistics were expressed as mean ± standard deviation and frequency (%). Data normality was assessed using the Shapiro-Wilk test. Pearson's correlation was applied for normally distributed data, while Spearman's correlation was used for non-normally distributed data. A p-value of < 0.05 was considered statistically significant.

RESULT

A total of 60 post-stroke patients participated in the study. The mean age of participants was 58.4 ± 10.6 years. Among them, 63.3% were male and 36.7% were female. The majority of participants had ischemic stroke (70%), while 30% had hemorrhagic stroke. The mean duration since stroke was 7.2 ± 3.5 months (Table 1).

Table 1. Demographic and Clinical Characteristics of Study Participants (n = 60)

Variable	Value
Mean Age (years)	58.4 ± 10.6
Male (%)	63.3%
Female (%)	36.7%
Ischemic Stroke (%)	70%
Hemorrhagic Stroke (%)	30%
Duration Since Stroke (months)	7.2 ± 3.5

The analysis of outcome measures revealed that the mean FMA-UE score was 38.6 ± 14.2, indicating a moderate level of upper limb motor impairment among the participants. The mean Barthel Index score was 61.4 ± 18.7, reflecting a moderate level of functional independence in activities of daily living.

Regarding synergy patterns, flexor synergy predominance was observed in 68.3% of participants, while 31.7% exhibited extensor synergy patterns, suggesting a higher prevalence of flexor-dominant movement abnormalities in the affected upper limb (Table 2).

Table 2. Upper Limb Motor Function, Functional Independence, and Synergy Pattern Distribution

Variable	Value
FMA-UE Score	38.6 ± 14.2
Barthel Index	61.4 ± 18.7
Flexor Synergy (%)	68.3%
Extensor Synergy (%)	31.7%

Further analysis demonstrated a statistically significant positive correlation between upper limb motor recovery and functional independence. The correlation coefficient indicated a moderate-to-strong relationship between FMA-UE and Barthel Index scores ($r = 0.64$, $p < 0.001$), suggesting that patients with better motor function exhibited higher levels of independence in daily activities. This finding highlights the clinical importance of improving motor recovery to enhance functional outcomes in post-stroke rehabilitation (Table 3).

Table 3. Correlation Between Upper Limb Motor Recovery and Functional Independence

Variables Compared	Correlation Coefficient (r)	p-value
FMA-UE vs Barthel Index	0.64	< 0.001

Observations/Results of your study should be written in this section along with tables/charts/figures etc. write serial numbers and appropriate heading/title of tables and legend/caption of figures.

DISCUSSION

The present study demonstrated a significant association between upper limb synergy patterns and functional independence in post-stroke patients. The observed moderate-to-strong positive correlation ($r = 0.64$) indicates that improved upper limb motor control is closely linked to enhanced performance in activities of daily living (ADLs). This finding supports existing evidence suggesting that upper limb motor function is positively correlated with functional independence measures such as the Barthel Index and Functional Independence Measure, with reported correlation coefficients ranging from moderate to strong ($r \approx 0.60–0.81$)[18] Furthermore, this reinforces the concept that motor recovery—particularly the ability to move beyond abnormal synergy patterns—plays a crucial role in achieving functional independence following stroke.[19]

The predominance of flexor synergy observed in this study is consistent with previous research, which indicates that flexor synergy patterns are more frequently manifested in the upper limb following

stroke due to disruptions in corticospinal pathways and a relative increase in reliance on brainstem motor pathways, leading to altered neural control mechanisms [20-21]. This phenomenon can be explained by damage to the corticospinal tract, leading to increased reliance on brainstem-mediated pathways, particularly the reticulospinal tract. As a result, patients tend to exhibit stereotyped and mass movement patterns, limiting their ability to perform selective and coordinated voluntary movements. Such impairments significantly affect fine motor control and functional task performance.

The mean FMA-UE score in this study reflects a moderate degree of motor impairment, which corresponds with the moderate level of functional independence observed in the Barthel Index scores. This relationship is consistent with previous research demonstrating a strong association between upper limb motor recovery and performance in activities of daily living (ADLs) [22,14]. Patients with better motor control and reduced abnormal synergy dominance tend to achieve greater independence in tasks such as feeding, dressing, and mobility. Conversely, increased severity of abnormal synergy patterns is associated with reduced functional capacity and greater dependency.

From a rehabilitation perspective, these findings highlight the importance of targeting abnormal synergy patterns during physiotherapy interventions. Approaches such as task-specific training, neurofacilitation techniques, and motor relearning strategies can help promote selective motor control and reduce compensatory movement patterns. Early identification and management of synergy patterns may enhance neural recovery, improve motor outcomes, and ultimately lead to better functional independence and quality of life in post-stroke patients.

The clinical implications of this study are noteworthy. Early assessment of upper limb synergy patterns using standardized tools such as the Fugl-Meyer Assessment for Upper Extremity, along with evaluation of functional independence using the Barthel Index, can provide valuable insights into a patient's recovery status. Integrating these assessments into routine clinical practice allows for better treatment planning and monitoring of rehabilitation progress. Targeted physiotherapy interventions focusing on improving motor control and reducing abnormal synergy patterns can significantly enhance ADL performance and overall independence.

Despite its contributions, this study has certain limitations. The relatively small sample size may limit the generalizability of the findings. The cross-sectional design restricts the ability to establish a causal relationship between synergy patterns and functional independence. Additionally, the absence of subgroup analysis based on stroke stage (acute, subacute, chronic) and the single-center setting may further limit the external validity of the results. Future studies with larger sample sizes, longitudinal designs, and multicenter participation are recommended to validate and extend these findings.

CONCLUSION

In conclusion, upper limb synergy patterns are significantly associated with functional independence in post-stroke patients. Reduction of abnormal synergy expression and improvement in selective motor control are key determinants of enhanced performance in activities of daily living. These findings emphasize the importance of early assessment and targeted physiotherapy interventions in optimizing functional recovery and promoting independence in individuals following stroke.

Declaration by Authors

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REFERENCES

1. Naghavi M, Kyu HH, Aalipour MA, Aalruz H, Ababneh HS, Abafita BJ, Abaraogu UO, Abbafati C, Abbasi M, Abbaspour F, Abbastabar H. Global burden of 292 causes of death in 204 countries and territories and 660 subnational locations, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023. The Lancet. 2025 Oct 18;406(10513):1811-72.
2. Hay SI, Ong KL, Santomauro DF, Aalipour MA, Aalruz H, Ababneh HS, Abaraogu UO, Abate BB, Abbafati C, Abbas N, Abbasifard M. Burden of 375 diseases and injuries, risk-attributable burden of 88 risk factors, and healthy life expectancy in 204 countries and territories, including 660 subnational locations, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023. The Lancet. 2025 Oct 18;406(10513):1873-922.
3. Feigin VL, Stark BA, Johnson CO, Roth GA, Bisignano C, Abady GG, Abbasifard M, Abbasi-Kangevari M, Abd-Allah F, Abedi V, Abualhasan A. Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. The Lancet Neurology. 2021 Oct 1;20(10):795-820.
4. Béjot Y. Forty years of descriptive epidemiology of stroke. Neuroepidemiology. 2022 Aug 2;56(3):157-62.
5. Béjot Y, Bailly H, Graber M, Garnier L, Laville A, Dubourget L, Mielle N, Chevalier C, Durier J, Giroud M. Impact of the ageing population on the burden of stroke: the Dijon stroke registry. Neuroepidemiology. 2019 Jan 2;52(1-2):78-85.
6. Johnson W, Onuma O, Owolabi M, Sachdev S. Stroke: a global response is needed. Bulletin of the World Health Organization. 2016 Sep 1;94(9):634.
7. Lee KB, Lim SH, Kim KH, Kim KJ, Kim YR, Chang WN, Yeom JW, Kim YD, Hwang BY. Six-month functional recovery of stroke patients: a multi-time-point study. International journal of rehabilitation research. 2015 Jun 1;38(2):173-80.
8. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. The Lancet. 2011 May 14;377(9778):1693-702.
9. Kwakkel G, Kollen BJ, Wagenaar RC. Therapy impact on functional recovery in stroke rehabilitation: a critical review of the literature. Physiotherapy. 1999 Jul 1;85(7):377-91.
10. Xing Y, Liu J, Wu L, Zhang K, Yang S. A narrative review of motor control dual pathways: the corticospinal and reticulospinal tracts in synergy and differentiation. Frontiers in Neuroanatomy. 2026 Apr 10; 20:1768036.
11. Kwakkel G, Kollen BJ, Van Der Grond J, Prevo AJ. Probability of regaining dexterity in the flaccid upper limb: impact of severity of paresis and time since onset in acute stroke. Stroke. 2003 Sep 1;34(9):2181-6.
12. Langhorne P, Coupar F, Pollock A. Motor recovery after stroke: a systematic review. The Lancet Neurology. 2009 Aug 1;8(8):741-54.
13. Woodbury M, Grattan ES, Li CY. Development of a short form assessment combining the Fugl-Meyer Assessment–Upper Extremity and the Wolf Motor Function Test for evaluating stroke recovery. Archives of physical medicine and rehabilitation. 2023 Oct 1;104(10):1661-8.
14. Sanford J, Moreland J, Swanson LR, Stratford PW, Gowland C. Reliability of the Fugl-Meyer assessment for testing motor performance in patients following stroke. Physical therapy. 1993 Jul 1;73(7):447-54.
15. Mahoney FI, Barthel DW. Barthel index. Maryland state medical journal. 1965 Feb.
16. Hartigan I. A comparative review of the Katz ADL and the Barthel Index in assessing the activities of daily living of older people. International journal of older people nursing. 2007 Sep;2(3):204-12.
17. O'Dell MW. Stroke rehabilitation and motor recovery. Continuum: Lifelong Learning in Neurology. 2023 Apr 1;29(2):605-27.
18. Yamamoto H, Takeda K, Koyama S, Morishima K, Hirakawa Y, Motoya I, Sakurai H, Kanada Y, Kawamura N, Kawamura M, Tanabe S. Relationship between upper limb motor function and activities of daily living after removing the influence of lower limb motor function in subacute patients with stroke: A cross-sectional study. Hong Kong Journal of Occupational Therapy. 2020 Jun;33(1):12-7.
19. Bowden MG, Clark DJ, Kautz SA. Evaluation of abnormal synergy patterns poststroke: relationship of the Fugl-Meyer

Assessment to hemiparetic locomotion. Neurorehabilitation and neural repair. 2010 May;24(4):328-37.
20. Twitchell TE. The restoration of motor function following hemiplegia in man. Brain. 1951 Dec 1;74(4):443-80.
21. Dewald JP, Beer RF. Abnormal joint torque patterns in the paretic upper limb of subjects with hemiparesis. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine. 2001 Feb;24(2):273-83.
22. Hsueh IP, Lee MM, Hsieh CL. Psychometric characteristics of the Barthel activities of daily living index in stroke patients. Journal of the Formosan Medical Association. 2001 Aug 1;100(8):526-32.

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