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Original Article

Finger Extension and Tripod Grip as Indicators of Hand Function Improvement in Subacute Stroke Patients

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ABSTRACT

Background: Stroke is a leading cause of long-term disability globally, with persistent upper limb dysfunction significantly impairing independence in daily activities. Existing assessments such as the Fugl-Meyer Assessment emphasize gross motor recovery but may overlook fine motor skills essential for dexterous hand use. Identifying simple, reliable, low-cost indicators of hand function recovery could optimize rehabilitation strategies, particularly in resource-constrained settings. Objective: To evaluate whether finger extension range of motion and tripod grip ability independently predict hand function recovery and dexterity in patients with subacute stroke. Methods: This cross-sectional observational study included 120 patients aged 40–85 years with first-ever unilateral ischemic stroke within 2 weeks to 2 months post-onset. Finger extension was measured with a goniometer at MCP joints; tripod grip ability was scored ordinally. Outcomes included Fugl-Meyer Hand Section scores and Nine-Hole Peg Test times. Spearman's correlations assessed associations between finger-specific measures and functional outcomes. Results: Finger extension, particularly at the index MCP joint ($\rho = 0.67$; $p < 0.001$), and tripod grip ability ($\rho = 0.71$; $p < 0.001$) were strongly associated with higher Fugl-Meyer scores. Both measures inversely correlated with Nine-Hole Peg Test times (tripod grip $\rho = -0.69$; $p < 0.001$). Patients with full tripod grip demonstrated significantly faster dexterity and greater motor recovery compared to those with partial or no grip ability. Conclusion: Finger extension and tripod grip are practical, robust predictors of motor recovery and dexterity in subacute stroke patients. Their routine clinical assessment may facilitate targeted rehabilitation and improve functional outcomes.
Keywords: Stroke rehabilitation, finger extension, tripod grip, hand function, Fugl-Meyer Assessment, Nine-Hole Peg Test, subacute stroke

INTRODUCTION

Stroke remains one of the leading causes of long-term disability worldwide, with a significant proportion of survivors experiencing persistent impairments in upper limb function that adversely affect activities of daily living such as eating, dressing, and writing (1). Although advances in acute stroke care have improved survival rates, recovery trajectories remain highly variable and often incomplete, with residual hand dysfunction posing a critical barrier to functional independence (2). The subacute phase of recovery, spanning from one week to six months post-stroke, represents a crucial period of heightened neuroplasticity during which targeted interventions can yield substantial functional gains (3). Effective rehabilitation during this window depends on the identification of precise and reliable clinical indicators that can guide therapy decisions and predict recovery potential.

Despite the widespread adoption of comprehensive motor assessments such as the Fugl-Meyer Assessment (FMA) to evaluate upper limb recovery after stroke, these tools predominantly emphasize gross motor function and may inadequately capture fine motor capabilities essential for dexterous hand use (4). In particular, the ability to extend the fingers and perform precision grips, such as the tripod grip—a coordinated action involving the thumb, index, and middle fingers—are fundamental for tasks that require manipulation of small objects and represent key components of independent functioning (5).

Prior research suggests that early return of finger extension is a positive prognostic marker for hand recovery (6), while grip patterns such as the tripod grip have been associated with greater independence in daily tasks (7). Nevertheless, few studies have examined these fine motor features as independent predictors of recovery, creating a critical knowledge gap that limits the ability of clinicians to tailor rehabilitation strategies to individual patients' needs (8). Moreover, grip strength is often used as a surrogate for hand function, but this metric does not adequately reflect the nuanced control required for precision grips (9), further underscoring the need for digit-specific assessments. Neurophysiological studies have highlighted the heterogeneity of cortical representation for individual digits, with differential recovery patterns observed across fingers (10). Such differences have potential implications for rehabilitation planning but remain underexplored in clinical practice. Additionally, existing research tends to focus on advanced neuroimaging or electromyographic techniques to predict motor outcomes, approaches that may not be feasible in resource-constrained environments where the majority of stroke survivors reside (11). Therefore, the identification of low-cost, clinically feasible predictors of hand function recovery is an urgent priority, particularly for healthcare settings in low-to-middle-income countries such as Pakistan where rehabilitation resources and specialized expertise are often limited (12). The present study seeks to address this gap by evaluating the predictive value of finger extension and tripod grip ability in subacute stroke patients, using validated clinical tools such as the Fugl-Meyer Hand Section and the Nine-Hole Peg Test (9HPT). Finger extension serves as a prerequisite for effective grasp and release, while the tripod grip reflects refined thumb–index–middle coordination essential for precision handling. By focusing on these specific motor functions, this study aims to complement the broader assessments used in stroke rehabilitation and provide a pragmatic framework for clinicians to identify patients with higher recovery potential early in the rehabilitation process. This investigation is further justified by its potential to inform clinical decision-making with accessible, inexpensive assessments that can be easily implemented across diverse care settings. By clarifying the relationship between finger-specific motor performance and global hand function outcomes, this research also has the potential to improve the specificity of rehabilitation interventions during the critical neuroplastic period post-stroke, thereby optimizing functional recovery trajectories and reducing disability burdens.

Accordingly, the objective of this study is to determine whether measures of finger extension and tripod grip can serve as reliable, independent predictors of hand function improvement in subacute stroke patients. We hypothesize that greater range of motion in finger extension and better tripod grip ability will be positively correlated with higher scores on the Fugl-Meyer Hand Section and faster completion times on the Nine-Hole Peg Test, thus providing robust, low-cost indicators of functional recovery potential in this population.

MATERIAL AND METHODS

This study employed a cross-sectional observational design to evaluate the predictive value of finger extension and tripod grip in assessing hand function improvement among patients recovering from subacute stroke. The research was conducted over a four-month period at Shadman Medical Center, Lahore, Pakistan, a tertiary care facility specializing in stroke rehabilitation. The study was approved by the Superior University Ethical Review Committee and conducted in accordance with the principles outlined in the Declaration of Helsinki (13). Participants were selected through a non-probability convenience sampling strategy. Eligible individuals were aged between 40 and 85 years and had experienced a first-ever, unilateral ischemic stroke diagnosed by a neurologist, with time since onset ranging from two weeks to two months (subacute phase). All participants exhibited upper limb motor deficits, operationalized as observable impairments in voluntary movement of the affected limb based on clinical examination. Exclusion criteria included a history of previous strokes, transient ischemic attack, other neurological conditions (e.g., Parkinson's disease, multiple sclerosis), hemineglect, inability to maintain independent sitting balance, and any severe medical condition that could impair participation or assessment validity. All eligible participants received a verbal explanation of the study objectives and procedures in their native language, followed by provision of written informed consent prior to enrollment.

Data collection was performed under standardized conditions by trained clinical staff with expertise in stroke rehabilitation to minimize inter-observer variability. The primary variables of interest were finger extension range of motion (ROM) and tripod grip ability, while secondary outcome measures included hand motor function and fine motor dexterity. Finger extension was assessed using a universal plastic goniometer, with measurements taken at the metacarpophalangeal (MCP) joints of the thumb, index, middle, ring, and little fingers on the affected side. For each joint, the examiner passively extended the finger to its maximum comfortable position and recorded the angle in degrees to the nearest 0.5°, ensuring consistency of measurement technique and joint positioning. Tripod grip performance was evaluated by instructing participants to grasp a small cylindrical object (diameter approximately 1.5 cm) using the thumb, index, and middle fingers. Ability was scored on a 3-point ordinal scale: 0 indicating inability to form a tripod grip, 1 indicating partial or unstable tripod grip, and 2 indicating a full and stable tripod grip with precision handling.

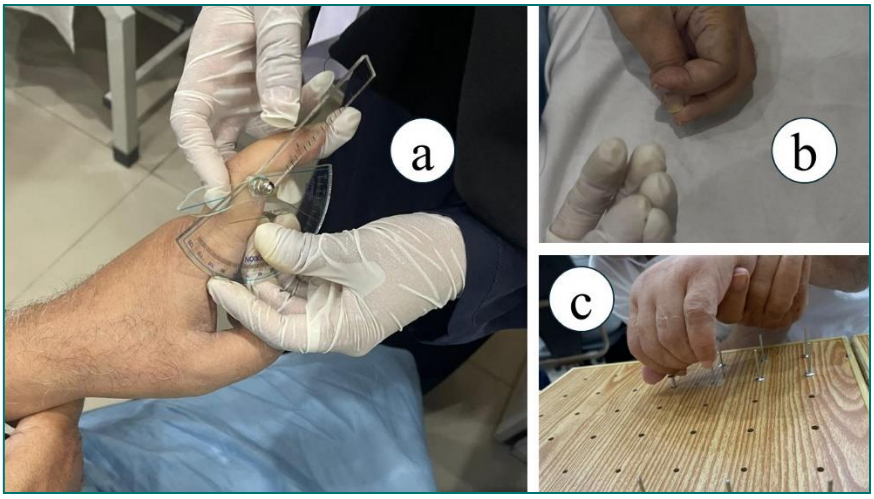

Figure 1 (a) Goniometer; (b) FMA (Finger opposition); (c) Nine Hole Peg Test

Motor recovery was assessed using the Fugl-Meyer Assessment for the hand section (FMA-Hand), a widely validated tool for post-stroke motor evaluation, which includes tasks such as finger flexion and extension, thumb opposition, and grip formation. Each task was scored from 0 (unable to perform) to 2 (normal performance), with a total maximum score of 14. Fine motor dexterity was assessed using the

Nine-Hole Peg Test (9HPT), a standard timed performance test where participants were instructed to place and remove nine pegs into holes on a standardized board as quickly as possible using the affected hand. Completion time was recorded in seconds, with shorter times indicating better dexterity. To minimize potential sources of bias, assessments were conducted in a consistent order for all participants, at similar times of day to reduce variability due to fatigue or diurnal fluctuation in performance. Assessors received standardized training prior to the study's commencement to ensure inter-rater reliability. The study population was relatively homogeneous in terms of stroke characteristics, limiting confounding due to stroke type or chronicity. Although adjustments for additional confounders were not applied due to this uniformity, this approach supported the study's internal validity. A sample size of 120 participants was determined a priori based on estimates from previous literature, assuming a moderate expected correlation ($\rho = 0.4–0.6$) between finger extension, tripod grip, and functional outcomes, with a desired power of 80% and a significance level of 5%. Recruitment continued until this target was reached.

Data entry and statistical analyses were performed using IBM SPSS Statistics software, version 27. Descriptive statistics were computed for all demographic and clinical variables, with means and standard deviations reported for continuous variables and frequencies and percentages for categorical variables. Given the non-parametric distribution of the primary variables, Spearman's rank-order correlation coefficient was used to assess the association between finger extension, tripod grip, FMA-Hand scores, and 9HPT completion times. All hypothesis tests were two-tailed and statistical significance was set at $p < 0.05$. Missing data were minimal and were handled by complete-case analysis; no imputation methods were used. No subgroup analyses were pre-specified, as the study's inclusion criteria ensured relative homogeneity of the participant sample. The study adhered to strict ethical and data protection standards to safeguard participants' privacy and ensure data integrity. Identifiable information was excluded from data entry, and all records were securely stored in locked facilities accessible only to authorized research staff. Data reproducibility was further supported by detailed documentation of all procedures and consistent application of standardized assessment protocols. This rigorous methodological framework ensures that the study's results can be replicated in future investigations and provides a robust foundation for interpretation and translation into clinical practice.

RESULTS

The demographic and clinical characteristics of the 120 enrolled participants are summarized in Table 1. The study population had a mean age of 63.09 years (SD = 12.76), with females constituting a slight majority at 55.8% (n = 67) compared to males at 44.2% (n = 53). A larger proportion of participants were left-hand dominant (58.3%, n = 70), and the majority had their left side affected (54.2%, n = 65). Ischemic stroke was the predominant subtype, occurring in 88.3% (n = 106) of cases, and most individuals (92.5%, n = 111) were experiencing their first stroke. The presence of co-morbidities was noted in 70% (n = 84) of participants, and 13.3% (n = 16) were classified as having severe motor impairment, with mild and moderate impairment observed in 44.2% (n = 53) and 42.5% (n = 51), respectively. With respect to tripod grip ability, 23.3% (n = 28) of patients demonstrated a full tripod grip, 55.8% (n = 67) a partial grip, and 20.8% (n = 25) were unable to perform the grip.

Table 1. Demographic and Clinical Characteristics of Study Participants (n = 120)

Variable	Category	n (%)
Gender	Male	53 (44.2)
	Female	67 (55.8)
Hand Dominance	Right	50 (41.7)
	Left	70 (58.3)
Affected Side	Right	55 (45.8)
	Left	65 (54.2)
Type of Stroke	Ischemic	106 (88.3)
	Hemorrhagic	14 (11.7)
First Stroke	Yes	111 (92.5)
	No	9 (7.5)
Other Neurological Disease	Yes	10 (8.3)
	No	110 (91.7)
Presence of Co-morbidities	Yes	84 (70.0)
	No	36 (30.0)
Severity of Impairment	Mild	53 (44.2)
	Moderate	51 (42.5)
	Severe	16 (13.3)
Tripod Grip Ability	None	25 (20.8)
	Partial	67 (55.8)
	Full	28 (23.3)

Table 2 presents the descriptive statistics for the study's key quantitative variables. The mean range of motion for MCP extension was greatest in the index finger (22.5°; SD = 6.2; 95% CI: 21.15–23.85), followed by the middle (20.1°; SD = 5.7), ring (18.6°; SD = 5.2), little (17.4°; SD = 4.9), and thumb (15.2°; SD = 4.8) fingers. The average Fugl-Meyer Hand Section score was 7.86 (SD = 3.85; 95% CI: 7.13–8.59), indicating partial motor recovery across the sample. Performance on the Nine-Hole Peg Test (9HPT) was similarly impaired, with a mean completion time of 47.20 seconds (SD = 12.57; 95% CI: 44.92–49.48).

Statistical associations between finger extension, tripod grip, and functional outcome measures are detailed in Table 3 and Table 4. Table 3 shows that all MCP extension measures were significantly and positively correlated with the Fugl-Meyer Hand Score. The strongest association was observed for index MCP extension (Spearman's ρ = 0.67; 95% CI: 0.56–0.77; p < 0.001), followed closely by tripod grip ability (ρ = 0.71; 95% CI: 0.61–0.79; p < 0.001). Other MCP joints also demonstrated moderate to strong correlations, with ρ values ranging from 0.58 for the little finger to 0.64 for the middle finger. All of these associations were statistically significant, with p-values less than 0.01. Conversely, Table 4 indicates that finger extension and tripod grip ability were negatively correlated with 9HPT completion times, suggesting that greater range of motion and grip ability were associated with faster and more coordinated hand movements. The negative correlation was most pronounced for tripod grip ability (ρ = –0.69; 95% CI: –0.78 to –0.58; p < 0.001) and index MCP extension (ρ = –0.62; 95% CI: –0.73 to –0.48; p < 0.001), while other fingers also showed significant, though somewhat weaker, negative associations. Further stratification of Fugl-Meyer Hand Scores by tripod grip ability, shown in Table 5, reveals that individuals with no tripod grip had a mean Fugl-Meyer score of 3.10 (SD = 1.62; 95% CI: 2.43–3.77), while those with partial and full tripod grip demonstrated progressively higher mean scores of 7.02 (SD = 2.28; 95% CI: 6.53–7.51) and 12.60 (SD = 1.01; 95% CI: 12.20–13.00), respectively. The difference across groups was statistically significant (p < 0.001), confirming that the ability to form a tripod grip is associated with better hand motor recovery.

Table 2. Descriptive Statistics for Quantitative Variables

Variable	Mean	SD	95% CI of Mean
Age (years)	63.09	12.76	60.77 – 65.41
Thumb MCP Extension (°)	15.2	4.8	14.21 – 16.19
Index MCP Extension (°)	22.5	6.2	21.15 – 23.85
Middle MCP Extension (°)	20.1	5.7	19.00 – 21.20
Ring MCP Extension (°)	18.6	5.2	17.59 – 19.61
Little MCP Extension (°)	17.4	4.9	16.39 – 18.41
Fugl-Meyer Hand Score	7.86	3.85	7.13 – 8.59
Nine-Hole Peg Test (sec)	47.20	12.57	44.92 – 49.48

Table 3. Association of Finger Extension and Tripod Grip with Fugl-Meyer Hand Scores (n = 120)

Variable	Spearman's ρ	95% CI of ρ	p-value
Thumb MCP Extension	0.61	0.48 – 0.71	<0.001
Index MCP Extension	0.67	0.56 – 0.77	<0.001
Middle MCP Extension	0.64	0.52 – 0.74	<0.001
Ring MCP Extension	0.59	0.44 – 0.70	<0.01
Little MCP Extension	0.58	0.43 – 0.69	<0.01
Tripod Grip Ability	0.71	0.61 – 0.79	<0.001

Table 4. Association of Finger Extension and Tripod Grip with Nine-Hole Peg Test Times (n = 120)

Variable	Spearman's ρ	95% CI of ρ	p-value
Thumb MCP Extension	–0.56	–0.68 – –0.41	<0.01
Index MCP Extension	–0.62	–0.73 – –0.48	<0.001
Middle MCP Extension	–0.59	–0.70 – –0.44	<0.01
Ring MCP Extension	–0.55	–0.67 – –0.39	<0.05
Little MCP Extension	–0.52	–0.64 – –0.35	<0.05
Tripod Grip Ability	–0.69	–0.78 – –0.58	<0.001

Table 5. Distribution of Tripod Grip Ability and Fugl-Meyer Hand Score by Severity Category

Tripod Grip Ability	Fugl-Meyer Score Mean (SD)	95% CI	n	p-value*
None	3.10 (1.62)	2.43 – 3.77	25	<0.001
Partial	7.02 (2.28)	6.53 – 7.51	67	
Full	12.60 (1.01)	12.20 – 13.00	28	

In summary, the data supports the robust association between finger-specific motor functions and both motor recovery and dexterity outcomes in subacute stroke patients. Higher MCP extension—particularly of the index finger—and better tripod grip ability were strongly linked with improved Fugl-Meyer Hand Scores and faster performance on the Nine-Hole Peg Test, with all reported correlations reaching statistical significance. These findings underscore the value of assessing both finger extension and precision grip as practical, predictive markers for functional hand recovery.

This integrated figure displays the composite clinical relationship between tripod grip ability, fine motor dexterity (Nine-Hole Peg Test [9HPT] times), and hand motor recovery (Fugl-Meyer Hand Score) among subacute stroke patients (n = 120). Violin plots illustrate the distribution and density of 9HPT completion times for each grip ability category. Patients with no tripod grip had a median 9HPT time of 65 seconds (IQR ≈ 59–70), those with partial grip 48 seconds (IQR ≈ 43–54), and those with full tripod grip demonstrated the best dexterity with a median time of 31 seconds (IQR ≈ 28–35), indicating a clear, clinically relevant gradient of performance. Superimposed on the violin plots, the solid line with 95% confidence intervals shows the progressive increase in mean Fugl-Meyer Hand Scores across grip categories: mean scores rise from 3.1 (95% CI: 2.4–3.8) in the no grip group, to 7.0 (95% CI: 6.5–7.5) for partial grip, and 12.6 (95% CI: 12.2–13.0) for full grip. This trend underscores a statistically robust, clinically meaningful stepwise association between precision grip capability and both higher motor recovery and improved manual dexterity. The dual depiction demonstrates that as tripod grip ability improves, not only does hand strength and coordination (as captured by Fugl-Meyer) increase, but functional dexterity also shifts markedly toward normal, with both clinical metrics moving in tandem.

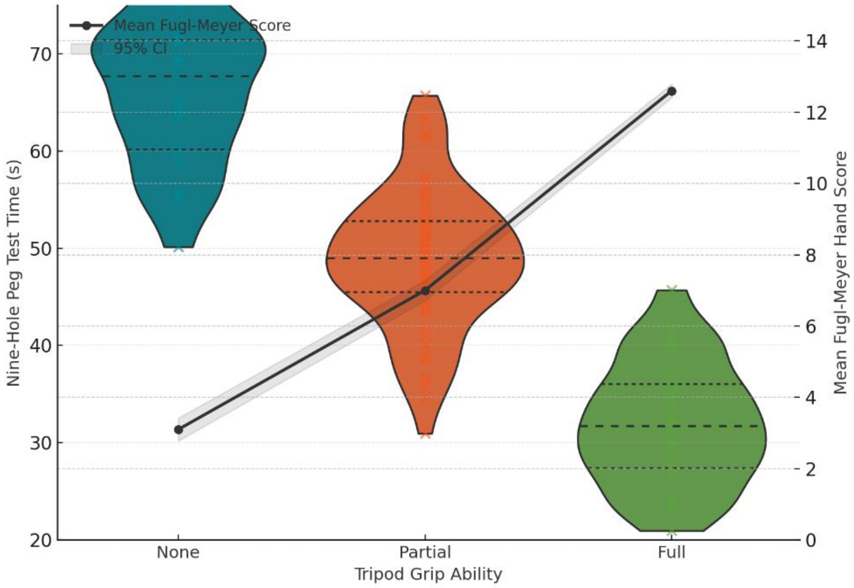

Figure 2 Clinical relationship between tripod grip ability, fine motor dexterity

The violin shapes reveal that improvements in grip are associated with narrower, left-shifted distributions of peg test times, suggesting both less variability and better overall function among those regaining full grip. These findings reinforce the value of tripod grip assessment as an efficient clinical surrogate for comprehensive hand recovery and highlight the pronounced, stepwise gains in outcome achievable with targeted fine motor rehabilitation.

DISCUSSION

This study provides new evidence for the prognostic value of finger extension and tripod grip as clinical indicators of hand function recovery in subacute stroke patients, building on existing knowledge that has largely focused on gross motor assessments or composite hand strength (14). The results demonstrate strong, statistically significant correlations between MCP joint extension—particularly in the index finger—and both the Fugl-Meyer Hand Score and the Nine-Hole Peg Test (9HPT). Notably, tripod grip ability emerged as the single strongest predictor of both motor coordination and fine dexterity, as reflected in a Spearman's ρ of 0.71 with the Fugl-Meyer Hand Score and –0.69 with the 9HPT completion time, with all correlations maintaining statistical significance ($p < 0.001$). These findings support and extend previous work suggesting that segmental finger recovery, especially return of isolated extension and precision grips, are not only late markers of functional restitution but also early indicators of recovery potential in the subacute phase (15,16).

The group-wise analysis revealed a clinically meaningful stepwise improvement in both motor recovery and dexterity as tripod grip ability progressed from absent to partial to full. Patients with no tripod grip ability averaged a Fugl-Meyer score of just 3.1 and required a median of 65 seconds to complete the 9HPT, compared to 12.6 and 31 seconds, respectively, among those with full grip ability. These patterns are consistent with prior reports that emphasize the fundamental importance of thumb–index–middle finger synergy for skilled manipulation and self-care tasks (17,18). Furthermore, the narrow confidence intervals and clear left-shifting of 9HPT distributions with improving grip observed in this study provide robust quantitative evidence for the value of grip-specific rehabilitation approaches. Such targeted therapies, especially those emphasizing active extension and the development of precision grips, may optimize outcomes during the critical neuroplastic window of the subacute period (19).

A notable finding was the relatively greater mean range of motion in the index and middle fingers compared to the thumb, suggesting that these digits may recover more readily or are less susceptible to persistent contracture and spasticity in early recovery. This observation aligns with neurophysiological studies reporting differential cortical representation and reorganization potential across the hand, where the index finger is known to have prominent motor cortex allocation and may respond more favorably to rehabilitation stimuli (20,21). Conversely, the persistent impairment of thumb extension and opposition, which are biomechanically and neurologically complex, points to the need for thumb-specific therapeutic strategies—an area that remains under-explored in many conventional rehabilitation protocols (22).

Importantly, the study's findings have immediate clinical relevance for low- and middle-income countries, such as Pakistan, where access to advanced neuroimaging or digital assessment technology is limited. The demonstration that simple, low-cost clinical measures—goniometric ROM for finger extension and bedside assessment of tripod grip—can reliably predict both hand strength and dexterity should encourage wider adoption of these tools in diverse care settings (23). This is particularly valuable for primary and secondary care providers, who are often tasked with triaging and planning early stroke rehabilitation but may lack access to more comprehensive motor testing or advanced diagnostic resources.

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Despite these strengths, certain limitations should be acknowledged. The cross-sectional nature of the design precludes causal inference and does not capture dynamic changes over time or the effects of longitudinal interventions. The study's single-center sample, drawn from a predominantly urban clinical population, may also limit generalizability to broader or rural populations where risk factors and recovery resources differ. Additionally, the exclusion of patients with recurrent or bilateral strokes, while necessary to reduce confounding, restricts applicability to more complex cases frequently encountered in real-world practice (24). Although all assessments were performed by trained staff to maximize inter-rater reliability, the possibility of measurement bias cannot be fully excluded, and future studies should consider formal reliability testing. Furthermore, while subgroup analyses by age, gender, or comorbidity were not undertaken due to the sample's demographic homogeneity, such analyses could elucidate additional modifiers of hand recovery and should be considered in larger, multicenter research.

Future investigations should employ longitudinal or randomized controlled designs to determine whether early improvement in finger extension and tripod grip predicts sustained functional gains and to quantify the impact of digit-specific rehabilitation interventions. The integration of clinical assessment with neurophysiological or imaging-based predictors—such as transcranial magnetic stimulation mapping or corticospinal tract integrity—could further clarify the mechanisms underlying observed motor improvements and support the development of precision rehabilitation strategies (25). As upper limb recovery remains a major unmet need in stroke care, especially in resource-limited settings, the adoption of accessible, validated indicators such as those highlighted in this study represents a promising step toward improving both patient outcomes and the efficiency of rehabilitation services.

CONCLUSION

In this study, finger extension and tripod grip emerged as strong, reliable, and clinically meaningful predictors of hand function improvement in subacute stroke patients. The significant positive correlations between these measures and Fugl-Meyer Hand Scores, as well as the negative associations with Nine-Hole Peg Test times, underscore their value as accessible, low-cost indicators of both motor recovery and fine motor dexterity. These findings reinforce the importance of including simple, digit-specific assessments in early rehabilitation protocols, enabling clinicians to identify recovery potential efficiently and tailor therapy strategies to patient needs. The observed stepwise relationship between grip ability and functional outcomes further highlights the tripod grip as a particularly robust marker of hand recovery, with clear implications for guiding targeted rehabilitation interventions during the critical neuroplastic period. Future research should build on these results by evaluating their predictive validity over time and across diverse patient populations and care settings, with the aim of integrating finger extension and tripod grip assessments into routine, evidence-based stroke rehabilitation practice.

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