

## Postprint of a Study on the Correlation between Post-Stroke Upper Limb Motor Function and Attention

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### Abstract

**Background:** Upper limb motor dysfunction is a common functional impairment following stroke. Attention may influence the recovery of upper limb motor function; however, current research evidence regarding the correlation between upper limb motor function and attention remains limited.

**Objective:** To explore the correlation between upper limb motor function and attention after stroke, and to provide a novel perspective for clinical approaches to upper limb functional rehabilitation.

**Methods:** A total of 480 stroke patients hospitalized in rehabilitation medicine departments across 26 institutions nationwide from March to October 2023 were enrolled. The Fugl-Meyer Assessment for Upper Limb (FMA-UL) and Montreal Cognitive Assessment (MoCA) were utilized to evaluate upper limb motor function and attention, respectively. Pearson correlation analysis was employed to investigate the correlation between total FMA-UL scores and attention assessment item scores in the MoCA.

**Results:** Among 480 patients, 105 failed to complete the full assessment, resulting in a final cohort of 375 stroke patients. The mean total FMA-UL score was  $(31.26 \pm 22.29)$ ; the mean MoCA-attention subscore was  $(4.74 \pm 1.60)$ ; the mean attention-digit span forward/backward task score was  $(1.62 \pm 0.63)$ ; the mean attention-read-1-tap-table-once task score was  $(0.74 \pm 0.45)$ ; and the mean attention-100-continuous-subtraction-of-7 task score was  $(2.39 \pm 0.95)$ . Male patients exhibited higher total FMA-UL scores than female patients ( $P < 0.05$ ). The total FMA-UL score of all patients demonstrated positive correlations with MoCA-attention subscore, digit span forward/backward task score, read-1-tap-table-once task score, and 100-continuous-subtraction-of-7 task score ( $r = 0.226, 0.146, 0.195, 0.182$ , respectively,  $P < 0.05$ ). Similarly, the total FMA-UL score

of male patients showed positive correlations with MoCA-attention subscore, digit span forward/backward task score, read-1-tap-table-once task score, and 100-continuous-subtraction-of-7 task score ( $r=0.236, 0.128, 0.213, 0.197$ , respectively,  $P<0.05$ ).

**Conclusion:** Upper limb motor function correlates positively with attention after stroke. Sustained attention demonstrates a relatively strong correlation with upper limb motor function, whereas attention span shows a relatively weak correlation with upper limb motor function. After stratification by sex, the correlation between upper limb motor function and attention in male patients remained consistent with the overall findings; however, this correlation was not significant in female patients, suggesting that sex may influence the relationship between upper limb motor function and attention.

## Full Text

### Correlation Between Upper Limb Motor Function and Attention After Stroke

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## Abstract

**Background:** Upper limb motor dysfunction is a common functional disorder after stroke. Attention may have an impact on the recovery of upper limb motor function, but there is currently limited evidence regarding the correlation between upper limb motor function and attention.

**Objective:** To explore the correlation between upper limb motor function and attention after stroke, and to provide a new perspective for clinical rehabilitation of upper limb function.

**Methods:** A total of 480 stroke patients hospitalized in the Department of Rehabilitation Medicine across 26 medical centers nationwide from March to October 2023 were selected as study subjects. The Fugl-Meyer Upper Limb Motor Function Score (FMA-UL) and Montreal Cognitive Assessment Scale (MoCA) were used to evaluate upper limb motor function and attention, respectively. Pearson correlation analysis was used to explore the correlation between the total FMA-UL score and attention assessment item scores in MoCA.

**Results:** Among the 480 patients, 105 did not complete the full assessment, leaving 375 stroke patients in the final analysis. The average FMA-UL total score was  $(31.26 \pm 22.29)$ . The average MoCA – Attention subscore was  $(4.74 \pm 1.60)$ . The average Attention – Forward/Backward Digit Span task score was  $(1.62 \pm 0.45)$ . The average Attention – Serial 7s task score was  $(2.39 \pm 0.95)$ . Male patients had higher FMA-UL total scores than female patients ( $P < 0.05$ ). In all patients, FMA-UL total score was positively correlated with MoCA-Attention total score, Digit Span task score, Vigilance task score, and Serial 7s task score ( $r = 0.226, 0.146, 0.195, 0.182$ , respectively;  $P < 0.05$ ). In male patients, FMA-UL total score was positively correlated with MoCA-Attention total score, Digit Span task score, Vigilance task score, and Serial 7s task score ( $r = 0.236, 0.128, 0.213, 0.197$ , respectively;  $P < 0.05$ ).

**Conclusion:** There is a significant positive correlation between upper limb motor function and attention after stroke, with sustained attention showing a stronger correlation with upper limb motor function than attention span. After grouping by gender, male patients showed the same positive correlation pattern, while female patients showed no significant correlation between upper limb motor function and attention, suggesting that gender may influence the relationship between these variables.

**Keywords:** Stroke; Upper limbs; Motor function; Attention; Correlation analysis

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## Introduction

Stroke is a leading cause of long-term disability, with 50%-70% of survivors experiencing various functional impairments including motor, cognitive, and sensory deficits that often coexist, severely impacting quality of life and creating substantial economic and social burdens [1-3]. Upper limb motor dysfunction is a particularly common sequela, affecting approximately 80% of stroke patients, especially hand motor function. However, fewer than 50% of patients achieve recovery of upper limb motor function within six months post-onset [4-6]. Hand function primarily comprises grasping and pinching, which together account for 90% of overall hand function. Post-stroke grasping dysfunction is characterized by decreased grip strength and reduced accuracy, with approximately 37% of patients still experiencing fine motor skill deficits three months after stroke, a problem more severe in patients with left hemisphere lesions [7].

Post-stroke cognitive impairment includes memory deficits, executive dysfunction, and attention deficits. Attention serves as a crucial indicator of cognitive function, forming the foundation for recovery in other cognitive domains and enabling daily activities and learning [8]. Attentional function refers to the ability to voluntarily or spontaneously select aspects of the external or internal environment for further cognitive processing while inhibiting interference from “irrelevant” information. Based on attentional processing characteristics and dimensions, it can be further categorized into “top-down” or “goal-driven” attention (conscious filtering of environmental distractions) and “bottom-up” or “stimulus-driven” attention (spontaneous environmental attention without deliberate effort), as well as “selective attention” (choosing to process some information while blocking others), “divided attention” (focusing on two or more tasks simultaneously), “sustained attention” (maintaining continuous focus on specific information), and “attention span” (focusing on multiple information fragments). Effective attentional function enables individuals to continuously filter effective information from the environment and process it efficiently [9-11].

Attention deficits are common in stroke patients and may negatively impact all activities. Clinically, stroke patients often demonstrate difficulty concentrating during rehabilitation training, easy distractibility, and problems re-engaging after distraction. Literature reports indicate that up to 92% of acute stroke survivors have attention impairment, with 50% showing persistent deficits long-term [1,8]. Stroke-related attention disorders include not only the commonly recognized spatial attention deficit (unilateral neglect) but also sustained attention deficits, attention span deficits, selective attention deficits, attention shifting deficits, and reduced attentional vigilance. These manifest as decreased ability to perform multiple tasks or attend to multiple targets, reduced efficiency in responding to continuous stimuli, and diminished capacity to select target stimuli from various distractions, making patients more susceptible to external or internal interference [9,12-13]. Neuroimaging studies suggest that, compared to motor impairment, attention impairment may cause more sensitive disruption to inter-regional coordination networks in the brain [14], leading to the hypothesis that attention may be a significant factor influencing functional impairment and upper limb motor recovery in stroke patients. Therefore, exploring the correlation between upper limb motor function and attention after stroke is critically important.

## Methods

### 1.1 Study Subjects

A total of 480 stroke patients hospitalized in the Department of Rehabilitation Medicine across 26 medical centers—including The First Affiliated Hospital of Fujian Medical University, Huashan Hospital of Fudan University, The Second Affiliated Hospital of Chongqing Medical University, The Second Affiliated Hospital of Kunming Medical University, Beijing Tiantan Hospital of Capital Medical University, General Hospital of Ningxia Medical University,

Shenzhen Longhua District Central Hospital, The Third Clinical Hospital of Changchun University of Chinese Medicine, Pudong Hospital of Fudan University, Shanghai Jing'an District Central Hospital, Shanghai Third Rehabilitation Hospital, Fuding City Hospital, Quanzhou First Hospital, Fujian Provincial Hospital, Longyan Traditional Chinese Medicine Hospital, Zhongshan Hospital Xiamen Branch of Fudan University, Xiamen Traditional Chinese Medicine Hospital, Nanping First Hospital Affiliated to Fujian Medical University, Xiamen International Trade Taihe Rehabilitation Hospital, Sanming Second Hospital, Changle District Hospital of Fuzhou, Yongchun County Hospital, Dehua County Hospital, Jianyang First Hospital of Nanping, Putian University Affiliated Hospital, and Fuzhou First Hospital—were selected as study subjects from March to October 2023.

**Inclusion criteria:** (1) Met diagnostic criteria for cerebral infarction or hemorrhage according to the “Diagnostic Criteria for Major Cerebrovascular Diseases in China 2019” [15]; (2) Stroke onset  $\leq 1$  year; (3) Age  $>18$  years; (4) Stable vital signs, able to complete routine post-stroke rehabilitation assessments; (5) Signed informed consent and voluntary participation.

**Exclusion criteria:** (1) Any disease or symptom where movement might exacerbate condition or cause adverse effects (secondary stroke, falls, fractures); (2) Cognitive dysfunction with Mini-Mental State Examination (MMSE) score  $<10$ , or inability to complete assessment due to psychological disorders; (3) Inability to sign informed consent.

This study was approved by the Medical Research and Clinical Technology Application Ethics Committee of The First Affiliated Hospital of Fujian Medical University (Approval No.: [2022]280). All participants provided informed consent and participated voluntarily.

## 1.2 Research Methods

This multicenter, cross-sectional, observational study assessed upper limb motor function and cognitive function at patient admission. Each subcenter's assessment was conducted by one dedicated rehabilitation therapist who received standardized training from the lead institution before performing evaluations.

**1.2.1 General Data Collection** Patient gender, age, and time since stroke onset were collected.

**1.2.2 Fugl-Meyer Upper Limb Motor Function Assessment (FMA-UL) [16]** The FMA-UL was used to evaluate upper limb motor function status in stroke patients. The assessment comprises 33 items, each scored 0-2 points (0 = unable to perform, 2 = fully able to perform), with a total possible score of 66 points. Higher scores indicate better upper limb motor function.

**1.2.3 Montreal Cognitive Assessment (MoCA) [17]** The MoCA was used to assess overall cognitive function in stroke patients. Cognitive domains evaluated include attention, executive function, memory, language, visuospatial ability, abstract thinking, calculation, and orientation, with a total possible score of 30 points. Scores  $\geq 26$  are considered normal. The attention assessment component includes three tasks: Digit Span Forward/Backward, Vigilance (tap table when hearing “1”), and Serial 7s Subtraction, with a maximum attention subscore of 6 points.

For Digit Span Forward/Backward, accurate repetition of each sequence earns 1 point (maximum 2 points). For the Vigilance task, 1 point is awarded if completely correct or with only one error (error defined as no response when hearing “1” or tapping when hearing other numbers; maximum 1 point). For Serial 7s Subtraction, the maximum score is 3 points: all incorrect = 0 points, one correct = 1 point, two-three correct = 2 points, four-five correct = 3 points. Scoring begins at 100, with each result evaluated separately; if a patient makes an error but subsequent subtractions of 7 from that incorrect result are correct, those subsequent correct results receive points.

The three attention tasks correspond to different attention domains: Digit Span Forward/Backward assesses attention span, the Vigilance task assesses sustained attention, and Serial 7s Subtraction assesses attentional shifting.

### 1.3 Statistical Analysis

SPSS 23.0 software was used for statistical analysis. Data normality was first tested; normally distributed data are presented as  $(\bar{x}\pm s)$ . Pearson correlation analysis was used for correlation analysis. Categorical data are presented as relative frequencies. Two-tailed tests were used with significance level  $\alpha=0.05$ .

## Results

### 2.1 Patient Characteristics

Among the 480 patients, 105 did not complete the full assessment, leaving 375 stroke patients in the final analysis. The cohort included 280 males and 95 females, with mean age  $(60.2\pm 12.0)$  years and mean time since stroke onset  $(68.8\pm 75.0)$  days. The average FMA-UL total score was  $(31.26\pm 22.29)$ . The average MoCA-Attention subscore was  $(4.74\pm 1.60)$ . The average Attention-Forward/Backward Digit Span task score was  $(1.62\pm 0.63)$ . The average Attention-Vigilance task score was  $(0.74\pm 0.45)$ . The average Attention-Serial 7s task score was  $(2.39\pm 0.95)$ .

There were no statistically significant differences between male and female patients in age, time since stroke onset, MoCA-Attention subscore, Attention-Forward/Backward Digit Span task score, Attention-Vigilance task score, or Attention-Serial 7s task score ( $P>0.05$ ). However, male patients had significantly higher FMA-UL total scores than female patients ( $P<0.05$ ).

**Table 1** Comparison of baseline characteristics between male and female patients ( $\bar{x}\pm s$ )

Category	Age (years)	Time since stroke onset (days)	FMA-UL total score	MoCA-Attention sub-score	Attention-Forward/Backward Digit Span	Attention-Serial Vigilance 7s
Male	280	59.6±12.3	69.2±73.9	33.38±22.54	4.79±1.57	1.64±0.61
Female	95	61.9±10.9				

Note: FMA-UL = Fugl-Meyer Upper Limb Motor Function Assessment, MoCA = Montreal Cognitive Assessment.

### 2.2 Correlation Between FMA-UL Total Score and MoCA Attention Assessment Items

In all patients and in male patients, FMA-UL total score was positively correlated with MoCA-Attention subscore, Digit Span task score, Vigilance task score, and Serial 7s task score ( $P < 0.05$ ). In female patients, FMA-UL total score showed no correlation with MoCA-Attention subscore, Digit Span task score, Vigilance task score, or Serial 7s task score ( $P > 0.05$ ).

**Table 2** Correlation between total FMA-UL score and attention assessment item scores in MoCA among all patients and by gender

Attention Measure	All Patients (n=375)	Male Patients (n=280)	Female Patients (n=95)
	r	P	r
MoCA-Attention subscore	0.226	<0.001	0.236
Digit Span task	0.146	0.004	0.128
Vigilance task	0.195	<0.001	0.213
Serial 7s task	0.182	<0.001	0.197

### Discussion

Our findings demonstrate a significant positive correlation between upper limb motor function and attention after stroke, with sustained attention showing a stronger relationship to upper limb motor function than attention span. When analyzed by gender, male patients exhibited the same positive correlation pattern, whereas female patients showed no significant correlation between upper limb motor function and attention.

In addition to upper limb motor dysfunction, various forms of attention deficits are common in stroke patients. This may result not only from brain lesions

affecting attention-related nodes but also from the inherently complex relationships among different attention components. Analysis of lesion locations and abnormal brain structure/function in stroke patients suggests that multiple attention deficits may be associated with dorsal brain regions or neural network dysfunction, including the dorsal and ventral attention networks, primary motor and sensory cortices, and related prefrontal functions [9,18-19]. The brain regions involved in attention deficits overlap partially with those associated with upper limb motor function, and the extent and location of this overlap may provide the anatomical basis for the positive correlation between upper limb motor function and attention after stroke.

Our results revealed significant gender differences in the correlation between upper limb motor function and attention. Baseline analysis showed significant gender differences in upper limb motor function, which may contribute to this discrepancy. The influence of gender requires further investigation. Zhang et al. [20] conducted a cross-sectional study based on the NHANES database exploring gender differences in the relationship between upper limb motor function (grip strength) and cognitive impairment, finding significant gender interactions in overall cognitive function and attention. Liu et al. [21] reported that during human development, males show clear trends in attention changes while females show less obvious changes, consistent with Bangasser et al.'s [22] proposal that attention deficits are less readily detected in females. At the physiological level, Boss et al. [23] found that estradiol levels correlate with cognitive function only in males, suggesting gender differences in attentional changes, while Commodari et al. [24] also identified significant gender differences in attention shifting across aging.

Stroke lesions may lead to coexisting cognitive and motor deficits, though these have traditionally been studied as separate entities [5]. Recent research has increasingly focused on rehabilitation approaches targeting both motor function and overall cognitive function [20-25]. However, attention as the foundation for recovery in other cognitive domains has received less attention regarding its specific relationship with upper limb motor function, with even less focus on different attention domains. While spatial attention deficit (unilateral neglect) has been extensively studied—both neglect and upper limb motor dysfunction are associated with poor stroke outcomes, and neglect may directly or indirectly affect upper limb motor recovery [25]—research on non-spatial attention remains limited and has not integrated spatial and non-spatial attention components for comprehensive analysis with upper limb motor function.

This multicenter, large-sample study has several limitations. First, as an observational study without intervention, future randomized controlled trials with appropriate interventions are needed to enhance the robustness of findings regarding the relationship between upper limb motor function and attention. Second, our attention assessment was relatively basic; future work should incorporate specialized attention assessments such as the Trail Making Test, Symbol Digit Modalities Test, cancellation tests, and line bisection tests to comprehensively

examine the relationship between attention and upper limb motor function. Third, our assessment methods relied solely on subjective scales; future studies should incorporate objective measures such as electroencephalography, near-infrared spectroscopy, and magnetic resonance imaging to enable more precise and objective evaluation.

## Conclusion

Upper limb motor function is positively correlated with attention after stroke, with sustained attention showing a stronger correlation than attention span. When analyzed by gender, male patients demonstrate this same positive correlation pattern, whereas female patients show no significant correlation between upper limb motor function and attention, suggesting that gender may influence this relationship.

**Author Contributions:** Jiali Lin was responsible for study design and implementation, statistical analysis, and manuscript writing. Shuyang Zhang, Jiaying Lin, Yuxin Zhou, Yuehua Zhao, and Yun Chen were responsible for assessment, data collection, and organization. Jie Jia was responsible for quality control and revision of the manuscript, overall supervision, and project management.

**Conflict of Interest:** The authors declare no conflicts of interest.

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