

# Functional Status and Rehabilitation Barriers in Adults of Working Age After Stroke: A Cross-Sectional Study

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## Research Article

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# Abstract

## Purpose

To describe functional status in working-age stroke survivors and examine its associations with perceived rehabilitation barriers.

## Methods

In this cross-sectional study, 59 working-age stroke survivors were recruited from post-stroke rehabilitation clinics. Median age was 48 years (IQR 44–54), and 54% were male. Standardized assessments included the National Institutes of Health Stroke Scale (NIHSS), modified Rankin Scale (mRS), modified Barthel Index (mBI), Stroke Impact Scale (SIS), and Cardiac Rehabilitation Barriers Scale (CRBS).

## Results

Participants demonstrated mild to moderate neurological impairment and moderate functional limitations, particularly in motor domains, with reduced independence in daily activities. Functional independence (mBI) was moderately to strongly correlated with SIS mobility ( $\rho = 0.57$ ; 95% CI 0.36–0.72) and ADL/IADL domains ( $\rho = 0.48$ ; 95% CI 0.25–0.65). Perceived rehabilitation barriers were most prominent in domains related to perceived needs and access, with strong interrelationships among contextual and personal barrier domains. Direct associations between barrier scores and functional measures were limited.

## Conclusions

Adults of working age recovering from stroke experience substantial functional challenges. Perceived rehabilitation barriers cluster mainly around contextual and personal factors rather than directly reflecting functional severity. Integrated, person-centered rehabilitation models are required to address both clinical recovery and broader socioeconomic determinants to optimize reintegration and participation.

## INTRODUCTION

Stroke is a leading cause of long-term disability worldwide and is characterized by the sudden onset of neurological deficits resulting from ischemic or hemorrhagic events affecting cerebral vessels [1]. Although stroke is frequently associated with older populations, approximately 75% of cases occur in individuals under 65 years of age, thereby significantly impacting adults of working age [2]. In Brazil, stroke remains one of the primary causes of death and disability [3], accounting for approximately 2% of

the national healthcare budget in 2016 [4–7]. Pronounced regional disparities persist, with higher mortality rates observed in the North and Northeast regions, often associated with socioeconomic inequalities and limited access to healthcare resources [8]. Among adults of working age, stroke frequently leads to persistent impairments in motor, cognitive, and communication functions, which compromise functional independence, social participation, and the ability to return to work [9, 10].

As part of the cardiovascular disease (CVD) spectrum, stroke shares common risk factors and pathophysiological mechanisms with other CVDs, underscoring the relevance of integrated and comprehensive rehabilitation approaches [11]. Evidence derived from cardiac rehabilitation (CR) programs has contributed to best practices in post-stroke rehabilitation, particularly regarding strategies aimed at improving functional capacity, social participation, and return to productive activities [12]. However, both stroke and CR services are affected by similar systemic and structural barriers, including limited access to services, transportation difficulties, socioeconomic constraints, and insufficient awareness of rehabilitation benefits [13, 14]. Addressing barriers for CR programs addresses barrier domains is thus highly relevant to stroke survivors, particularly those of working age who must balance health demands with occupational and family responsibilities. Qualitative research has highlighted systemic barriers affecting stroke recovery, including limited collaboration with health teams and inadequate community support [15]. A recent systematic review identified intrapersonal factors as the most frequent determinants of adherence, highlighting the multidimensional nature of rehabilitation engagement [16]. However, similar comprehensive syntheses are lacking in stroke populations, particularly among working-age adults.

Despite growing recognition of the multidimensional consequences of stroke, few studies in Brazil have examined the combined relationships between functional status and perceived rehabilitation barriers among adults of working age after stroke. Brazilian epidemiological studies in young adults have primarily focused on risk factor profiles and stroke subtype distribution [17]. However, functional outcomes and perceived barriers to rehabilitation were not addressed. Moreover, evidence remains limited regarding how barriers identified through instruments such as the CRBS relate to functional outcomes in this population.

The primary aims of this study were: (1) to describe functional status in adults of working age after stroke; and (2) to examine the associations between functional status and perceived barriers to rehabilitation participation. We hypothesized that adults of working age after stroke would present relevant limitations in functional status. Additionally, we hypothesized that higher perceived socioeconomic and structural barriers, as assessed by the CRBS, were expected to be associated with poorer functional status.

## **METHODS**

### **Ethical Considerations**

This study adhered to ethical standards outlined in the Declaration of Helsinki. The study protocol was approved by the Research Ethics Committee before execution following national regulations (approval number: CAAE: 76491623.0.0000.5235). Written informed consent was obtained from all participants before their inclusion in the study.

## Study Design and Setting

This was a cross-sectional observational study reported according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines [18]. The study was carried out in rehabilitation clinics located in Juazeiro do Norte, Ceará, Brazil. Data collection occurred during the months of July 2024 to November 2024.

## Sample Size

The sample size was estimated based on the primary objective of assessing correlations between functional status and rehabilitation barriers. Using G\*Power 3.1.9.7 [19], a priori analysis was conducted for a correlation analysis. Assuming a moderate effect size (0.40),  $\alpha = 0.05$  (two-tailed), and power  $(1 - \beta) = 0.80$ , the required sample size was 46 participants.

## Participants

Participants were consecutively recruited from clinical records of selected rehabilitation clinics, aiming to represent adults receiving post-stroke rehabilitation in the region. Eligible participants were adults of working age (18–65 years) of both sexes who had experienced a stroke. Individuals were required to have sufficient motor, cognitive, and communicative capacity to complete the study assessments. Exclusion criteria included the presence of neurodegenerative or musculoskeletal conditions that prevented test completion, as well as inability to communicate orally or to read and write.

## Data Collection and Outcomes

Data collection was conducted in person by trained professionals using standardized protocols to ensure consistency across assessments. Assessments were performed in clinical or home settings according to participant availability. All instruments were administered at study entry, defined as the period following hospital discharge and at the initiation of outpatient rehabilitation. Data were recorded in electronic spreadsheets to ensure data integrity and facilitate statistical analysis. All outcome measures were administered in a structured interview format to enhance comprehension and ensure accurate responses.

## Sociodemographic and Clinical Data

Sociodemographic and clinical information – including age, sex, marital status, body mass index (BMI), type and location of neurological lesion, comorbidities, medication use, and lifestyle factors – was collected through structured interviews and review of medical records. Cognitive status was assessed using the Mini-Mental State Examination (MMSE) [20], validated for the Brazilian population, with established cut-off values for the Brazilian population [21].

## **Functional Assessments**

Neurological impairment severity was assessed using the Portuguese-Brazil version [22] of the NIHSS [23], which quantifies deficits across domains such as level of consciousness, motor function, language, and sensory function. Higher scores indicate greater neurological impairment.

Global disability and dependence in daily activities were evaluated using the Portuguese-Brazil version [22] of the Modified Rankin Scale (mRS) [24]. The mRS ranges from 0 (no symptoms) to 6 (death), with higher scores reflecting greater disability.

Independence in basic activities of daily living was assessed using the Portuguese-Brazil version [22] of the modified Barthel Index (mBI) [25], which evaluates functions such as feeding, bathing, and mobility. Total scores range from 0 to 100, with higher scores indicating greater functional independence.

The subjective impact of stroke was assessed using the Portuguese-Brazil version [26, 27] of the Stroke Impact Scale (SIS). The SIS evaluates multiple domains, including physical function, memory, emotion, communication, and social participation, with higher scores indicating better perceived functional status and quality of life.

## **Barriers to Cardiac Rehabilitation**

Perceived barriers to cardiac rehabilitation were assessed using the Portuguese-Brazil version [28] of the CRBS [29]. The CRBS identifies obstacles across domains such as logistical challenges (e.g., transportation, distance), socioeconomic factors, lack of information, and personal attitudes. Each item is rated on a Likert scale, with higher scores indicating greater perceived barriers.

## **Bias Control**

Selection bias was minimized through the consecutive recruitment of eligible participants from multiple rehabilitation clinics. Information bias was reduced by the use of validated and standardized assessment instruments. All assessments were conducted by trained personnel following standardized protocols, who were blinded to the specific study hypotheses. No missing data were observed for the study variables; therefore, all analyses were conducted using complete-case data.

## **Statistical Analysis**

All statistical analyses were conducted using R software version 4.5.2 (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were assessed for distributional characteristics and, given the non-normal distribution of most outcomes, were summarized using medians and 25th–75th percentiles (P25–P75). Categorical variables were summarized as absolute and relative frequencies (n, %).

Correlations between functional status measures (NIHSS, mRS, mBI, and SIS domains) and perceived rehabilitation barriers (CRBS domains and total score) were examined using Spearman rank correlation coefficients, due to the ordinal nature of several scales and the non-normal distribution of the data. Correlations were computed using pairwise complete observations. For each correlation, 95% confidence intervals and corresponding P-values were estimated. To account for multiple comparisons, p-values were adjusted using the false discovery rate (FDR) method according to Benjamini and Hochberg. Both unadjusted and FDR-adjusted p-values are reported.

Correlation matrices were visualized graphically using correlation plots, in which the magnitude and direction of associations were represented by proportional symbols. Statistical significance was assessed at a two-sided alpha level of 0.05.

## RESULTS

### Sample characteristics

A total of 59 working-age stroke survivors participated in the study (Table 1). The sample comprised 54% men and 46% women, with a median age of 48 years (P25–P75: 44–54). Regarding ethnicity, 41% of participants self-identified as White, 27% as Black, 29% as mixed, and 3% as Asian. Most participants were married (64%), followed by single (19%), separated (12%), and widowed (5%). The median body mass index (BMI) was 26 kg/m<sup>2</sup> (P25–P75: 24–27). Median cognitive performance, assessed by the Mini-Mental State Examination (MMSE), was 24 points (P25–P75: 22–26). Approximately 27% of participants reported a history of previous stroke. The median length of hospital stay was 8 days (P25–P75: 6–11), and the median time from hospital discharge to study entry assessment was 145 days (P25–P75: 8–366). Hypertension (58%), diabetes mellitus (41%), and primary cardiovascular disease (66%) were the most prevalent comorbidities. Additionally, 21% reported other comorbid conditions.

Table 1  
Demographic characteristics of the study sample.

<b>Variables</b>	<b>Total (N = 59)</b>
<b>Sex (n)</b>	
Female	27 (46%)
Male	32 (54%)
<b>Ethnicity (n)</b>	
Asian	2 (3%)
Black	16 (27%)
Mixed	17 (29%)
White	24 (41%)
<b>Age (years)</b>	48 (44–54)
<b>Body mass (kg)</b>	72 (63–78)
<b>Height (cm)</b>	166 (160–172)
<b>Body mass index (kg/m<sup>2</sup>)</b>	26 (24–27)
<b>Marital status (n)</b>	
Married	38 (64%)
Separated	7 (12%)
Single	11 (19%)
Widowed	3 (5%)
<b>Mini Mental State Examination (points)</b>	24 (22–26)
<b>Previous stroke (n)</b>	
No	43 (73%)
Yes	16 (27%)
<b>Length of stay (days)</b>	8 (6–11)
<b>Length from hospital discharge to study entry assessment (days)</b>	145 (8–366)
<b>Primary CVD (n)</b>	
Values are presented as median (interquartile range) or n (%). Abbreviations: MEEM, Mini Mental State Examination; CVD, cardiovascular disease.	

<b>Variables</b>	<b>Total (N = 59)</b>
<b>Sex (n)</b>	
No	20 (34%)
Yes	39 (66%)
<b>Hypertension (n)</b>	
No	25 (42%)
Yes	34 (58%)
<b>Diabetes (n)</b>	
No	35 (59%)
Yes	24 (41%)
<b>Other comorbidities (n)</b>	
No	38 (64%)
Yes	21 (36%)
Values are presented as median (interquartile range) or n (%). Abbreviations: MEEM, Mini Mental State Examination; CVD, cardiovascular disease.	

PLEASE INSERT Table 1 HERE

## Functional characteristics

Table 2 summarizes the functional characteristics of the study sample. The median NIHSS score was 4 (P25–P75: 2–8). Functional independence, assessed using the mBI, showed a median score of 48 (P25–P75: 30–54), while the mRS demonstrated a median score of 2 (P25–P75: 1–3). Although the median mRS indicated mild disability, the median Barthel score suggests residual limitations in basic activities, reinforcing the multidimensional nature of post-stroke functional impairment.

Table 2  
Functional characteristics of the study sample.

<b>Variables</b>	<b>Summary (N = 59)</b>
NIHSS (points)	4 (2–8)
mRS (points)	2 (1–3)
mBI (points)	48 (30–54)
SIS (Strength) (points)	25 (0–50)
SIS (Hand function) (points)	25 (0–62)
SIS (Mobility) (points)	55 (30–82)
SIS (ADL/IADL) (points)	50 (23–76)
SIS (Memory) (points)	88 (62–98)
SIS (Communication) (points)	93 (75–98)
SIS (Emotion) (points)	44 (25–50)
SIS (Participation) (points)	50 (33–75)
Values are presented as median (interquartile range) or n (%). Abbreviations: NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin Scale; mBI, modified Barthel Index; SIS, Stroke Impact Scale.	

SIS domain scores varied across functional domains. Median scores were 25 (P25–P75: 0–50) for SIS-Strength, 25 (P25–P75: 0–62) for SIS-Hand Function, and 55 (P25–P75: 30–82) for SIS-Mobility. The median SIS-ADL/IADL score was 50 (P25–P75: 23–76), and SIS-Participation was 50 (P25–P75: 33–75), indicating moderate limitations in daily activities and social participation. SIS-Communication (93, P25–P75: 75–98) and SIS-Memory (88, P25–P75: 62–98) scores were relatively preserved, whereas SIS-Emotion showed greater variability (44, P25–P75: 25–50).

PLEASE INSERT Table 2 HERE

## Perceived barriers

Perceived barriers to CR demonstrated a heterogeneous profile across domains (Table 3). The median CRBS sum score was 11 (P25–P75: 8–15), indicating a moderate overall burden of perceived barriers. Among subdomains, perceived needs showed a median score of 3 (P25–P75: 0–5), and access-related barriers had a median of 2 (P25–P75: 0–5), suggesting that informational gaps and structural limitations were relatively prominent in this cohort. In contrast, personal/family problems and travel/work conflicts presented low median scores of 0 (P25–P75: 0–1), indicating that these barriers were less frequently endorsed. The comorbidities/functional status domain showed a median score of 5 (P25–P75: 0–5),

reflecting variability in how participants perceived health-related constraints affecting rehabilitation participation.

Table 3  
Rehabilitation barriers of the study sample.

Variables	Summary (N = 59)
CRBS (Comorbidities/Functional status) (points)	5 (0–5)
CRBS (Perceived needs) (points)	3 (0–5)
CRBS (Personal/Family problems) (points)	0 (0–1)
CRBS (Travel/Work conflicts) (points)	0 (0–1)
CRBS (Access) (points)	2 (0–5)
CRBS sumscore (points)	11 (8–15)
Values are presented as median (interquartile range) or n (%). Abbreviations: CRBS, Cardiac Rehabilitation Barriers Scale.	

PLEASE INSERT Table 3 HERE

## Correlation analysis

Correlation analysis revealed significant associations between functional status and perceived barriers to rehabilitation participation (Fig. 1; Supplementary File 1). After FDR adjustment, Spearman correlation coefficients showed that the mBI was strongly and positively correlated with SIS mobility ( $\rho = 0.57$ , 95% CI [0.36, 0.72],  $p < 0.001$ ) and SIS ADL/IADL ( $\rho = 0.48$ , 95% CI [0.25, 0.65],  $p < 0.001$ ), indicating that higher levels of functional independence were associated with better mobility and performance of daily activities. In addition, SIS hand function and SIS mobility demonstrated a strong positive association ( $\rho = 0.67$ , 95% CI [0.49, 0.79],  $p < 0.001$ ), reflecting substantial overlap between upper-limb function and mobility-related domains.

PLEASE INSERT FIGURE 1 HERE

Regarding perceived rehabilitation barriers, FDR adjustment showed significant positive associations were observed between the CRBS domains of perceived needs and personal/family problems ( $\rho = 0.37$ , 95% CI [0.12, 0.57],  $p = 0.025$ ). In addition, the CRBS total score showed strong correlations with its subdomains, particularly perceived needs ( $\rho = 0.64$ , 95% CI [0.45, 0.77],  $p < 0.001$ ) and personal/family problems ( $\rho = 0.39$ , 95% CI [0.14, 0.58],  $p = 0.017$ ), reflecting internal coherence among barrier domains.

## DISCUSSION

This study aimed to assess functional status among adults of working age after stroke and to explore their correlations with perceived barriers to CR participation. Our findings indicate that participants presented with mild to moderate disability and reduced independence in daily activities. Perceived rehabilitation barriers were prominent, especially in domains related to perceived needs and access, and showed strong interrelationships among contextual and personal factors. Although direct correlations between rehabilitation barriers and functional or work outcomes were limited, the clustering of socioeconomic and structural barriers highlights the complexity of challenges faced by working-age stroke survivors. Together, these findings suggest the importance of rehabilitation models that integrate clinical recovery with strategies addressing contextual and social determinants, which may be particularly relevant for supporting return to productive life after stroke.

The findings of this study are consistent with prior literature indicating that stroke among adults of working age is frequently associated with persistent limitations across physical, cognitive, and occupational domains. Even relatively mild strokes can be accompanied by substantial psychological and functional sequelae, particularly when reintegration into work and social life is delayed [9, 10]. These findings are in line with those reported by Santos et al., who emphasize the importance of multidimensional assessments for capturing the complex effects of stroke on daily functioning and participation [30].

In addition, the prominence of structural and socioeconomic barriers identified through the CRBS is consistent with evidence describing transportation difficulties, limited awareness, and systemic constraints as major challenges to rehabilitation access in cardiovascular disease contexts, including stroke [12, 14]. The predominance of intrapersonal and contextual barriers observed in our cohort aligns with findings from other rehabilitation populations, as adherence to exercise-based rehabilitation in musculoskeletal conditions is largely influenced by intrapersonal determinants such as self-efficacy and perceived benefits, as well as environmental constraints [16]. Similar contextual challenges have been described from the perspective of family caregivers of stroke survivors [15], including lack of collaboration with the health care team, insufficient discharge coordination, and limited community support were perceived as major barriers to sustaining post-stroke care. This issue is particularly relevant in Brazil, where regional disparities in healthcare access persist [8], potentially placing working-age stroke survivors at increased risk of delayed or fragmented rehabilitation. Collectively, these findings reinforce the importance of rehabilitation models that extend beyond clinical interventions to address contextual and social determinants of recovery, including flexible service delivery and integration with primary care to improve reach among underserved populations.

The interrelationships between functional status, emotional well-being, and perceived rehabilitation barriers emerged as relevant aspects of this study. Lower scores in the SIS emotion domain suggest that psychological challenges (e.g., emotional distress, frustration, and reduced self-efficacy) may coexist with functional limitations among adults of working age after stroke. This observation is consistent with prior literature highlighting the psychological burden experienced by stroke survivors during the recovery process [10], and suggests the need for care models that extend beyond physical rehabilitation alone.

The correlations observed between CRBS subdomains – particularly perceived needs and personal or family-related problems – indicate clustering of logistical, social, and contextual challenges. These overlapping barriers may be associated with increased emotional strain and reduced perceived capacity to engage in rehabilitation activities. Taken together, these findings highlight the potential value of personalized rehabilitation strategies that incorporate psychological support, family education, and social assistance. Public rehabilitation initiatives may benefit from integrating mental health resources, family-centered approaches, and community-based support networks to promote continuity of care and address the broader determinants of recovery.

This study has several limitations that should be acknowledged. First, the cross-sectional design precludes causal inference regarding the observed associations and limits the ability to examine temporal changes in functional status and perceived rehabilitation barriers. Second, the regional scope of the sample may limit the generalizability of the findings to other populations of adults of working age after stroke in Brazil or in different healthcare contexts. Despite these limitations, the study also presents important strengths. To our knowledge, it is among the first studies in Brazil to examine, within a single analytical framework, the relationships between functional status and perceived rehabilitation barriers among adults of working age after stroke, using a multidimensional approach and validated assessment instruments. Future studies employing longitudinal designs are warranted to better characterize changes over time and to clarify the directionality of these relationships.

## **CONCLUSIONS**

Adults of working age recovering from stroke experience substantial challenges related to functional limitations. This study demonstrates that perceived rehabilitation barriers – particularly those related to access, perceived needs, and personal or family circumstances – were prominent and showed substantial interrelationships. Integrated and person-centered rehabilitation approaches that extend beyond physical recovery are required to address emotional well-being and broader socioeconomic conditions.

## **Declarations**

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### **Competing Interests**

The authors have no relevant financial or non-financial interests to disclose.

### **Author Contributions**

All authors contributed to the study conception and design. Data collection was performed by Paulo Cesar de Lima Andrelino. Data analysis was performed by Arthur de Sá Ferreira. The first draft of the manuscript was written by Paulo Cesar de Lima Andrelino and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

### **Data Availability**

Due to ethical restrictions, the datasets generated during and analysed during the current study are available from the corresponding author on request.

### **Ethics approval**

This study adhered to ethical standards outlined in the Declaration of Helsinki. The study protocol was approved by the Research Ethics Committee before execution following national regulations (approval number: CAAE: 76491623.0.0000.5235).

### **Consent to participate**

Written informed consent was obtained from all participants before their inclusion in the study.

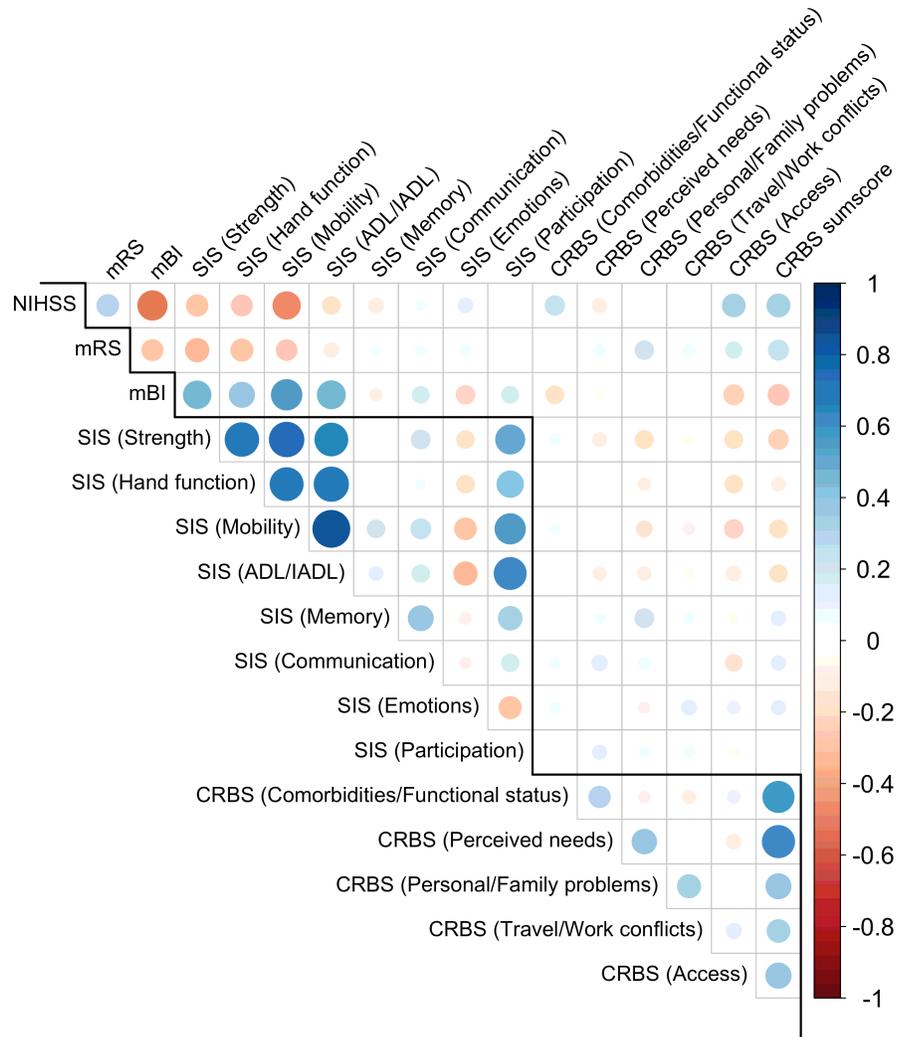
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## Figures



**Figure 1**

Correlation matrix of functional status (National Institutes of Health Stroke Scale, NIHSS; Modified Rankin Scale, mRS; modified Barthel Index, mBI; and Stroke Impact Scale subdomains, SIS) and cardiac rehabilitation barriers (Cardiac Rehabilitation Barriers Scale and its subdomains, CRBS). Significant correlations ( $p < 0.05$ ) are highlighted, while insignificant ones are left blank

## Supplementary Files

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