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# Impact of Shoulder–Hand Syndrome on Upper Extremity–Related Functional Independence Among Chronic Stroke Patients

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## ABSTRACT

**Background:** Shoulder–hand syndrome (SHS), commonly conceptualized within post-stroke complex regional pain syndrome type I, is a disabling complication that may exacerbate dependence in chronic stroke survivors by limiting functional use of the affected upper limb. **Objective:** To determine the association between SHS pain intensity and activities-of-daily-living (ADL) functional independence among chronic stroke patients. **Methods:** A cross-sectional observational study was conducted over six months at PSRD Hospital and Lahore General Hospital. Using non-probability convenience sampling, 164 chronic ischemic supratentorial stroke patients (>6 months post-stroke) meeting Budapest criteria for SHS were enrolled. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS; 0–10), and functional independence was evaluated using the Barthel Index. Pearson correlation was applied to examine the association between NPRS and Barthel total score (SPSS v25; two-tailed  $\alpha=0.05$ ). **Results:** Participants had a mean age of  $59.35\pm9.52$  years; 152 (92.7%) were male. Mean NPRS pain intensity was  $2.48\pm2.03$ , and mean Barthel total score was  $63.4\pm18.9$ . Greater pain intensity was associated with lower ADL independence ( $r=-0.414$ ; 95% CI  $-0.54$  to  $-0.27$ ;  $p<0.001$ ). Dependency was most pronounced in stair negotiation (42.7% unable) and transfers (56.1% requiring assistance). **Conclusion:** In chronic stroke patients with SHS, higher pain intensity is significantly associated with poorer functional independence, supporting the clinical importance of targeted pain management within long-term stroke rehabilitation.

## Keywords

Shoulder–hand syndrome; complex regional pain syndrome; chronic stroke; pain intensity; Barthel Index; functional independence

## INTRODUCTION

Stroke remains a major cause of long-term disability worldwide, with substantial functional sequelae arising from motor, sensory, and autonomic disturbances following cerebral injury (1). Among stroke survivors, persistent impairment of the upper limb is particularly consequential because upper extremity performance underpins self-care, transfers, assistive mobility, and community participation, thereby shaping dependency and quality of life trajectories in both the subacute and chronic phases (2). Even when ambulation is partially restored, deficits in hand strength and upper limb motor control can continue to constrain activities of daily living (ADL), highlighting the clinical importance of characterizing modifiable factors that exacerbate functional dependence in chronic stroke populations (3).

Pain syndromes after stroke are among the most functionally disruptive and therapeutically challenging complications, with complex regional pain syndrome (CRPS) representing a multifactorial pain condition involving neuroinflammatory, autonomic, and central sensitization mechanisms (4). In post-stroke contexts, the entity commonly described as shoulder–hand syndrome (SHS) is frequently conceptualized within the spectrum of CRPS—typically CRPS type I—manifesting as disproportionate pain, edema, trophic skin changes, abnormal temperature, and restricted range of motion in the affected upper limb (5). Although the pathophysiology of CRPS remains incompletely elucidated, contemporary models support a staged clinical evolution characterized by early pro-inflammatory processes and later tissue and bone remodeling pathways, which can consolidate disability if not recognized and managed appropriately (6). Epidemiologic observations further indicate that post-stroke CRPS/SHS tends to emerge within the first month after stroke, and prevalence estimates vary according to patient severity profiles and diagnostic ascertainment, underscoring the need for robust, criteria-based identification and functional characterization in clinical cohorts (7).

From a rehabilitation and health-services perspective, the clinically salient question is not only whether SHS occurs, but how its symptom burden—particularly pain intensity—relates to functional independence in established (chronic) stroke. Prior work has linked post-stroke CRPS/SHS with reduced use of the affected limb and worse upper limb activity patterns, suggesting that pain and associated autonomic/edematous changes may reinforce learned nonuse and functional decline (8). Complementary evidence in broader post-stroke shoulder pain populations indicates that shoulder pain is associated with increased functional dependency and compromised upper extremity-related skills, although the magnitude and pathways of these relationships can vary by paresis severity and measurement approach (9). Importantly, the functional construct under consideration must be explicit: many studies quantify “upper limb function” using impairment- or activity-specific instruments, whereas clinical decision-making often relies on global ADL indices that capture the real-world consequences of upper limb limitations on feeding, dressing, toileting, transfers, and mobility-related tasks that require bilateral or assisted upper extremity participation (2,3). Despite accumulating literature on post-stroke pain syndromes, there remains a practical knowledge gap regarding how SHS pain severity—ascertained using a standardized pain metric—relates to ADL mobility/independence among chronic stroke patients meeting Budapest diagnostic criteria in routine rehabilitation settings, where resources, referral patterns, and long-term follow-up differ from controlled research cohorts (5,7,8).

Accordingly, using a PICO-driven framework, the present study focuses on chronic stroke survivors (Population) who meet Budapest criteria for SHS/CRPS type I (Exposure/Condition), evaluating whether greater pain intensity (Exposure gradient) is associated with worse ADL mobility and functional independence (Outcome), as measured using a standardized ADL index commonly applied in clinical rehabilitation contexts (Comparator implicitly defined by lower pain intensity levels within the cohort) (5). The primary objective was to investigate the association between SHS pain intensity and ADL mobility/functional independence among chronic stroke patients. We hypothesized that higher SHS pain intensity would be associated with lower ADL mobility and greater dependence in day-to-day functioning (8,9).

## MATERIALS AND METHODS

This study employed a cross-sectional observational design to examine the association between shoulder–hand syndrome (SHS) pain intensity and functional independence related to activities of daily living among individuals with chronic stroke. A cross-sectional approach was selected as appropriate for quantifying the magnitude and direction of associations between clinical variables within a defined population at a single point in time, particularly when the objective is to explore relationships rather than establish causality (10). The study was conducted over a six-month period in outpatient and inpatient rehabilitation departments of tertiary-care hospitals in Lahore, Pakistan, including Pakistan Society for the Rehabilitation of the Disabled (PSRD) Hospital and Lahore General Hospital, both of which serve as major referral centers for neurological rehabilitation.

Participants were recruited using a non-probability convenience sampling strategy from eligible patients attending rehabilitation services during the study period. Individuals were considered eligible if they were aged between 45 and 80 years, had a confirmed diagnosis of ischemic supratentorial stroke, and were classified as having chronic stroke defined as a duration of more than six months since stroke onset. All participants were required to meet the Budapest diagnostic criteria for complex regional pain syndrome type I, clinically manifesting as shoulder–hand syndrome on the affected side (11).

Both male and female patients were included. Exclusion criteria were applied to minimize confounding related to alternative neurological or musculoskeletal causes of upper limb dysfunction and included a history of traumatic brain injury, epilepsy, neurodegenerative disorders, bilateral hemispheric stroke, apraxia, global aphasia, visuospatial hemineglect, prior injury or surgery of the affected upper limb, and clinically evident cognitive impairment that could interfere with valid assessment of pain or functional status (12).

Potential participants were identified through screening of medical records and direct referral by treating rehabilitation physicians and physiotherapists. Eligible individuals received a standardized verbal and written explanation of the study objectives, procedures, potential risks, and confidentiality safeguards. Written informed consent was obtained from all participants prior to enrollment, in accordance with ethical research principles for human subjects (13). Recruitment was conducted consecutively during routine clinical visits to reduce selection bias associated with selective enrollment on specific days or services.

Data collection was performed by trained assessors using standardized assessment tools to ensure consistency and reproducibility. Pain intensity related to shoulder–hand syndrome was quantified using the Numeric Pain Rating Scale (NPRS), an 11-point ordinal scale ranging from 0 (no pain) to 10 (worst imaginable pain), which has demonstrated reliability and validity in musculoskeletal and neurological pain populations, including post-stroke conditions (14). Functional independence related to activities of daily living was assessed using the Barthel Index, a widely used and validated measure of ADL performance in stroke rehabilitation, encompassing feeding, bathing, grooming, dressing, bowel and bladder control, toilet use, transfers, mobility, and stair negotiation, with higher scores indicating greater independence (15). All assessments were conducted during a single session to maintain temporal consistency between exposure and outcome measurements.

The primary exposure variable was SHS pain intensity, operationalized as the total NPRS score. The primary outcome variable was functional independence, operationalized as the total Barthel Index score. Secondary descriptive variables included age, sex, and item-level Barthel performance categories to characterize patterns of dependency. To mitigate measurement bias, assessors followed standardized administration protocols for both instruments, and data were recorded immediately after assessment to minimize recall or transcription errors. Restrictive eligibility criteria were used to reduce confounding from cognitive, perceptual, and alternative neurological impairments known to independently affect ADL performance after stroke (12). The sample size was determined a priori using Epi tool software, based on detecting a moderate correlation between pain intensity and functional independence with a two-tailed alpha level of 0.05 and a statistical power of 80%, accounting for potential non-response. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 25.

Descriptive statistics were computed for all variables, with means and standard deviations reported for continuous variables and frequencies with percentages for categorical variables. Normality of continuous variables was assessed using visual inspection of histograms and distributional characteristics to justify the use of parametric tests. The association between SHS pain intensity and Barthel Index score was examined using Pearson's correlation coefficient. Missing data were handled using complete-case analysis, as assessments were conducted in a controlled clinical setting with immediate data verification. A two-tailed *p*-value of less than 0.05 was considered statistically significant (16).

Ethical approval for the study was obtained from the Institutional Review Board of the affiliated institutions prior to commencement, and all procedures were conducted in accordance with the Declaration of Helsinki. Participant confidentiality was ensured by anonymizing data and restricting access to study files to the research team only. Data integrity was maintained through double-checking of entries and secure storage of both paper-based and electronic records, enabling reproducibility and transparency for future verification or secondary analysis.

## RESULTS

Table 1 summarizes the demographic and clinical profile of the 164 chronic stroke patients with shoulder–hand syndrome included in the analysis. The cohort had a mean age of  $59.35 \pm 9.52$  years, indicating that most participants were in late middle to older adulthood. Males constituted an overwhelming majority of the sample (152 participants, 92.7%), while females accounted for only 12 participants (7.3%). All participants had ischemic supratentorial stroke and were in the chronic phase, defined as more than six months post-stroke. The mean pain intensity score measured using the Numeric Pain Rating Scale was  $2.48 \pm 2.03$ , reflecting mild-to-moderate pain levels overall but with notable inter-individual variability. Table 2 details the item-wise distribution of functional independence as assessed by the Barthel Index. In self-care domains, 72 participants (43.9%) were independent in feeding, while 53 (32.3%) required assistance and 39 (23.8%) were fully dependent. Bathing showed a higher dependency burden, with 58 participants (35.4%) needing help and 106 (64.6%) being independent. Grooming independence was observed in 109 participants

(66.5%), whereas 55 (33.5%) required assistance. Dressing ability was more evenly distributed, with 49 participants (29.9%) dependent, 53 (32.3%) needing help, and 62 (37.8%) independent. Continence was relatively preserved, as bowel continence was reported in 116 participants (70.7%) and bladder continence in 95 participants (57.9%). Mobility-related activities demonstrated greater functional compromise: 70 participants (42.7%) required assistance for toilet use, 71 (43.3%) required minor help during transfers, and 72 (43.9%) ambulated with the help of another person. Stair negotiation was particularly affected, with 70 participants (42.7%) unable to climb stairs and only 32 (19.5%) able to do so independently.

The mean total Barthel Index score for the cohort was  $63.4 \pm 18.9$ , consistent with a moderate level of functional dependence. Table 3 presents the inferential analysis examining the association between shoulder–hand syndrome pain intensity and functional independence. A statistically significant moderate negative correlation was identified between Numeric Pain Rating Scale scores and total Barthel Index scores ( $r = -0.414$ , 95% CI  $-0.54$  to  $-0.27$ ,  $p < 0.001$ ).

This finding indicates that higher pain intensity was associated with lower levels of ADL independence. Numerically, participants reporting higher pain scores tended to demonstrate greater dependency across multiple ADL domains, particularly those involving transfers, mobility, and stair use, reinforcing the clinical relevance of pain severity as a determinant of functional limitation in chronic stroke patients with shoulder–hand syndrome. A total of 164 chronic stroke patients diagnosed with shoulder–hand syndrome were included in the analysis.

The mean age of participants was 59.35 years ( $SD = 9.52$ ), indicating a predominantly late middle-aged to older adult cohort. Male participants constituted the majority of the sample ( $n = 152$ , 92.7%), while females represented a smaller proportion ( $n = 12$ , 7.3%). The mean pain intensity score measured using the Numeric Pain Rating Scale was 2.48 ( $SD = 2.03$ ), reflecting mild-to-moderate pain severity at the time of assessment. Descriptive demographic and clinical characteristics are summarized in Table 1.

**Table 1. Demographic and Clinical Characteristics of Participants (N = 164)**

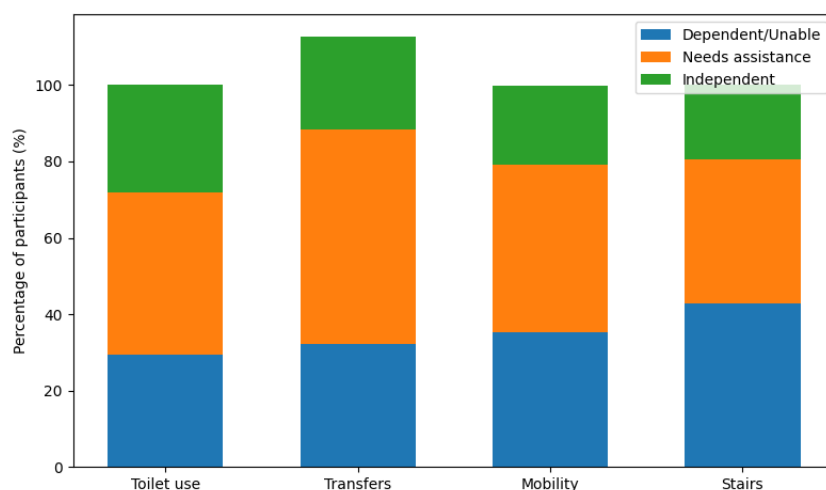
Variable	Mean $\pm$ SD / n (%)
Age (years)	59.35 $\pm$ 9.52
Sex	
Male	152 (92.7%)
Female	12 (7.3%)
Pain intensity (NPRS, 0–10)	2.48 $\pm$ 2.03
Stroke chronicity (>6 months)	164 (100%)
Stroke type (ischemic, supratentorial)	164 (100%)

**Table 2. Distribution of Barthel Index Item Scores (N = 164)**

Barthel Item	Category	n (%)
Feeding	Dependent	39 (23.8)
	Needs help	53 (32.3)
	Independent	72 (43.9)
Bathing	Needs help	58 (35.4)
	Independent	106 (64.6)
Grooming	Needs help	55 (33.5)
	Independent	109 (66.5)
Dressing	Dependent	49 (29.9)
	Needs help	53 (32.3)
	Independent	62 (37.8)
Bowels	Incontinent	23 (14.0)
	Occasional accident	25 (15.2)
	Continent	116 (70.7)
Bladder	Incontinent	21 (12.8)
	Occasional accident	48 (29.3)
	Continent	95 (57.9)
Toilet use	Dependent	48 (29.3)
	Needs help	70 (42.7)
	Independent	46 (28.0)
Transfers	Unable	32 (19.5)
	Major help	21 (12.8)
	Minor help	71 (43.3)
	Independent	40 (24.4)
Mobility	Immobile	34 (20.7)
	Wheelchair independent	24 (14.6)
	Walks with help	72 (43.9)
	Independent	34 (20.7)
Stairs	Unable	70 (42.7)
	Needs help	62 (37.8)
	Independent	32 (19.5)

**Table 3. Association Between Pain Intensity and Functional Independence (N = 164)**

Variables	Pearson r	95% CI	p-value
NPRS pain score vs Barthel Index total score	−0.414	−0.54 to −0.27	<0.001



**Figure 1** Figure. Gradient of Functional Dependence Across Mobility-Related ADL Domains in Chronic Stroke with Shoulder–Hand Syndrome The figure illustrates a graded pattern of functional dependence across mobility-related activities of daily living among chronic stroke patients with shoulder–hand syndrome, derived from aggregated Barthel Index item distributions. Dependence was most pronounced in stair negotiation, where 42.7% of participants were unable to perform the task and only 19.5% were fully independent. Transfers showed a similarly high assistance burden, with 56.1% of participants requiring either major or minor help and only 24.4% achieving independence. For general mobility, 35.3% of patients were immobile or wheelchair dependent, while 43.9% required assistance for ambulation and just 20.7% walked independently. Toilet use demonstrated a comparable gradient, with 29.3% dependent, 42.7% requiring help, and 28.0% independent. Collectively, the layered distribution highlights a clinically meaningful shift toward assisted or dependent performance as task complexity and upper extremity demand increase, underscoring the functional impact of shoulder–hand syndrome–related pain and impairment on mobility-intensive ADL domains in chronic stroke survivors.

## DISCUSSION

The present study examined the association between shoulder–hand syndrome (SHS) pain intensity and functional independence related to activities of daily living among individuals with chronic stroke. The findings demonstrate a statistically significant moderate negative association between pain severity and ADL performance, indicating that higher levels of SHS-related pain are associated with greater functional dependence. This relationship was particularly evident in mobility-intensive domains such as transfers, ambulation, toilet use, and stair negotiation, which require coordinated upper extremity involvement for balance, support, and task execution. These results extend existing evidence by focusing specifically on a chronic stroke cohort meeting Budapest diagnostic criteria and by contextualizing pain severity within clinically meaningful ADL outcomes rather than isolated impairment-level measures.

The observed association is consistent with prior research indicating that CRPS/SHS substantially limits daily use of the affected upper limb and contributes to persistent disability. Kindl et al. demonstrated that patients with CRPS exhibit markedly reduced real-world upper extremity activity, comparable in magnitude to disability observed in severe peripheral nerve injuries, underscoring the functional burden of this condition beyond pain alone (17). Similarly, Katsura et al. reported that post-stroke CRPS was associated with upper limb inactivity and reduced functional engagement in hemiplegic patients, reinforcing the link between pain syndromes and diminished activity patterns after stroke (18). The current findings align with these reports and further suggest that pain-related limitations translate into broader ADL dependency in the chronic phase of recovery.

Importantly, the results highlight that SHS-related pain is not confined to discomfort but is functionally consequential, particularly in tasks that integrate upper limb support with whole-body movement. This observation is clinically relevant, as earlier work has shown mixed findings regarding the impact of post-stroke shoulder pain on quality of life and functional outcomes, especially in individuals with mild to moderate paresis (19). By focusing on a cohort with confirmed SHS/CRPS and chronic stroke duration, the present study provides evidence that pain intensity remains functionally relevant beyond the subacute phase, potentially perpetuating dependence even after neurological recovery has plateaued.

The relationship between pain and functional limitation observed in this study also aligns with broader CRPS literature emphasizing the multifactorial contributors to disability. Previous investigations have demonstrated that pain intensity in CRPS is associated with both physical and psychosocial factors, including altered pain processing and fear-avoidance behaviors, which can further restrict activity and participation (20,21). However, the extent to which psychological factors contribute to CRPS-related disability remains debated. While some studies report strong associations between psychological variables and pain-related impairment (21), others have found no clear link between psychological factors and the development of CRPS type I (22). The present study did not assess psychosocial variables, but the strength of the observed association suggests that pain itself is a key driver of functional dependence in this population, independent of unmeasured psychological contributors.

Comparisons with studies in other CRPS populations further contextualize the findings. Research in lower-limb CRPS has shown that activity limitations are influenced not only by pain severity but also by pain-related fear and perceived harmfulness of movement (23). In contrast, the current results suggest that in post-stroke SHS affecting the upper limb, pain intensity alone demonstrates a meaningful association with ADL dependence, particularly in tasks requiring upper extremity stabilization. This distinction may reflect differences in task demands, compensatory strategies, and rehabilitation exposure between upper and lower extremity CRPS populations.

The functional patterns identified in this study are also supported by evidence from post-stroke shoulder pain research more broadly. Ateş Sari et al. reported that shoulder pain after stroke is associated with increased functional dependency and reduced upper extremity-related skills, findings that parallel the present results despite differences in diagnostic specificity (24). Moreover, the distribution of dependency across ADL domains in this study is consistent with earlier work demonstrating that upper extremity impairments are moderately to strongly correlated with activity limitations, particularly in strength-dependent and mobility-related tasks, while associations with participation-level outcomes may be weaker (25). Studies employing objective upper limb activity monitoring have further shown that reduced grip strength and limited wrist and finger range of motion account for a substantial proportion of activity restrictions in CRPS type I, supporting the functional relevance of upper limb pain and impairment (26).

From a rehabilitation perspective, these findings underscore the importance of early identification and targeted management of SHS-related pain to mitigate long-term functional consequences. Systematic reviews indicate that physiotherapy-based interventions remain the cornerstone of SHS/CRPS management, with evidence supporting modest but clinically meaningful improvements in pain and function (27). Adjunctive modalities such as occupational therapy, graded motor imagery, and neuromodulatory techniques have also demonstrated benefit in selected populations (28). Although the present study is cross-sectional and cannot establish causality, the demonstrated association between pain severity and ADL dependence reinforces the rationale for proactive pain management as part of comprehensive stroke rehabilitation, even in the chronic stage.

Several limitations should be considered when interpreting these findings. The cross-sectional design precludes causal inference, and residual confounding related to stroke severity, spasticity, or rehabilitation intensity cannot be excluded despite restrictive eligibility criteria. The predominance of male participants may limit generalizability, and functional independence was assessed using a global ADL measure rather than an upper limb-specific activity scale. Nevertheless, the use of standardized diagnostic criteria and clinically relevant outcome measures enhances the applicability of the results to routine rehabilitation settings.

## CONCLUSION

In conclusion, this study demonstrates a significant moderate association between shoulder-hand syndrome pain intensity and reduced functional independence among individuals with chronic stroke, with higher pain levels corresponding to greater dependency in mobility-related activities of daily living. These findings highlight that SHS-related pain remains functionally consequential beyond the subacute phase of stroke recovery and emphasize the clinical importance of integrating targeted pain management strategies into long-term stroke rehabilitation to support functional independence and quality of life.

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