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Impact of Shoulder Pain on Upper Limb Function: An Observational Study in Post-Stroke Individuals

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HIGHLIGHTS

- Pain severity correlated strongly with pain interference after stroke.
- Motor recovery related to functional independence, grip strength, and spasticity.
- Time since stroke and stroke type significantly influenced outcomes.

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Impact of Shoulder Pain on Upper Limb Function: An Observational Study in Post-Stroke Individuals

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Conflict of Interest
The authors have no potential conflicts of interest to disclose.

ABSTRACT

Shoulder pain is a frequent complication after stroke, often associated with reduced arm function, decreased independence, and poorer quality of life. This study aimed to investigate the relationship between post-stroke shoulder pain, motor performance, functional outcomes, and spasticity to provide clinically relevant evidence for rehabilitation. We conducted an observational study including individuals who had experienced a stroke and were undergoing neurorehabilitation. Pain severity and its interference with daily activities were measured through structured clinical evaluation. Motor outcomes were assessed with standardized functional and strength tests, and spasticity was measured using a validated clinical scale. Sociodemographic and clinical variables, including time since stroke and stroke type, were also collected. The mean pain severity score was 4.82 (standard deviation 1.72). Pain severity correlated strongly with pain interference, although neither was significantly associated with motor or functional performance. Motor and functional variables were interrelated: motor recovery scores correlated positively with functional independence and grip strength, and negatively with spasticity. Time since stroke influenced outcomes, with poorer motor and functional results in participants more than two years post-event. Stroke type influenced pain, with greater interference reported in patients with ischemic stroke. No significant differences were observed between sexes. These findings highlight the multifactorial nature of shoulder pain after stroke and emphasize the importance of early and individualized rehabilitation strategies. Addressing pain, spasticity, and functional limitations together may improve long-term outcomes and quality of life for individuals living with the consequences of stroke.

Keywords: Stroke; Shoulder Pain; Upper Extremity; Motor Skills; Activities of Daily Living

INTRODUCTION

Stroke is the second leading cause of death and the third leading cause of disability worldwide [1-3]. Considered as one of the most prominent causes of long-term disability, stroke can impair any body system depending on the vascular territory of the brain that is affected [4]. These impairments can lead to severe problems in functionality that reflects in

Author Contributions
Conceptualization: Lopes S, Fernandes Â; Data curation: Lopes S; Formal analysis: Lopes S, Fernandes Â; Supervision: Fernandes Â; Writing - original draft: Lopes S; Writing - review & editing: Lopes S, Fernandes Â.

daily participation of different areas of occupation, including activities of daily living (ADLs), instrumental ADLs, health management, work, leisure and social participation [5].

Pain is associated with increased disability, poorer health outcomes and reduced quality of life [6]. In addition to causing immediate and significant effects on an individual's functionality and independence, stroke can also induce pain syndromes, that can hinder recovery and negatively impact functional outcomes [6].

Shoulder pain is reported in approximately 50% to 80% of individuals with post-stroke sequelae, typically emerging within two to three months after the event [7-9]. Its origin may be central, such as thalamic pain due to impaired inhibitory mechanisms, or peripheral, arising from local musculoskeletal factors [8].

The etiology of post-stroke shoulder pain is multifactorial and often interrelated, involving both neurological and mechanical factors [10]. These factors can lead to a series of musculoskeletal conditions such as shoulder subluxation, frozen shoulder or adhesive capsulitis, bursitis, tone disorders and therefore postural changes, rotator cuff abnormalities and biceps tendinitis [11,12]. Research shows that tone disorders like lower tone have a high incidence of shoulder subluxation and increased tone can lead to higher muscular tension and contractures [13].

Given this complexity, rehabilitation approaches cannot be limited to a single area of intervention [14]. Shoulder pain after stroke has been identified as a predictor of poorer outcomes in variables such as motor rehabilitation, functionality, depression and quality of life [14].

This study aims to analyze the impact of shoulder pain in upper limb functionality, in individuals post stroke. Therefore, examining the perceived shoulder pain and parameters such as function in daily life, function of the upper limb, motor function, manual force and hand dexterity.

MATERIALS AND METHODS

Study design

This study is an observational quantitative cross-sectional, with a non-probabilistic convenience sampling method [15,16]. It was approved by the ethics committee of E2S, Polytechnic of Porto with the number of registration CE0006F. Furthermore, it was approved by written by the Director and the Head Coordinator of the Rehabilitation Department in which the study took place.

Participants

The sample comprises patients attending, the physical medicine and rehabilitation department in north of Portugal, in ambulatory setting. The subjects were selected according to predefined inclusion and exclusion criteria [17]. The inclusion criteria comprised individuals with a history of stroke, of any type and location, over 18 years old and capable of giving informed consent, with shoulder pain at the hemiplegic side. The exclusion criteria included the presence of a diagnosis of global aphasia, Neglect, agnosia, somatosensorial deficits and the presence of shoulder pain prior to the stroke.

After the selection process, the participants signed an informed consent form based on the Declaration of Helsinki [18], to ensure that the will and rights of those involved in the study were respected and that they were fully aware of the information relevant to their voluntary decision to participate. The document also guaranteed the privacy and confidentiality of both the study and the data collected [18]. Participants were informed that they could refuse their participation and the use of their data at any time without repercussions. The data was stored in an encrypted excel file, where each participant's information remain anonymous and protected. An alphanumeric code was assigned to each participant for data processing purposes.

Data sources/measurements

Data collection was carried out by the responsible researcher at a single time point, with the application of a protocol that included:

The sociodemographic questionnaire was designed to collect information on the participants' sociodemographic variables, such as age, gender, civil and professional status, as well as their clinical history, with information regarding the stroke, personal history and therapeutic intervention. The Modified Ashworth Scale (MAS) to assess muscle tone, with a 0 to 4 scale point including 1+ to increase sensitivity [19]. The inter and intra-reliability of MAS ranges from moderate to high in general, with better results in the upper limbs, which means that it is a reliable measure [20,21]. The Brief Pain Inventory is a questionnaire used to assess pain severity and how pain interference with daily activities. It includes items rated from 0 to 10 [22,23]. It shows good reliability ($r = 0.8$) and high internal consistency, with Cronbach's alpha ranging from 0.81–0.89 for severity and 0.88–0.95 for interference [22]. The Functional Independence Measure (FIM) is a standardized instrument used in rehabilitation to quantify functional independence [24-26]. It consists of 18 items scored on a 7-point scale (1 = total assistance, 7 = complete independence), with total scores ranging from 18 to 126 and is administered via direct observation or structured interview [24-26]. The Fugl-Meyer Assessment of Upper Extremity (FMA-UE) is a widely recommended tool for evaluating sensorimotor function post-stroke [27]. It includes 33 items across four subscales, each scored on a 3-point ordinal scale (0–2), with a maximum score of 66 [27]. Higher scores indicate better motor function. The FMA-UE demonstrates excellent reliability, validity, and responsiveness [27]. Maximal grip strength was assessed using the digital Jamar hand dynamometer, a gold-standard device for measuring isometric grip force [28,29]. Participants were positioned with the elbow at 90°, forearm neutral, and wrist extended 0–30° [29]. Three trials were conducted per hand, with the mean used for analysis. The device shows excellent intra-rater reliability ($ICC > 0.95$) and internal consistency ($\alpha > 0.95$) [29]. The Jebsen-Taylor Hand Function Test (JTHFT) is a standardized tool for assessing manual dexterity in daily activities [30]. It includes seven timed tasks simulating ADLs such as writing and object manipulation [30]. The test shows strong internal consistency ($\alpha \geq 0.92$), and good validity compared to other upper limb motor function measures in post-stroke adults [30]. The Box and Block Test (BBT) is a valid and reliable tool for assessing manual dexterity [31]. Participants move as many blocks as possible, one at a time, from one compartment to another within 1 minute, using each hand separately, with the total number of transferred blocks reflecting hand function [31]. The BBT is widely used to monitor motor recovery in both clinical and research settings [31].

To minimize potential sources of bias in the data, the protocol was standardized for all participants, using assessment instruments validated for the study population. The procedures were consistently applied in the same environment, strictly adhering to the specific instructions of each instrument.

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Statistical analysis

Variables included shoulder pain severity and interference, muscle tone, hand strength, and manual dexterity as determinants of upper limb functionality. Non-modifiable factors (age, sex, time since stroke, stroke type, lesion side), vascular risk factors, and sociodemographic characteristics were also considered for contextual interpretation. Age, functional and motor scores, increased muscle tone and pain measures were analyzed as continuous variables. Time since stroke (≤ 2 vs. > 2 years), stroke type (ischemic vs. hemorrhagic) and sex (male vs. female) were grouped for clinical interpretability.

Statistical analyses were performed using SPSS version 29 (SPSS Inc., Chicago, IL, USA). Descriptive statistics summarized sample characteristics. The Shapiro-Wilk tests were applied to assess the normality of quantitative variables. Between-group differences were analyzed using the Mann–Whitney U test. Correlations between pain, motor, and functional measures were examined using Spearman's rho coefficient. For correlation analyses, effect sizes (Spearman's rho) are presented together with 95% confidence intervals (CIs) calculated using Fisher's z transformation. For non-parametric group comparisons, median differences with 95% CIs are reported for statistically significant results. Statistical significance was $p < 0.05$ [16].

RESULTS

Of the 44 patients screened for eligibility, 15 were excluded for not meeting inclusion criteria (**Fig. 1**). Thus, 29 patients were included in the final analysis in which consists in most men, with a mean age of 58,7 years. There were more participants with stroke with more than two years, more with ischemic stroke and more with the non-dominant hand affected, according to the data in **Table 1**.

Regarding risk factors, the most reported was hypertension and a sedentary lifestyle (**Table 2**).

Examining the data on **Table 3**, the mean FIM score was 113.3 (standard deviation [SD] = 16.2), indicating moderate functional independence. Upper limb motor function assessed by the FMA-UE had a mean score of 41.4 (SD = 16.4), meanwhile pain severity had a mean value of 4.82 (SD = 1.72) and pain interference averaged 4.43 (SD = 2.19). Dexterity in the affected hand

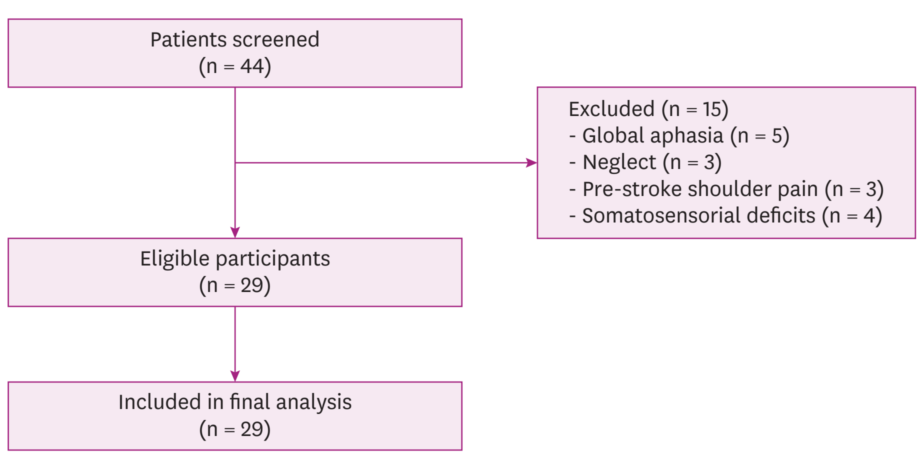

Fig. 1. Participants eligibility.

Table 1. Sociodemographic characterization of the sample

Sociodemographic variables	Values
Age (yr)	58.7 ± 9.90
Sex	
Male	22 (75.90)
Female	7 (24.10)
Education level (yr)	6.62 ± 4.20
Time of stroke	
Less than 2 yr	13 (44.80)
More than 2 yr	16 (55.20)
Type of stroke	
Ischemic	21 (72.40)
Hemorrhagic	8 (27.60)
Local of lesion	
Right hemisphere	16 (55.20)
Left hemisphere	13 (44.80)
Affected hand dominance	
Dominant hand affected	14 (48.30)
Non-dominant hand affected	15 (51.70)

Values are presented as mean ± standard deviation or number (%).

Table 2. Sample characterization of vascular risk factors

Vascular risk factors	Values
Obesity	5 (17.20)
Hypertension	25 (86.20)
Sedentariness	20 (69.00)
Hypercholesterolemia	19 (65.50)
Smoking	8 (27.60)
Diabetes	13 (44.80)

Values are presented as number (%).

was reduced, with a mean JTHFT performance of 30.7 (SD = 17.2) and a Box and Blocks mean of 35.8 (SD = 12.4). Participants with a MAS score of 3 or higher were excluded from the BBT, grip strength assessment, and the JTHFT, as increased muscle tone prevented adequate motor performance. Consequently, these analyses were conducted on a reduced subsample (n = 24).

In the analysis of the correlations between pain, motor function and functional independence, pain severity correlated strongly with pain interference ($\rho = 0.626$; 95% CI, 0.337 to 0.807; $p < 0.001$), but no significant associations were observed between pain and functional outcomes. In contrast, motor and functional measures were interrelated. The BBT correlated positively with grip strength ($\rho = 0.442$; 95% CI, 0.047 to 0.717; $p = 0.030$) and FMA-UE ($\rho = 0.707$; 95% CI, 0.425 to 0.864; $p < 0.001$), and negatively with JTHFT ($\rho = -0.588$; 95% CI, −0.801 to −0.242; $p = 0.003$). JTHFT scores correlated negatively with FMA-UE ($\rho = -0.622$; 95% CI, −0.820 to −0.292; $p = 0.001$) and FIM ($\rho = -0.471$;

Table 3. Functional and pain characterization of the sample

Functional/pain variable	No.	Mean ± SD	Min–max
MAS	29	1.10 ± 1.24	0.00–4.00
FIM	29	113.28 ± 16.17	56.00–126.00
FMA-UE	29	41.41 ± 16.42	7.00–65.00
Pain severity (BPI)	29	4.82 ± 1.72	0.75–7.25
Pain interference (BPI)	29	4.43 ± 2.19	0.29–9.14
BBT	24	35.83 ± 12.39	14.00–57.00
Grip strength	24	12.01 ± 8.17	0.00–30.80
JTHFT	24	30.74 ± 17.16	11.40–66.20

No., sample size; SD, standard deviation; Min–max, minimum and maximum; MAS, The Modified Ashworth Scale; FIM, The Functional Independence Measure; FMA-UE, Fugl-Meyer Assessment of Upper Extremity; BPI, The Brief Pain Inventory; BBT, The Box and Block Test; JTHFT, The Jebsen-Taylor Hand Function Test.

Table 4. Spearman's rho correlations (ρ) with 95% CIs between pain, motor function, and functional independence

Variable	Pain severity	Pain interference	BBT	JTHFT	Grip strength	FMA-UE	FIM	MAS
Pain severity	-	0.626** (0.337 to 0.807)	−0.044 (−0.403 to 0.328)	−0.067 (−0.423 to 0.300)	−0.306 (−0.609 to 0.081)	−0.134 (−0.478 to 0.239)	0.062 (−0.309 to 0.417)	−0.031 (−0.388 to 0.335)
Pain interference	0.626** (0.337 to 0.807)	-	−0.351 (−0.649 to 0.062)	0.221 (−0.171 to 0.558)	−0.318 (−0.618 to 0.067)	−0.113 (−0.459 to 0.258)	−0.121 (−0.464 to 0.249)	−0.117 (−0.462 to 0.253)
BBT	−0.044 (−0.403 to 0.328)	−0.351 (−0.649 to 0.062)	-	−0.588** (−0.801 to −0.242)	0.442* (0.047 to 0.717)	0.707** (0.425 to 0.864)	0.163 (−0.239 to 0.517)	−0.333 (−0.629 to 0.052)
JTHFT	−0.067 (−0.423 to 0.300)	0.221 (−0.171 to 0.558)	−0.588** (−0.801 to −0.242)	-	−0.020 (−0.414 to 0.379)	−0.622** (−0.820 to −0.292)	−0.471* (−0.735 to −0.083)	0.599** (0.258 to 0.807)
Grip strength	−0.306 (−0.609 to 0.081)	−0.318 (−0.618 to 0.067)	0.442* (0.047 to 0.717)	−0.020 (−0.414 to 0.379)	-	0.472* (0.085 to 0.735)	0.138 (−0.265 to 0.498)	−0.393 (−0.677 to 0.002)
FMA-UE	−0.134 (−0.478 to 0.239)	−0.113 (−0.459 to 0.258)	0.707** (0.425 to 0.864)	−0.622** (−0.820 to −0.292)	0.472* (0.085 to 0.735)	-	0.394* (0.032 to 0.665)	−0.794** (−0.899 to −0.603)
FIM	0.062 (−0.309 to 0.417)	−0.121 (−0.464 to 0.249)	0.163 (−0.239 to 0.517)	−0.471* (−0.735 to −0.083)	0.138 (−0.265 to 0.498)	0.394* (0.032 to 0.665)	-	−0.499** (−0.732 to −0.162)
MAS	−0.031 (−0.388 to 0.335)	−0.117 (−0.462 to 0.253)	−0.333 (−0.629 to 0.052)	0.599** (0.258 to 0.807)	−0.393 (−0.677 to 0.002)	−0.794** (−0.899 to −0.603)	−0.499** (−0.732 to −0.162)	-

Values are presented as Spearman's rho (ρ) with 95% CIs.
CI, confidence interval; BBT, The Box and Block Test; JTHFT, The Jebsen-Taylor Hand Function Test; FMA-UE, Fugl-Meyer Assessment of Upper Extremity; FIM, The Functional Independence Measure; MAS, The Modified Ashworth Scale.
*$p < 0.05$, **$p < 0.01$.

95% CI, −0.735 to −0.083; p = 0.020), and positively with MAS (ρ = 0.599; 95% CI, 0.258–0.807; p = 0.002). Moreover, FMA-UE correlated positively with FIM (ρ = 0.394; 95% CI, 0.032 to 0.665; p = 0.034) and negatively with MAS (ρ = –0.794; 95% CI, −0.899 to −0.603; p < 0.001) (**Table 4**).

Furthermore, group comparisons were made by analyzing the time between stroke, the stroke type and sex differences. Significant differences were observed according to time since stroke, with worse scores in patients with more than two years since onset in JTHFT (U = 21.0, p = 0.003), FMA-UE (U = 41.5, p = 0.006), FIM (U = 43.5, p = 0.008), and MAS (U = 37.5, p = 0.002). No differences were observed in pain severity or interference. Stroke type also influenced pain outcomes: pain interference was significantly higher in ischemic compared to hemorrhagic patients (U = 37.0, p = 0.022), while pain severity showed a non-significant trend towards higher scores in the ischemic group (U = 46.0, p = 0.062). No differences were found for functional outcomes between stroke types (p > 0.05). Finally, no significant sex differences were observed in pain severity (U = 45.5, p = 0.106) or pain interference (U = 73.0, p = 0.838), although women tended to report higher pain severity. Median differences with 95% CIs for statistically significant results are reported in **Table 5**. Additional exploratory analyses considering sex, hand dominance, and vascular risk factors did not reveal significant associations with pain or functional outcomes (all p > 0.05) (data no present in table).

DISCUSSION

This study aimed to analyze the impact of shoulder pain on upper limb functionality in individuals after stroke. The results showed that, although pain severity and pain interference were not significantly associated with motor or functional outcomes, motor and functional measures were strongly interrelated.

In contrast, previous literature consistently reports a negative relationship, with higher pain levels being linked to poorer functionality [32-34] and some studies have even identified

Table 5. Group comparisons (Mann–Whitney U test) with effect estimates

Grouping variable	Outcome	U	Median difference (95% CI)	p value	Result
Time since stroke	JTHFT	21.00	12.4 (5.10 to 21.3)	0.003**	Worse in > 2 yr
	FMA-UE	41.50	−14.0 (−24.60 to −4.30)	0.006**	Worse in > 2 yr
	FIM	43.50	−18.00 (−31.20 to −5.40)	0.008**	Worse in > 2 yr
	MAS	37.50	1.00 (0.40 to 1.80)	0.002**	Worse in > 2 yr
	Pain severity	-	-	> 0.05	n.s.
	Pain interference	-	-	> 0.05	n.s.
Stroke type	Pain interference	37.00	1.90 (0.30 to 3.60)	0.022*	↑ Ischemic
	Pain severity	46.00	-	0.062	Trend ↑ ischemic
	Functional outcomes	-	-	> 0.05	n.s.
Sex	Pain severity	45.50	-	0.106	Trend ↑ female
	Pain interference	73.00	-	0.838	n.s.

Values are presented as median differences with 95% CIs for statistically significant results.
U, Mann–Whitney test statistic; CI, confidence interval; JTHFT, The Jebsen-Taylor Hand Function Test; FMA-UE, Fugl-Meyer Assessment of Upper Extremity; FIM, The Functional Independence Measure; MAS, The Modified Ashworth Scale; n.s., not significant.
*$p < 0.05$, **$p < 0.01$.

shoulder pain as a major barrier to rehabilitation [14,35,36]. A possible explanation for this discrepancy lies in the characteristics of the present sample, which consisted mainly of individuals with motor deficits, while those with somatosensory deficits were excluded. Somatosensory impairments are not only recognized as predictors of post-stroke shoulder pain but may also influence pain perception and contribute negatively to upper limb functionality [37-40]. Therefore, by excluding participants with such deficits, the sample was more homogeneous and more specifically representative of motor function, which may account for the absence of a significant relationship between shoulder pain and functional outcomes in this study.

Increase muscle tone, emerged as a key determinant of functional impairment, showing strong negative correlations with motor function and functional independence. This was further supported by the fact that participants with MAS scores greater than 3 were unable to complete functional assessments such as the BBT, the grip strength test and the JTHFT. These results are consistent with previous studies reporting that individuals with higher muscle tone present reduced motor function and, consequently, greater limitations in ADLs [41,42]. According to some authors, spasticity may reduce daily functioning and quality of life in approximately 10%–12% of chronic stroke survivors [43]. Moreover, increased muscle tone has been identified as a risk factor for the development of shoulder pain, although in the present study this association was not statistically significant, with variability observed in both pain severity and interference [33,44].

Time since stroke was also a significant factor, with patients more than two years post-stroke presenting worse motor and functional outcomes compared to those in the earlier phase. It is well established in the literature that the critical window for stroke recovery is within the first six months post-event [45]. However, evidence demonstrates that neuroplasticity and rehabilitation potential may extend beyond one year [46]. Recent findings even suggest cortical plasticity and functional gains up to 7,5 years after stroke, following aerobic exercise and neural stimulation [47]. This highlights the importance of sustained rehabilitation efforts. In the present study, participants were categorized into two groups (≤ 2 years vs. > 2 years since stroke) to better capture the influence of time on functional outcomes.

Stroke type influenced pain outcomes, with patients with ischemic stroke reporting higher pain interference. This is consistent with previous literature indicating that the incidence of post-stroke pain is higher among individuals with ischemic stroke compared to those with hemorrhagic stroke [48,49].

Other variables such as sex, hand dominance, and vascular risk factors were not significantly associated with pain or functionality. However, pain severity tended to be higher among female participants, a finding that has also been reported in previous studies, where female sex has been identified as a predictor of greater post-stroke pain severity [50-52].

These findings reinforce the notion that motor impairment, rather than pain alone, is the main determinant of functional independence. Clinically, this suggests that rehabilitation should prioritize motor recovery and strength training, while also addressing pain as a relevant factor [51,53].

Further studies with larger samples and longitudinal designs are needed to clarify whether shoulder pain contributes to long-term disability. Participants were recruited from a single rehabilitation setting, therefore extrapolation to populations with severe disability, different rehabilitation contexts, or other cultural backgrounds is limited.

This study has several limitations. The small sample size reduces statistical power and may have limited the detection of subtle associations. The cross-sectional design also precludes causal inferences regarding the relationship between shoulder pain and functionality. As mentioned above, participants were recruited from a single rehabilitation center, and therefore the generalizability of these findings to other settings or populations may be limited, which represents another limitation. These factors together may have biased the results, potentially underestimating the true impact of shoulder pain on functionality.

In this observational study of post-stroke individuals, shoulder pain severity and interference were not significantly associated with motor or functional outcomes, whereas motor performance measures were strongly interrelated and identified as the primary determinants of functional independence. Increased muscle tone emerged as a key factor negatively affecting functionality, reinforcing its clinical relevance in rehabilitation. Time since stroke also influenced outcomes, with poorer performance observed in participants more than two years post-event. Overall, these findings suggest that rehabilitation should mainly focus on motor recovery and muscle tone management, with pain control included as a complementary approach to support independence and quality of life.

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