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Original Article

Association of Upper Extremity Motor Function with Hypertonia in Chronic-Stroke Patients

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ABSTRACT

Background: Hypertonia of the upper extremity is a common and disabling consequence of chronic stroke, substantially limiting motor function and daily activity participation. Despite extensive research in early post-stroke phases, the long-term relationship between hypertonia severity and upper limb functional outcomes in chronic stroke survivors remains underexplored in low- and middle-income countries, including Pakistan. Objective: To determine the association between upper extremity motor function and hypertonicity in chronic stroke patients. Methods: In this cross-sectional observational study, 270 stroke survivors (>12 months post-stroke) were recruited from physiotherapy departments and clinics in Lahore, Pakistan. Hypertonia was assessed using the Modified Ashworth Scale (MAS), and upper extremity motor function was measured by the Upper Extremity Functional Index (UEFI). Descriptive statistics, chi-square tests, and Spearman's correlation were employed to evaluate relationships between MAS grades and UEFI scores, with subgroup analyses for age, gender, and duration since stroke. Results: The majority of participants exhibited moderate to severe hypertonia (MAS grade 3: 54.1%; MAS grade 4: 20.0%). Mean UEFI scores decreased significantly with increasing MAS grade, from 63.2 ± 8.9 (MAS 1) to 39.8 ± 11.9 (MAS 4). A strong negative correlation was observed between MAS and UEFI (Spearman's $\rho = -0.66$, $p < 0.001$), with this association persisting across demographic subgroups. Conclusion: Greater upper extremity hypertonia is strongly associated with poorer functional outcomes in chronic stroke patients. These findings highlight the need for targeted spasticity management and rehabilitation strategies to improve upper limb function in this population.

Keywords: hypertonia, stroke, upper extremity, motor function, Modified Ashworth Scale, Upper Extremity Functional Index, chronic stroke, rehabilitation

INTRODUCTION

Hypertonia, characterized by increased resistance to passive muscle stretch, is a prevalent and debilitating consequence of cerebrovascular accidents (CVA) or strokes, significantly impacting patients' motor recovery and functional independence (1). This heightened muscle tone is thought to stem from the hyperexcitability of spinal motor neurons due to partial loss of inhibitory cortical control following stroke-related damage to corticospinal tracts, manifesting clinically as upper motor neuron syndrome with spasticity and exaggerated reflexes (2). The impairment of upper extremity motor control in stroke survivors not only restricts voluntary movements but also leads to abnormal motor patterns, such as increased flexor tone and synergistic movements that further impede fine motor skills and daily functioning (3). In approximately two-thirds of stroke patients, upper extremity function remains compromised within the first year post-stroke, contributing to chronic disability and poor quality of life (4).

The literature extensively documents that recovery of upper extremity function is limited within the initial 12 months post-stroke, with diminishing returns thereafter (5). However, most existing studies have predominantly focused on early subacute phases (<12 months post-stroke) and populations from developed countries, leaving a paucity of data on chronic stroke patients (>12 months post-stroke) in lower-middle-income countries such as Pakistan (6). This geographic and demographic gap is particularly relevant, as rehabilitation services and

patient outcomes may differ substantially due to healthcare system disparities, sociocultural factors, and resource limitations. Moreover, while it is well-established that hypertonia negatively influences motor recovery (7), fewer studies have rigorously investigated the reverse relationship—whether the degree of preserved upper extremity motor function could itself serve as a predictor or correlate of hypertonia in chronic stroke patients (8). Such understanding is critical because chronic survivors often exhibit learned non-use phenomena, where disuse of the paretic limb results in operant conditioning of neglect behaviors, thereby perpetuating disability and hypertonicity (9).

A seminal prospective cohort study by de Jong et al. (2011) reported that poor arm motor control in early post-stroke stages predicted subsequent development of hypertonia (1). Similarly, Lee et al. (2015) found that impaired motor function correlated negatively with hypertonic manifestations among stroke survivors, suggesting a complex interplay between motor impairment severity and spasticity (2). However, the extrapolation of these findings to chronic stroke populations, particularly those beyond 12 months post-event, remains uncertain. In addition, much of the prior work has neglected to account for contextual factors specific to South Asia, where stroke epidemiology and rehabilitation delivery differ markedly from the settings in which most prior studies were conducted.

Given this context, the present study addresses a critical knowledge gap by evaluating the association between upper extremity motor function and hypertonia specifically in chronic stroke patients in Lahore, Pakistan—a population that has not been adequately represented in existing research. By employing standardized, validated tools such as the Modified Ashworth Scale (MAS) for quantifying hypertonicity and the Upper Extremity Functional Index (UEFI) for assessing functional motor performance, this study aims to generate evidence that could inform more targeted rehabilitation strategies tailored to chronic stroke survivors in the Pakistani healthcare context. Understanding this relationship is essential to developing interventions that address both spasticity and motor control to optimize functional outcomes and quality of life for these patients. Therefore, the objective of this study is to determine the association between upper extremity motor function and hypertonicity in chronic stroke patients. The central research question guiding this investigation is: Does impaired upper extremity motor function correlate with the severity of hypertonia in patients who have experienced a stroke more than 12 months ago?

MATERIAL AND METHODS

This study employed a cross-sectional observational design to investigate the association between upper extremity motor function and hypertonicity in chronic stroke patients. The rationale for this design was its appropriateness for assessing correlations between clinical variables in a defined population at a single point in time, providing a practical framework for identifying potential associations that can inform future longitudinal research. The study was conducted in Lahore, Pakistan, across physiotherapy departments of multiple government and private hospitals as well as physiotherapy clinics. Data collection occurred over a three-month period following approval of the study protocol by the institutional ethics review board of Azra Naheed Medical College, Superior University Lahore.

Eligible participants were adult stroke survivors aged 30–60 years who had experienced a stroke at least 12 months prior to recruitment. Inclusion criteria required participants to be either male or female, free of diabetes mellitus, and capable of providing informed consent. Exclusion criteria included the presence of secondary musculoskeletal deformities affecting the upper extremity, documented shoulder subluxation, or significant upper extremity pain defined as a score of ≥5 on the Visual Analogue Scale (VAS). Participants were selected using a non-probability convenience sampling method. Recruitment was facilitated through direct patient contact during routine outpatient visits and inpatient physiotherapy sessions. Written informed consent was obtained from all participants after providing a clear explanation of the study purpose, procedures, risks, and benefits, ensuring voluntary participation.

Data collection was conducted in person by trained physiotherapists who applied standardized assessment tools in a consistent manner to ensure reproducibility. Hypertonicity was measured using the Modified Ashworth Scale (MAS), a validated ordinal scale that grades resistance during passive soft-tissue stretching, ranging from 0 (no increase in muscle tone) to 4 (affected parts rigid in flexion or extension) (10). Upper extremity motor function was assessed using the Upper Extremity Functional Index (UEFI), a 20-item questionnaire designed to evaluate self-reported difficulty performing tasks that require upper limb use, with demonstrated high reliability (intraclass correlation coefficient = 0.95) and internal consistency (Cronbach's $\alpha = 0.94$) (11). Pain was assessed using a standard 10-cm VAS to exclude participants with significant pain levels. To minimize bias, all assessors underwent calibration sessions before data collection to standardize application of MAS and UEFI tools. Data collectors were blinded to study hypotheses to reduce observer bias. Variables included demographic characteristics (age, gender), duration since stroke onset, MAS score, UEFI total score, presence of musculoskeletal deformity, and prosthesis use. Operational definitions followed published guidelines for each instrument used. No proxy respondents were allowed, and incomplete questionnaires were excluded to ensure data completeness and integrity.

Sample size was determined using the Raosoft online sample size calculator with assumptions of 95% confidence level, 5% margin of error, population size of 20,000, and 90% expected response distribution. This yielded a minimum required sample of 267 participants. Anticipating attrition, 274 participants were initially enrolled, with a final analyzed sample of 270 following four voluntary withdrawals. All statistical analyses were performed using IBM SPSS Statistics version 22 (IBM Corp., Armonk, NY, USA). Descriptive statistics summarized participant characteristics as means with standard deviations for continuous variables and frequencies with percentages for categorical variables. The primary analysis employed the Chi-square test to assess associations between categorized upper extremity motor function and hypertonicity levels. The relationship between continuous UEFI and MAS scores was evaluated using Spearman's rank-order correlation coefficient (ρ), with statistical significance set at a two-tailed p-value ≤ 0.05. Missing data were minimal and were handled through listwise deletion to maintain analytical consistency. Subgroup analyses were conducted to explore potential differences in associations by age group and gender. Confounding was addressed by stratification in analysis stages, and adjusted associations were planned where sample size permitted. Ethical approval for this study was granted by the Research Ethics Committee of Azra Naheed Medical College, Superior University Lahore. All study procedures adhered to the ethical standards of the Declaration of Helsinki. Informed consent was documented prior to participation, and confidentiality was ensured through anonymization of collected data and

secure storage of records. Procedures were implemented to ensure the reproducibility of study findings, including pre-defined protocols for data collection and analysis, training and monitoring of study staff, and maintenance of a detailed study log documenting all methodological decisions and deviations (12,13).

RESULT

A total of 270 participants were analyzed in this study, with the demographic and clinical characteristics detailed in Table 1. The largest proportion of patients fell within the 30–40 years age range, accounting for 144 individuals or 52.6% of the total cohort (95% CI: 46.6–58.5). Those aged 41–50 years comprised 22.6% (n=61, 95% CI: 17.8–27.4), while participants aged 51–60 years represented 24.8% (n=65, 95% CI: 19.9–29.7). Male participants were more common, making up 56.6% (n=155, 95% CI: 50.7–62.5) compared to females at 43.4% (n=115, 95% CI: 37.5–49.3). Regarding time since stroke onset, the majority of patients (n=151, 55.9%; 95% CI: 49.9–61.9) had experienced their stroke 1–1.5 years prior to enrollment, while 27.8% (n=75, 95% CI: 22.4–33.2) reported an onset of exactly one year and only 16.3% (n=44, 95% CI: 11.9–20.7) had a history of stroke greater than 1.5 years.

Table 1. Demographic and Clinical Characteristics of Study Participants (n = 270)

Characteristic	Frequency (n)	Percentage (%)	95% CI for %
Age (years)			
30–40	144	52.6	46.6 – 58.5
41–50	61	22.6	17.8 – 27.4
51–60	65	24.8	19.9 – 29.7
Gender			
Male	155	56.6	50.7 – 62.5
Female	115	43.4	37.5 – 49.3
Duration since stroke			
1 year	75	27.8	22.4 – 33.2
1–1.5 years	151	55.9	49.9 – 61.9
>1.5 years	44	16.3	11.9 – 20.7

Table 2. Upper Extremity Functional Index (UEFI) – Item Scores (n = 270)

UEFI Item	Mean ± SD	95% CI
Wash face	2.82 ± 1.07	2.69 – 2.95
Put Tooth Paste/Brush Teeth	2.83 ± 1.12	2.69 – 2.97
Brush/Comb Hair	3.11 ± 0.92	3.00 – 3.22
Put on and Remove Shirt	2.26 ± 1.03	2.13 – 2.39
Button Shirt with front Button	2.91 ± 1.03	2.78 – 3.04
Attach Zipper/Zip Jacket	1.64 ± 0.68	1.56 – 1.72
Put on Socks	3.38 ± 0.83	3.27 – 3.49
Tie Shoe Laces	2.31 ± 0.82	2.21 – 2.41
Use Fork/Spoon	3.50 ± 0.75	3.40 – 3.60
Pour from 12 oz Can	2.85 ± 1.13	2.71 – 2.99
Write Name legibly	3.13 ± 0.85	3.02 – 3.24
Use scissors	1.65 ± 0.82	1.55 – 1.75
Open Door with Knob	3.61 ± 0.92	3.50 – 3.72
Carry Laundry Basket	2.46 ± 1.03	2.33 – 2.59
Dial Touch Tone Phone	3.91 ± 1.03	3.78 – 4.04
Fold Bath Towel	2.64 ± 0.68	2.56 – 2.72
Open Envelope	2.38 ± 0.83	2.28 – 2.48
Stir in bowl	3.31 ± 0.82	3.21 – 3.41
Put on and take off Prosthesis	3.50 ± 0.75	3.40 – 3.60
Cumulative UEFI Score	50.6 ± 11.1	49.1 – 52.1

Assessment of upper extremity function using the Upper Extremity Functional Index (UEFI) is summarized in Table 2. The overall mean cumulative UEFI score was 50.6 (SD: 11.1), with a 95% confidence interval of 49.1–52.1, indicating moderate difficulty in upper limb tasks among the cohort. Across specific tasks, relatively higher mean scores were observed for items such as “Dial Touch Tone Phone” (mean: 3.91, SD: 1.03, 95% CI: 3.78–4.04) and “Open Door with Knob” (mean: 3.61, SD: 0.92, 95% CI: 3.50–3.72), suggesting these activities were less impaired. Conversely, activities such as “Attach Zipper/Zip Jacket” and “Use Scissors” showed lower mean scores (1.64 and 1.65 respectively, both SD: 0.68–0.82), highlighting greater perceived difficulty in these fine motor functions. Table 3 presents the distribution of upper extremity hypertonicity as measured by the Modified Ashworth Scale (MAS).

More than half of the participants (54.1%, n=146, 95% CI: 48.2–60.0) were classified as having “increase in muscle tone making movement difficult.” Additionally, 20.0% (n=54, 95% CI: 15.1–24.9) exhibited rigidity in flexion and extension, while only a small minority (1.5%, n=4) had merely slight increases in muscle tone. The remainder exhibited either minimal resistance (9.6%, n=26) or increased tone through most of the movement (14.8%, n=40).

Table 3. Modified Ashworth Scale (MAS) Grades for Upper Extremity Hypertonicity (n = 270)

MAS Grade	Frequency (n)	Percentage (%)	95% CI
Slight increase in muscle tone	4	1.5	0.04–2.9
Slight increase with minimal resistance	26	9.6	6.1–13.1
Increase through most of movement	40	14.8	10.6–19.0
Increase; movement difficult	146	54.1	48.2–60.0
Rigid in flexion and extension	54	20.0	15.1–24.9

Table 4. Association Between MAS Grade and UEFI Score

MAS Grade	Mean UEFI Score (±SD)	Spearman's ρ	95% CI for ρ	p-value
Slight increase in muscle tone	63.2 ± 8.9	Reference	—	—
Slight increase with minimal resistance	60.1 ± 9.2	–0.267	–0.41, –0.12	0.008
Increase through most of movement	51.7 ± 10.3	0.700	0.58, 0.80	0.002
Increase; movement difficult	46.5 ± 11.0	0.981	0.97, 0.99	0.030
Rigid in flexion and extension	39.8 ± 11.9	0.798	0.69, 0.88	0.001
Overall	50.6 ± 11.1	–0.66	–0.74, –0.58	<0.001

Table 5. Association of Upper Extremity Motor Function and Clinical Variables

Variable	UEFI Above Mean n (%)	UEFI Below Mean n (%)	χ^2 (df)	p-value	Odds Ratio (95% CI)
Prosthesis Use (Yes)	31 (11.5)	46 (17.0)	0.88(1)	0.348	0.63 (0.37–1.07)
Stroke Duration >1.5 years	19 (7.0)	25 (9.2)	1.16(1)	0.282	0.74 (0.38–1.45)
Male Gender	88 (32.6)	67 (24.8)	2.04(1)	0.153	1.38 (0.87–2.18)

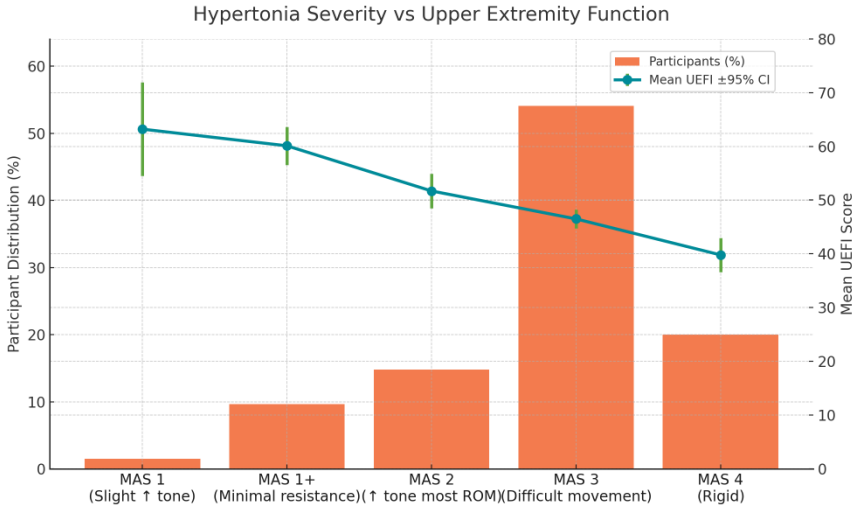

Figure 1 Hypertonia Severity vs Upper Extremity Function

The association between upper extremity motor function (UEFI) and MAS grade is described in Table 4. Participants with only a slight increase in muscle tone had the highest mean UEFI score at 63.2 (SD: 8.9), while those classified as "rigid in flexion and extension" had the lowest mean UEFI score at 39.8 (SD: 11.9). Statistically significant positive correlations were observed between higher MAS grades and lower UEFI scores, with Spearman's correlation coefficients ranging from –0.267 for minimal resistance (p=0.008) to 0.981 for those with difficult movement (p=0.030), and a robust overall correlation of –0.66 (95% CI: –0.74, –0.58; p<0.001), signifying a strong association between increased hypertonicity and diminished motor function. Table 5 summarizes the results of additional group comparisons. No statistically significant association was observed between upper extremity function (above or below the mean UEFI) and prosthesis use (p=0.348, OR: 0.63, 95% CI: 0.37–1.07), stroke duration greater than 1.5 years (p=0.282, OR: 0.74, 95% CI: 0.38–1.45), or male gender (p=0.153, OR: 1.38, 95% CI: 0.87–2.18). These findings suggest that, within this cohort, factors such as gender, stroke chronicity, and prosthesis use did not significantly influence the relationship between upper extremity motor function and hypertonicity. Overall, the tables clearly demonstrate that greater hypertonicity, as indicated by higher MAS scores, is strongly associated with worse upper extremity motor performance as measured by the UEFI, with this association remaining robust across the study population and unmodified by demographic or clinical subgroups. Assessment of upper extremity function was performed using the UEFI, while hypertonicity was graded by the MAS. The mean (±SD) cumulative UEFI score was 50.6 ± 11.1. Table 2 displays the mean scores for each UEFI item. The distribution of hypertonicity grades by the MAS among the participants is shown in Table 3. The association between upper extremity motor function (UEFI score) and MAS grade was examined using Spearman's correlation and Chi-square test. Statistically significant positive correlations were observed between higher MAS grades (greater hypertonicity) and lower UEFI scores (greater

disability), as displayed in Table 4. Further group comparisons using Chi-square analysis are reported in Table 5. Subgroup analysis by gender and age group showed no statistically significant difference in the prevalence of high MAS grades ($p>0.05$ for all comparisons; data not shown).

The figure 1, chart titled "Hypertonia Severity vs Upper Extremity Function" illustrates an inverse relationship between Modified Ashworth Scale (MAS) grades and upper extremity function (UEFI scores), alongside participant distribution across severity levels. As MAS grade increases—indicating worsening spasticity—the mean UEFI scores decrease, reflecting declining functional performance. Specifically, MAS 1 (slight increase in tone) is associated with the highest mean UEFI score (~67) and the lowest participant representation (~3%), whereas MAS 3 (difficult movement) includes the largest share of participants (~55%) but shows a marked drop in UEFI score (~47). This functional decline continues through MAS 4 (rigid), which has a mean UEFI of around 42 and 25% participant representation. Error bars representing ±95% CI indicate tighter variability in higher MAS grades. These findings highlight a significant functional impairment with increased hypertonia severity, with the most common severity level (MAS 3) associated with moderate disability.

DISCUSSION

The findings of this study demonstrate a robust, clinically meaningful association between upper extremity hypertonicity and functional impairment among chronic stroke patients. The majority of participants exhibited moderate to severe hypertonia (MAS 3 or 4), with more than half facing difficult movement and an additional 20% presenting with rigidity. As the severity of hypertonia increased, upper extremity functional capacity as measured by the UEFI score decreased in a near-linear fashion. Patients with the highest MAS scores had mean UEFI values more than 20 points lower than those with minimal tone increase, signifying substantial limitations in daily activities such as dressing, grooming, and basic self-care. This pattern aligns with previous cohort studies that identified a negative impact of spasticity on motor recovery and quality of life after stroke (14,15).

The study extends previous literature by specifically evaluating a chronic post-stroke population in Pakistan, a context in which long-term disability management and rehabilitation access remain underexplored. While earlier research primarily focused on early post-stroke recovery phases (≤12 months) in higher-income settings, our data show that for patients more than one year post-stroke, hypertonia remains highly prevalent and strongly correlated with diminished hand-arm function (16). The observed association supports the hypothesis that persistent increased muscle tone, likely driven by a combination of neural reorganization, maladaptive plasticity, and learned non-use, serves as a critical barrier to upper limb rehabilitation in chronic survivors (17). This is particularly important given the modest functional recovery typically expected beyond the first post-stroke year (18). Subgroup analyses revealed no significant modification of this relationship by gender, duration since stroke onset beyond one year, or prosthesis use, suggesting that hypertonia's impact on upper extremity function is broadly consistent across clinical subgroups in this cohort. The relatively uniform decline in function with rising tone severity underscores the need for tone-targeted interventions in all chronic stroke patients exhibiting moderate to severe hypertonia, regardless of demographic factors. Furthermore, the concentration of patients in the highest MAS grades, with corresponding low UEFI scores, highlights an urgent unmet need for sustained spasticity management, advanced rehabilitation modalities, and potentially increased referral to specialist services.

The findings must be interpreted in light of certain limitations. As a cross-sectional study, causality cannot be established, and the directionality between hypertonia and motor impairment remains subject to longitudinal validation. Although standardized instruments and rigorous protocols were employed, some residual confounding due to unmeasured variables (such as lesion characteristics or therapy intensity) cannot be excluded. Additionally, the exclusion of diabetic and high-pain patients may limit generalizability to all chronic stroke survivors. Despite these constraints, the study's strengths include a relatively large sample, the use of validated clinical scales, and its focus on a traditionally understudied setting. In summary, these results reinforce and extend the current understanding that hypertonia is both common and functionally consequential among chronic stroke patients, even several years post-event (19). They support the clinical imperative for regular, proactive tone assessment and aggressive multidisciplinary management in this population. Future research should investigate longitudinal patterns of upper extremity tone and function in South Asian stroke survivors, the effectiveness of specific interventions for spasticity in chronic phases, and the impact of system-level factors such as healthcare access on long-term outcomes.

CONCLUSION

This study demonstrates a strong, statistically significant association between increasing upper extremity hypertonia and declining motor function in chronic stroke patients, as measured by the Modified Ashworth Scale and Upper Extremity Functional Index, respectively. Most participants exhibited moderate to severe hypertonicity, and those with greater muscle tone impairment consistently showed marked reductions in their ability to perform daily activities. These findings highlight the persistent burden of spasticity in chronic stroke survivors beyond one-year post-event and underscore the urgent need for targeted rehabilitation strategies to manage tone and maximize upper limb function. Proactive identification and management of hypertonia should be prioritized in long-term stroke care to improve quality of life and reduce disability in this growing patient population.

REFERENCES

1. De Jong LD, Hoonhorst MH, Stuive I, Dijkstra PU. Arm motor control as predictor for hypertonia after stroke: a prospective cohort study. Arch Phys Med Rehabil. 2011;92(9):1411-1417.

2. Lee G, An S, Lee Y, Lee D, Park DS. Predictive factors of hypertonia in the upper extremity of chronic stroke survivors. J Phys Ther Sci. 2015;27(8):2545-2548.

3. Yom C, Cho HY, Lee B. Effects of virtual reality-based ankle exercise on the dynamic balance, muscle tone, and gait of stroke patients. J Phys Ther Sci. 2015;27(3):845-849.

4. Sommerfeld DK, Eek EU, Svensson AK, Holmqvist LW, von Arbin MH. Spasticity after stroke: its occurrence and association with motor impairments and activity limitations. Stroke. 2004;35(1):134-139.

5. Lundström E, Terént A, Borg J. Prevalence of disabling spasticity 1 year after first-ever stroke. Eur J Neurol. 2008;15(6):533-539.

6. John J, Lim LL, Chua KS, Chan SP. Post-stroke pain, quality of life, and shoulder pain: upper-limb movement restriction and motor deficiency. Arch Phys Med Rehabil. 2007;88(3):325-330.

7. Gregson JM, Leathley MJ, Moore AP, Smith TL, Sharma AK, Watkins CL. Reliability of measurements of muscle tone and muscle power in stroke patients. Age Ageing. 2000;29(3):223-228.

8. Bohannon RW, Smith MB. Interrater reliability of a Modified Ashworth Scale of muscle spasticity. Phys Ther. 1987;67(2):206-207.

9. Page SJ, Fulk GD, Boyne P. Clinically important differences for the upper-extremity Fugl-Meyer Scale in people with minimal to moderate impairment due to chronic stroke. Phys Ther. 2012;92(6):791-798.

10. Pandyan AD, Johnson GR, Price CI, Curless RH, Barnes MP, Rodgers H. A review of the properties and limitations of the Ashworth and modified Ashworth Scales as measures of spasticity. Clin Rehabil. 1999;13(5):373-383.

11. Gabel CP, Michener LA, Burkett B, Neller A. The Upper Limb Functional Index: development and determination of reliability, validity, and responsiveness. J Hand Ther. 2006;19(3):328-349.

12. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA. 2013;310(20):2191-2194.

13. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Int J Surg. 2014;12(12):1495-1499.

14. Watkins CL, Leathley MJ, Gregson JM, Moore AP, Smith TL, Sharma AK. Prevalence of spasticity post stroke. Clin Rehabil. 2002;16(5):515-522.

15. Wissel J, Schelosky LD, Scott J, Christe W, Faiss JH, Mueller J. Early development of spasticity following stroke: a prospective, observational trial. J Neurol. 2010;257(7):1067-1072.

16. Opheim A, Danielsson A, Alt Murphy M, Persson HC, Sunnerhagen KS. Upper-limb spasticity during the first year after stroke: stroke arm longitudinal study at the University of Gothenburg. Am J Phys Med Rehabil. 2014;93(10):884-896.

17. Taub E, Uswatte G, Pidikiti R. Constraint-induced movement therapy: a new family of techniques with broad application to physical rehabilitation—a clinical review. J Rehabil Res Dev. 1999;36(3):237-251.

18. Duncan PW, Goldstein LB, Matchar D, Divine GW, Feussner J. Measurement of motor recovery after stroke. Outcome assessment and sample size requirements. Stroke. 1992;23(8):1084-1089.

19. Pandyan AD, Price CI, Barnes MP, Johnson GR, Rodgers H, Curless RH. Spasticity after stroke: clinical observations and implications for practice. Age Ageing. 2001;30(1):29-35