Original Article

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Physiotherapy Section

Development, Validation and Test-retest Reliability of the Stroke Specific Gait Assessment Scale: A Cross-sectional Study

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ABSTRACT

Introduction: Gait impairments are frequently observed after stroke and can significantly affect a patient's independence and overall Quality of Life (QoL). Despite their prevalence, standardised tools designed to assess gait in stroke survivors are lacking. The Stroke-Specific Gait Assessment Scale (SSGAS) was created to offer a detailed and comprehensive evaluation of gait function in stroke rehabilitation to address this gap. The present study outlines the development of the SSGAS and examines its content validity. Test-retest reliability was assessed using Interclass Correlation Coefficients (ICC) analysis.

Aim: To develop and analyse the content validity and test-retest reliability of the SSGAS to assess gait in individuals who have suffered a stroke.

Materials and Methods: The present cross-sectional content validation study was conducted at a tertiary hospital, Ambala, Haryana, India, from August 2024 to March 2025. The SSGAS was developed through extensive clinical research and consultation with a panel of experts to ensure it addressed the key gait parameters impacted by stroke. The scale consists of 24 items, each rated on a 0-4 ordinal scale. A group of eight validators, including physiotherapists and neurologists, reviewed the scale for relevance, clarity, and completeness. Content validity was measured using the Item-level Content Validity Index (I-CVI) and Scale-level Content Validity Index (S-CVI), both of which were assessed against established validity thresholds.Test-retest reliability was assessed using ICC.

Results: The SSGAS demonstrated a high degree of validity, with an I-CVI of 0.98 and an S-CVI of 0.98 overall. These results indicate strong agreement among experts, affirming the scale's comprehensiveness and clarity. The experts also expressed that the scale is both practical and valuable for planning rehabilitation and monitoring patient progress. Test-retest reliability was assessed with 51 patients and the ICC score was 0.99 which shows excellent reliability.

Conclusion: The SSGAS has been validated as a comprehensive tool for assessing gait in stroke patients. Its excellent content validity underscores its potential as an essential resource in clinical practice and research, providing important information for developing personalised rehabilitation plans and tracking patient outcomes. Further research is recommended to examine the scale's reliability across different populations of patients with stroke.

Keywords: Content validity, Delphi survey, Gait impairments, Quality of life

INTRODUCTION

Stroke is the second leading cause of disease in the world, closely behind ischaemic heart disease, and the fourth in the UK, with a first-time stroke occurring every two seconds (World Health Organisation (WHO), 2017) [1]. In 1970, the WHO defined stroke as 'rapidly developed clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than of vascular origin [2]. Stroke is a neurological deficit attributed to vascular injury of the central nervous system [3]. It is also one of the largest causes of disability; half of all stroke survivors have a disability [1]. It is the second most common cause of mortality and the fourth major cause of disability worldwide [4]. Approximately, 20 million people experience a stroke each year, and around 26% remain disabled in basic Activities of Daily Living (ADL) (Framingham cohort), and 50% have reduced mobility due to hemiparesis [5].Walking dysfunction is a major problem for many subjects afflicted by stroke [6]. Researchers who study the problem of stroke most often evaluate the influence of Post-Stroke Depression (PSD) on functional independence, as well as on the quality of life of people after stroke [7].

After a stroke, 50% of the patients were initially unable to walk, 12% could walk with assistance, and 37% could walk independently. At the end of 11 weeks of stroke rehabilitation, 18% of the patients were still unable to walk, 11% could walk with assistance, and 50% could walk independently [8]. To evaluate the effectiveness of different treatment approaches for gait rehabilitation after a stroke, researchers need a cost-effective, valid, reliable, and freely accessible method to quantify gait dysfunction. Several gait assessment scales are available [9-11]; however, no published scale has been developed specifically for comprehensively evaluating gait impairments and related deficits in the stroke-specific population. Various functional scales, such as the Functional Gait Assessment (FGA) [9], Wisconsin Gait Scale (WGS) [10], and Dynamic Gait Index (DGI) [11], are available in the literature. Overall, adequate levels of quality were rarely reached, and the dissemination of the tools was poor [12]. Hence, developing a stroke-specific scale for gait assessment is necessary for effective use. The primary objective of the present study was to create, validate, and test-retest the reliability of a SSGAS.

MATERIALS AND METHODS

The present cross-sectional content validation study was conducted at a tertiary hospital, Ambala, Haryana, India, from August 2024 to March 2025. Ethical clearance has been received from the Institutional Research Ethics (IEC-3130). The current study consists of two parts. An extensive literature search and patient interviews led to the initial item production regarding step length consistency,

stride length consistency, foot clearance, arm swing, trunk posture, step regularity, cadence, heelstrike, foot flat, midstance, hell off, toe off, swing phase, ankle in stance phase, knee in stance phase, hip in stance phase, ankle in swing phase, knee in swing phase, hip in swing phase, stability during a two-minute walk, pain or discomfort, confidence, symmetry, and smoothness. The scale was developed, and the Delphi approach was used to validate the scale. Before participating in the current study, each of the eight interviewees completed a signed informed consent form [13]. The electronic consent document was signed by professionals who participated in the Delphi survey. For the content validity phase, eight experts were included, according to Lynn's criteria [14]. For test-retest reliability, a sample of 51 stroke patients was chosen based on guidelines by Walter SD et al., who recommended at least 45 subjects for reliability testing [15].

Content Validity

Phase 1: Domain and item development: During this phase of study items were generated under the domains of Step length consistency, stride length consistency, foot clearance, arm swing, trunk posture, step regularity, cadence, heelstrike, foot flat, midstance, hell off, toe off, swing phase, ankle in stance phase, knee in stance phase, hip in stance phase, ankle in swing phase, knee in swing phase, hip in swing phase, stability during a two-minute walk, pain or discomfort, confidence, symmetry, and smoothness. There were sub-phases within this phase.

- **1a. In-depth interviews with experts:** Two physiotherapists, each possessing ten years of experience in treating stroke patients, were subjected to comprehensive interviews aimed at identifying the factors linked to gait impairment and generating relevant items
- **1b. Extensive literature search:** From 1980 to 2021, relevant materials were sourced from English-language databases including Google Scholar, PubMed, ProQuest, Scopus, and the Cochrane Library. The search terms utilised encompassed hemiplegic gait, gait impairment, stroke outcome measures, gait assessment scales, and gait assessment questionnaires. Fifteen papers, and pre-existing articles [16-30] were utilised in the development of a SSGAS.
- **1c. Direct patient interview:** Ten stroke patients were interviewed in person throughout this research phase. People of both sexes, aged 40 to 70, who have had an ischaemic stroke, were included if they could follow basic instructions and if their Mini-Mental Status Examination (MMSE) score was at least 23 [31]. Interviewees with numerous strokes and haemorrhagic strokes were not allowed to participate. A list of the components that each participant felt were necessary to put on the scale was requested of them. They were also directed to include articles that came from the literature search under different domains.

Phase 2: Content validation via Delphi method: To validate the scale using the Delphi approach, experts and professionals who have treated stroke patients for at least eight years were contacted [13]. Eight of the ten experts who were emailed to participate in the content validation Delphi survey consented to participate in the study. Two neurologists and six physical therapists made up the eight professionals. The experts were instructed to use a four-point rating system to evaluate the items' relevance. One indicates that the item is not relevant, two that it needs to be adjusted, three that it is important but only needs a small alteration, and four that it is extremely relevant. During the content validity analysis, items that received a score of 3 or 4 on an expert relevance rating scale were given a score of 1, while items that received a score of 1 or 2 were given a score of 0.1.

The S-CVI/Ave score was 0.98, which is appropriate [14]. The authors received a suitable content validity index (0.98) in the first round only, which satisfied the Lynn MR requirements [14], hence asecond Delphi survey round was not required.

Draft of scale after Delphi survey: The final draft of the scale is attached in [Appendix]

Test-retest reliability: A total of 51 Stroke survivors from Tertiary care Hospitals and Community settings were recruited. Each participant underwent a gait assessment using the SSGAS. The assessment took place in a controlled setting with standardised instructions to ensure consistency. Participants were reassessed using the SSGAS after a set interval (48 hours). This interval is chosen to minimise the likelihood of significant changes in the participant's condition that could impact gait. The retest was conducted using the same protocols as the baseline assessment, guaranteeing that the conditions, instructions, and surroundings were identical to those of the original exam.

STATISTICAL ANALYSIS

Content validity analysis: The data analysis process involved compiling the outcomes from an extensive literature review and face-to-face interviews while eliminating any identified duplicates. Each item generated was examined and documented using I-CVI terminology. Following the completion of each Delphi survey, S-CVI was employed to determine the overall validation of the proposed scale with the desired item set. The calculation of S-CVI utilised both the universal agreement method and the average approach. In the process of content validation, Lynn MR [14] advised an S-CVI of 0.78 for 6-10 experts, and an S-CVI/Ave of 0.90 was regarded as outstanding content validity.

Test-retest reliability analysis: Reliability analysis was done by testing the same patient at two different occasions with an interval of 48 hours, which guaranteed accuracy. Using ICC [32], the SSGAS test-retest reliability was assessed, and a strong reliability score of 0.885 was obtained. Other tests used for the reliability analysis includes Spearman's rho for rank correlation, Cronbach's alpha for internal consistency Standard Error of Measurement (SEM) and Minimal Detectable Change (MDC). This supports the dependability of the scale for assessing gait in stroke patients by showing a high degree of consistency across repeated evaluations.

RESULTS

Validity: The proposed stroke-specific shoulder disability index achieved an I-CVI/Ave score of 0.98 [Table/Fig-1] The demographic details of the stroke patients have been depicted in [Table/Fig-2].

S. No.	Domains	I-CVI	S-CVI/UA
1	D1 step length consistency	1	1
2	D2 stride length consistency	1	1
3	D3 Foot Clearance	0.8	0
4	D4 arm swing	1	1
5	D5 trunk posture	0.8	0
6	D6 step regularity	1	1
7	D7 cadence	1	1
8	D8 heel strike	1	1
9	D9 foot flat	1	1
10	D10 mid stance	1	1
11	D11 heel off	1	1
12	D12 toe off	1	1
13	D13 swing phase	1	1
14	D14 ankle in stance phase	1	1
15	D15 knee in stance phase	1	1
16	D16 hip in stance phase	1	1
17	D17 ankle in swing phase	1	1
18	D18 knee in swing phase	1	1

19	D19 hip in swing phase	1	1
20	D20 stability during two min walk	1	1
21	D21 Pain or Discomfort	1	1
22	D22 confidence	1	1
23	D23 symmetry	1	1
24	D24 smoothness	1	1
	S-CVI/ Ave	0.98	
	S-CVI/ UA		0.91

[Table/Fig-1]: Content validity index scores in each round of the Delphi survey. I-CVI, S-CVI/UA: Scale level content validity index/Universal acceptance.

Variables	Frequency
Mean age (years)	54.83
Male	36
Female	15

[Table/Fig-2]: Demographic details of participants.

Reliability: The SSGAS scale has excellent test-retest reliability (ICC=0.999) and is highly consistent (Cronbach's Alpha=0.999). The p-value (0.0001) confirms that the results are statistically significant [Table/Fig-3].

Test	Median	Spearman's rho (p)	ICC	Cronbach's alpha	SEM	MDC
Test 1	49.0	0.99	0.99	0.99	1.53	4.19
Test 2	49.0					

[Table/Fig-3]: Values for reporting test-retest reliability of SSGAS determining. 1. ICC for absolute agreement type; 2. Spearman's rho for rank correlation; 3. Cronbach's alpha for internal consistency; 4. SEM and MDC calculated from the reliability data

DISCUSSION

To the best of the author's knowledge, no related articles have been published on the present study topic. Eight panelists participated in each round of the Delphi survey. The SSGAS proved to be highly reliable, with an ICC of 0.99, which is even stronger than what is typically found with other well-known gait assessments. For instance, the FGA usually reports an ICC around 0.94, the WGS around 0.85, and the DGI tends to fall between 0.83 and 0.89. This suggests that the scale not only gives very consistent results when repeated, but might be more dependable than these commonly used tools. Plus, it captures a wider range of stroke-specific gait features, making it especially valuable for this patient group. Eight to ten experts are sufficient for content validation, using Lynn MR's criteria [14]. Issues with data processing and analysis are likely to arise with larger sample sizes [33]. To determine the panel's consensus on a certain topic, a panel of recognised experts in that field was asked to answer a series of questions in the Delphi survey. Because Delphi surveys had advantages over focus groups, they were utilised to validate the domains and items. Because members are not compelled to participate, it is more effective than other approaches. Without any communication between responders, the agreement is reached, potentially eliminating the chance of a dominant expert swaying the views of other experts [34].

I-CVI for each item, S-CVI/Ave and S-CVI/UA for each domain, and S-CVI/Ave and S-CVI/UA for the entire scale were the outcomes of content validation [Table/Fig-1]. For content validation, Lynn MR believes that an S-CVI/Ave score of 0.83 for six to eight experts is a good score [14]. Even though the first round of content validation in this study had an appropriate S-CVI/Ave of 0.95, a second Delphi survey round was not conducted. In the first round only, the suggested scale obtained a high I-CVI/Ave and I-CVI/UA, score for content validity, indicating that its content validity was remarkable. Its high ranking among experts is also a result of its inclusion of all categories associated with gait disability. By adopting a single outcome measure, clinicians and researchers will be able to achieve a full and thorough result.

The scale has received a high content validity score indicating that its content validity was Impressive.

SSGAS's high reliability is demonstrated by its ICC of 0.99 (95% CI: X-X, $p<0.05$). For evaluating gait abnormalities in stroke patients, this scale is a reliable tool because it regularly yields steady and repeatable results.When compared to existing gait assessment tools, SSGAS demonstrates a level of reliability that aligns with or even surpasses established scales. For instance, the FGA has reported an ICC of 0.94, while the WGS has an ICC of 0.85.Despite these positive findings, minor variations in domain-specific ICC values were observed. This could be due to natural fluctuations in patient performance, fatigue, or the complexity of scoring certain gait parameters. The validity of using SSGAS as a precise and reliable assessment for stroke-related gait impairment in clinical and research settings is supported by the study's reliability.

Limitation(s)

The research has numerous shortcomings, such as the absence of confirmatory factor analysis, to evaluate if a single item is suited for a specific domain. As a result of the limited sample size and the use of convenience sampling to determine participants for direct patient interviews, there was a risk of selection bias.

CONCLUSION(S)

The scale was developed and earned a strong validation and reliability score. In the present study, 24-item scale was developed designed specifically to assess gait problems in post stroke patients. The scale showed excellent content validity, with an S-CVI of 0.98, and demonstrated outstanding test-retest reliability with an ICC of 0.99. These results suggest that the SSGAS is reliable and can help tailor rehabilitation to each individual's needs and serve as a reliable way to track progress in gait recovery after stroke. Therefore, the items collected under various domains may be utilised to develop a unique gait assessment scale for stroke patients.

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APPENDIX

Stroke-Specific Gait Assessment Scale (SSGAS)

Total score:	
1. Step Length Consistency:	**Score:**
0. Step length below 12.5 cm.	
1. Step length between 12.5 cm to 24.9 cm	
2. Step length between 24.9 cm to 37.4 cm.	
3. Step length mostly falls within 37.4 cm - 49.9 cm.	
4. Step length consistently falls within 49.9cm or more.	
2. Stride length consistency:	
0. Stride length below 26.2 cm.	
1. Stride length between 26.2 cm to 52.7 cm	
2. Stride length between 52.7 cm to 79 cm.	
3. Stride length mostly falls within 79 cm - 105.4 cm.	
4. Stride length consistently falls within 105.41 cm or more.	
3. Foot clearance:	
0. Fails to achieve adequate foot clearance, with the foot frequently colliding with obstacles or dragging along the ground.	
1. Frequently exhibits inadequate foot clearance, with the foot often brushing against obstacles or even making contact with the ground.	
2. Demonstrates moderate foot clearance, with occasional instances of insufficient clearance or brushing against obstacles.	
3. Maintains adequate foot clearance, with occasional minor instances of brushing against obstacles.	
4. Consistently achieves optimal foot clearance, with the foot clearing obstacles comfortably and safely.	
4. Arm swing:	
0. Limited or absent arm swing.	

1. Reduced or asymmetrical arm swing.	
2. Moderate arm swing, somewhat coordinated.	
3. Coordinated arm swing with each step during instruction.	
4. Full and coordinated arm swing with each step without instruction.	
5. Trunk posture:	
0. Unable to stand	
1. Pronounced forward/lateral leaning/slouching, Poor posture.	
2. Moderate deviation from upright posture, Fair posture, slight slouching or leaning.	
3. Slight deviation from upright posture, generally good posture.	
4. Perfectly upright and stable trunk posture maintained throughout, excellent posture.	
6. Step regularity:	
0. Irregular steps, frequent stumbling.	
1. Moderate irregularity in a step pattern, noticeable stumbles.	
2. Slightly irregular step pattern observed, minimal stumbling.	
3. Smooth regular step pattern with rare stumbling.	
4. Perfectly smooth and flawless step pattern, no stumbling observed.	
7. Cadence (Step Rate):	
0. Below 24 steps per minute, extremely slow cadence significantly deviated from normal pace.	
1. 24-48 steps per minute Moderate deviation from normal cadence, noticeable speed fluctuations.	
2. 48-71 steps per minute, Consistent with expected cadence for age and condition, with minor variations.	
3. 71-96 steps per minute, very close to the expected cadence, with occasional slight deviations.	
4. 96 or more steps per minute, perfectly consistent with the expected cadence, with no noticeable variations.	
8. Heel strike:	
0. Absent, no visible indication of heel striking the ground.	
1. Partially present, heel striking observed.	
2. Moderately present, occasional inconsistency in heel striking.	
3. Moderately present, without any inconsistency heel striking observed.	
4. Perfectly present, flawless, and consistent heel striking observed.	
9. Foot flat:	
0. Absent, no indication of the foot being flat on the ground.	
1. Partially present, flatness of the foot observed.	
2. Moderately present, occasional inconsistency in foot flatness.	
3. Moderately present, without any inconsistency flatness of the foot observed.	
4. Perfectly present, flawless, and consistent foot flatness observed.	
10. Midstance:	
0. Absent, no indication of midstance position during gait.	
1. Partially present, inconsistent midstance observed.	
2. Moderately present, occasional inconsistency in midstance.	
3. Moderately present, without any inconsistency in midstance observed.	
4. Completely present, flawless, and consistent midstance observed.	
11. Heel off:	
0. Absent, no visible indication of heel lifting off the ground.	
1. Partially present, inconsistent heel lifting observed.	
2. Moderately present, occasional inconsistency in heel lifting.	
3. Moderately present, without any inconsistency in heel lifting observed.	
4. Perfectly present, flawless and consistent heel lifting observed.	
12. Toe off:	
0. Absent, no visible indication of toe lifting off the ground.	
1. Partially present, inconsistent toe lifting observed.	
2. Moderately present, occasional inconsistency in toe lifting.	
3. Moderately present, without any inconsistency toe lifting observed.	
4. Perfectly present, flawless and consistent toe lifting observed.	
13. Swing phase:	
0. Absent, no observable swing phase in the gait.	
1. Partially present, some signs of swing phase but inconsistent.	
2. Moderately present, occasional inconsistency in swing phase.	

3. Moderately present, without any inconsistency swing phase observed.	
4. Perfectly present, flawless and consistent swing phase observed.	
14. Ankle in stance phase:	
0. Entire sole down.	
1. Toe first/noticeable inversion in early stance or throughout.	
2. Heel-toe action near normal, with minimal pronation or supination.	
3. Affected foot leads.	
4. Effortless heel-toe action, with no observable pronation or supination, and consistent gait mechanics.	
15. Knee in stance phase:	
0. Knee buckles, showing significant instability.	
1. Hyperextension (mild, moderate, severe), stable in slight flexion, or slight varus or valgus alignment.	
2. Near normal alignment, with slight varus or valgus stability.	
3. Slight varus or valgus alignment with minimal impact on stability or gait.	
4. Perfectly aligned, stable knee with no varus or valgus deviation, maintaining consistent gait mechanics.	
16. Hip in stance phase:	
0. Trendelenburg gait, significant lateral hip drop on weight-bearing side.	
1. Trunk forward, with noticeable hip hiking or anterior pelvic tilt.	
2. Near normal hip alignment, with minimal lateral or anterior/posterior pelvic movement.	
3. Slight lateral or anterior/posterior pelvic tilt, with minimal impact on gait.	
4. Perfectly aligned hips, maintaining stable pelvic position throughout the stance phase.	
17. Ankle in swing phase:	
0. Toes dragging, with pronounced inversion or eversion.	
1. Inversion or eversion observed during swing, impacting gait symmetry.	
2. Normal swing phase, with minimal inversion or eversion.	
3. Slight inversion or eversion during swing, with minimal impact on gait.	
4. Effortless swing phase, with no observable inversion or eversion, maintaining symmetrical gait pattern.	
18. Knee in swing phase:	
0. Stiff knee, limited flexion or extension during swing.	
1. Moderately stiff knee, with reduced range of motion or exaggerated flexion.	
2. Free, near normal knee flexion and extension during swing.	
3. Slight exaggerated flexion during swing, with minimal impact on gait.	
4. Effortless knee flexion and extension, maintaining smooth and natural swing phase.	
19. Hip in swing phase:	
0. Circumduction, noticeable hip hiking, or exaggerated external rotation.	
1. Pelvic hike or tilt, moderately stiff hip with reduced flexion, or exaggerated external rotation.	
2. Near normal hip flexion and extension during swing, with minimal external rotation.	
3. Slight stiffness or external rotation, with minimal impact on gait symmetry.	
4. Effortless hip flexion and extension, maintaining symmetrical swing phase with no observable stiffness or external rotation.	
20. Stability during 2-minute walk:	
0. Inability to walk	
1. Frequent loss of balance or instability, walk with assistance.	
2. Moderate difficulty maintaining balance, walk with assistance.	
3. Moderate difficulty maintaining balance, and walk without assistance.	
4. Perfect stability, no signs of imbalance throughout the walk.	
21. Pain or Discomfort:	
0. Severe pain or discomfort significantly affecting gait	
1. Moderate discomfort influencing gait	
2. Mild discomfort, influencing gait	
3. Gait unaffected by pain or discomfort (but pain or discomfort present)	
4. No pain or discomfort at all	
22. Confidence:	
0. Very low confidence in walking ability, hesitant or cautious	
1. Moderate confidence, with assistance and family members.	
2. Moderate confidence, with assistance.	
3. Moderate confidence, without any assistance.	
4. Extreme confidence, assertive gait	

23. Symmetry:	
0. Highly asymmetric gait, with noticeable limp or irregularities.	
1. Moderately asymmetric, with deviations from normal gait	
2. Partially asymmetric, with noticeable irregularity	
3. Partially symmetrical, with minimal irregularity	
4. Perfect symmetry, flawless gait	
24. Smoothness:	
0. Jerky or irregular movements, lack of fluidity	
1. Moderately smooth, noticeable jerky movements	
2. Partially smooth, noticeable jerky movements.	
3. Partially smooth, without any jerky movements.	
4. Perfectly smooth, effortless motion	

Severe Impairment: Total score range: 0-23
Moderate Impairment: Total score range: 24-47
Mild Impairment: Total score range: 48-71
No Impairment: Total score range: 72-96