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# Construct validity of the Wisconsin Gait Scale in acute, subacute and chronic stroke

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ABSTRACT

*Objective:* To assess the construct validity of the Wisconsin Gait Scale (WGS) in subjects after stroke.
*Methods:* A retrospective observational study was conducted at inpatient rehabilitation hospital. Data from 61 stroke patients was compiled. The Functional Ambulatory Categories (FAC), the Berg Balance Scale (BBS), the Postural Assessment Scale for Stroke Patients (PASS), the Barthel Index (BI) and the Functional Independence Measure (FIM) were selected to analyze the WGS construct validity at four specific time points after stroke (acute, subacute and chronic stages). Spearman correlation coefficients investigated the relationship between WGS and clinical measures.
*Results:* The construct validity of the WGS in patients with stroke at acute stage was moderate with the FAC ($r = -.773$), the BBS ($r = -.676$), the PASS ($r = -.646$) and the FIM ($r = -.592$). At subacute stage, the construct validity of the WGS was excellent with the FAC ($r = -878$), the BBS ($r = -.882$), the PASS ($r = -.847$) and the BI ($r = -.813$). The correlation was moderate with the FIM ($r = -.693$). At six and twelve months, the construct validity of WGS with the FAC, the BBS, the PASS, the BI and the FIM was excellent ($r \geq .8$).
*Conclusion:* The WGS has moderate construct validity with walking, balance and functionality scales in patients with acute stroke. The correlation with the FAC, the BBS, the PASS and the BI at subacute and chronic stages was excellent.

## 1. Introduction

Gait recovery is one of the main aims of stroke patients because it causes major impairment and thus a reduction in participation in society [1,2], and it widely determines patient's status with respect to activities of daily living and quality of life [3].

The gait of stroke patients is characterized by several abnormal features such as asymmetry of stride time and length, reduced velocity, poor posture control, muscle weakness, abnormal muscle tone, abnormal muscle activation patterns and altered energy expenditure, mostly affecting the paretic side [3]. For gait assessment, a three-dimensional computerized analysis may be considered the gold standard because it provides objective data on kinematic and kinetic parameters. Nevertheless, it requires custom instrumentation, it takes longer time, and its use in clinical practice is not always available; so, the most commonly used methods in the therapeutic environment are clinical tests and scales [2].

Observational gait assessment scales have been designed for this purpose because they evaluate deviations from normal gait patterns [2]. To considerate a scale suitable for clinical use, it is necessary to explore its psychometric properties [4,5]. The COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) [6] establish that the main measurement properties are: validity, reliability and responsiveness. One component of validity is the construct validity which presents different components [7]: structural validity, hypothesis-testing and the cross-cultural validity. In a rehabilitation context, a scale is considered useful when it is consistent with hypotheses (for example, relationship to scores of other instruments).

The Wisconsin Gait Scale (WGS) was created to assess gait in patients with stroke. The test consists of 14 observable items that analyze components of gait (Table 1): 13 of them assess lower limb during gait and one assesses the use of handheld gait aid. Each item scored from 1

*Abbreviations:* (BI), Barthel Index; (BBS), Berg Balance Scale; (FAC), Functional Ambulatory Categories; (FIM), Functional Independence Measure; (PASS), Postural Assessment Scale for Stroke Patients; (STROBE), STrengthening the Reporting of OBservational studies in Epidemiology; (WGS), Wisconsin Gait Scale

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**Table 1**
Parameters assessed in the Wincosin Gait Scale.

| Sections | Items | Scores |
|---|---|---|
| Stance phase of the affected leg | *1.Use of hand-held gait aid* | *No gait aid: 1*<br>*Minimal gait aid use: 2*<br>*Minimal gait aid use wide base: 3*<br>*Marked use: 4*<br>*Marked use wide base: 5* |
| | *2.Stance time on impaired side* | *Equal (time spent on affected side same as time spent on unaffected side during single leg stance): 1*<br>*Unequal: 2*<br>*Very brief: 3* |
| | *3.Step length of unaffected side* | *Step through (heel of unaffected foot clearly advances beyond the toe of the affected foot): 1*<br>*Foot does not clear: 2*<br>*Step to (unaffected foot placed behind or up to affected foot but not beyond): 3* |
| | *4.Weight shift to the affected side with or without gait aid* | *Full shift (head and trunk shift laterally over the affected foot during the single stance): 1*<br>*Decreased shift: 2*<br>*Very limited shift: 3* |
| | *5.Stance width* | *Normal (up to 1 shoe width between feet): 1*<br>*Moderate (up to 2 shoe widths): 2*<br>*Wide (more than 2 shoe widths): 3* |
| Toe-off of the affected leg | *6. Guardedness* | *None (good forward movement with no hesitancy noted): 1*<br>*Slight: 2*<br>*Marked hesitation: 3* |
| | *7. Hip extension of the affected leg* | *Equal extension (hips equally extend during push off; maintains erect posture during toe off): 1*<br>*Slight flexion: 2*<br>*Marked extensión: 3* |
| Swing phase of the affected leg | *8. External rotation during initial swing* | *Same as unimpaired leg: 1*<br>*Increased rotation: 2*<br>*Marked: 3* |
| | *9. Circumduction at mid-swing* | *None (affected foot adducts no more than unaffected foot during swing): 1*<br>*Moderate: 2*<br>*Marked: 3* |
| | *10. Hip hiking at mid-swing* | *None (pelvis slightly dips during swing): 1*<br>*Elevation: 2*<br>*Vaults: 3* |
| | *11. Knee flexion from toe off to mid-swing* | *Normal (affected knee flexes equally to unaffected side): 1*<br>*Some: 2*<br>*Minimal: 3*<br>*None: 4* |
| | *12. Toe clearance* | *Normal (toe clears floor throughout swing): 1*<br>*Slight drag: 2*<br>*Marked: 3* |
| | *13. Pelvic rotation at terminal swing* | *Forward (pelvis rotated forward to prepare for heel strike): 1*<br>*Neutral: 2*<br>*Retracted: 3* |
| Heel strike of the affected leg | *14. Initial foot contact* | *Heel strike (heel makes the initial contact with the floor): 1*<br>*Foot flat: 2*<br>*No contact of heel: 3* |

(normal) to 3 (atypical), except for the first item (gait aid), which is scored from 1 to 5, and 11$^{th}$ item, which is scored from 1 to 4 [2]. The best possible WGS total score is 13.35, and the worst possible is 42. Therefore, higher scores reflect greater gait impairments [8,9].

The WGS is a reliable and responsive measure of gait pattern for acute [10,11], subacute [10,11] and chronic stroke subjects [3,8]. Regarding validity, the WGS has demonstrated to have a good correlation with motor performance and gait velocity in subjects with acute, subacute [11] and chronic stroke [1,9]. However, the correlation between the WGS with other walking independence scales and other constructs (such balance and functionality), relevant for the rehabilitation treatment, either has not been studied, or is inconsistent (i.e. functionality).

Balance has a predictive value for walking recovery [12,13] and both are relevant objectives for the rehabilitation treatment. Balance is frequently assessed using clinical scales as the Berg balance scale (BBS), the Tinetti Performance Oriented Mobility Assessment or the Postural Assessment Scale for Stroke Patients (PASS) in stroke patients [14]. In addition, frequent balance disturbance during walking is one of the most important risk of falls factors [15], which could disturb gait ability commonly evaluated with the Functional Ambulatory Categories (FAC) [15]. Therefore, to establish a correlation between balance and walking scales is an important objective in stroke subjects. Related to functionality, Pizzi et al. [3] showed in chronic stroke patients a good correlation between the WGS and the functional level measured with the Barthel Index (BI). However, Turani et al. [11], did not found a correlation between WGS and the Functional Independence Measure (FIM) in acute and subacute stroke patients.

Therefore, there is a need of studies that analyze the WGS construct validity with walking independence, balance and functionality in acute, subacute and chronic stroke participants. The purpose of this study was to assess the construct validity of the WGS in subjects with stroke before 8 weeks of evolution and after three, six and twelve months.

## 2. Materials and methods

### 2.1. Design

This retrospective study utilized data from one inpatient rehabilitation hospital in Madrid, Spain, where subjects are typically admitted immediately after stroke. STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) guidelines were followed to standardize the reporting of this work. The study was approved by the Local Ethical Committee.

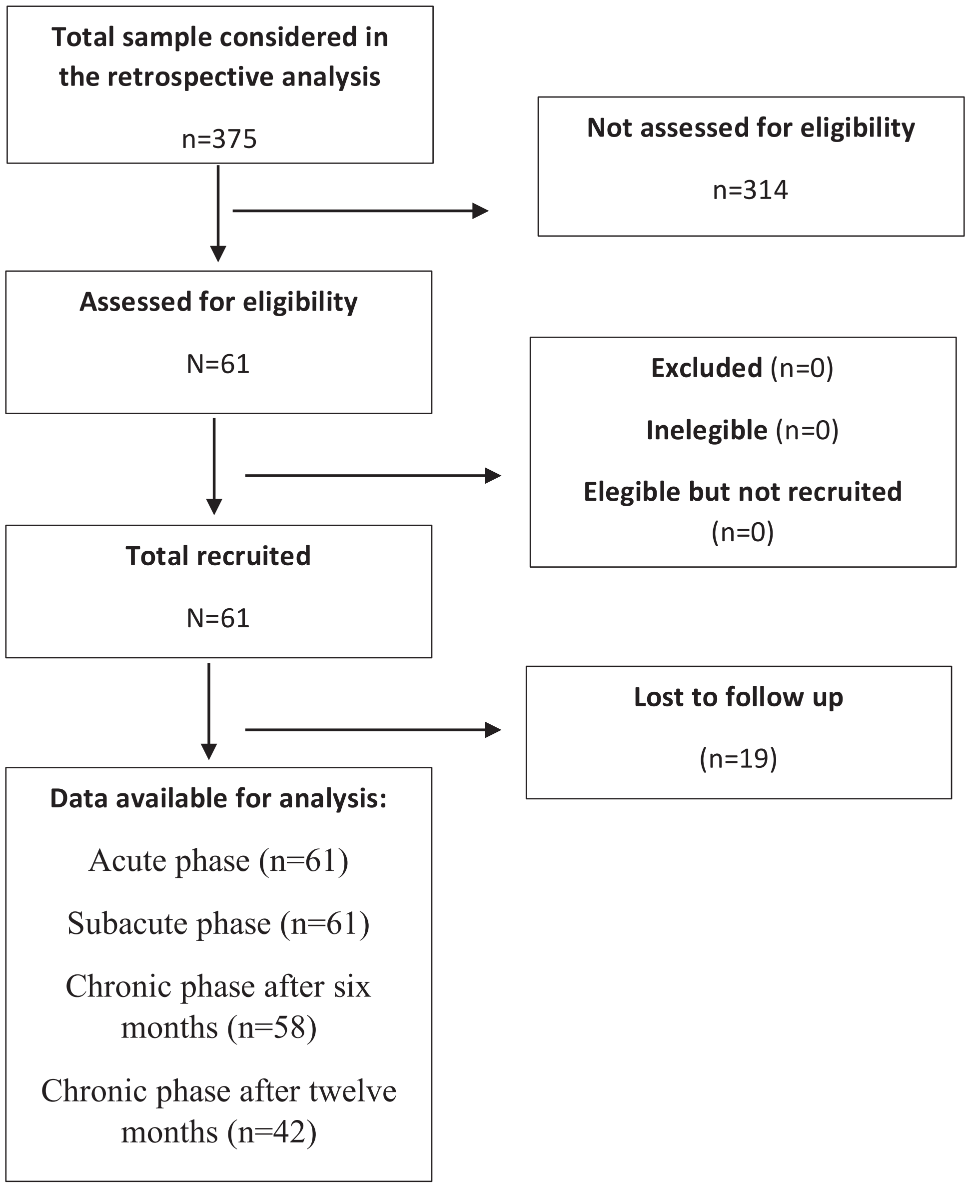


**Fig. 1.** Strobe flowchart.

### *2.2. Participants*

The data was compiled retrospectively by one researcher (C.E-B). Subjects were screened for eligibility from October 2016 to May 2017. Participants were included if: (1) gait and balance treatment had been identified as a goal by the patient and the rehabilitation team, according to SMART goals [17]; (2) their stroke occurred less than 8 weeks; (3) was confirmed by a neurologist using either magnetic resonance imaging or computed axial tomography; and (4) all patients should follow the same individual rehabilitation treatment oriented to gait and balance improvements. Subjects were excluded if they had unstable cardiovascular status, relevant musculoskeletal or neurological conditions other than stroke or inability to understand instructions. Demographic characteristics were collected in addition to the variables listed below.

### *2.3. Procedure*

Several evaluation scales used in stroke patients – FAC, BBS, PASS, BI and FIM– were selected to analyzed the WGS validity at four specific time points after stroke: after admission (acute phase) and after three (subacute phase), six and twelve months (chronic phase) [18] at an inpatient rehabilitation hospital. A clinician administrated all assessments in the same day. Table 1 showed the items evaluated by the WGS.

The FAC is a functional walking test that evaluates ambulation ability first described by Holden et al in 1984. The FAC distinguishes 6 levels of walking ability on the basis of the amount of physical support required when walking [16]. The FAC is a reliable, valid, and responsive tool for assessing gait ability after stroke [19].

The BBS is a 14-item scale designed to measure balance, with each item scored on a 4-point ordinal scale ranging from 0 (the lowest level of function) to 4 (the highest level of function). The total possible score on the BBS is 56 points [16,20].

The PASS assesses balance in lying, sitting and standing positions. The PASS consists of 12 items of graded difficulty. The PASS is a 4-point scale where items are scored from 0 (lowest level of function) – 3 (highest level of function), creating the total score of 36 [21]. A Spanish version of the PASS was used [22].

The BI is a 10-item scale designed to measure the activities of daily living. The total score for the BI ranges from 0 for a minimal performance to 100 for a maximal performance [23].

The FIM is an 18-item global measure of functionality. Each item is scored on 7 ordinal levels (1 is complete dependence and 7 is fully independent) [24]. The categories include self-care activities, sphincter control, mobility, locomotion and communication.

The FAC, the BBS, the PASS, the BI and the FIM have been demonstrated to be valid and reliable to assess its domains in subjects with stroke [14,19,21,25–28].

### 2.4. Sample size

The construct validity sample size was calculated using the G*Power software (version G*Power 3.1.9.2). We retrospectively established the following parameters to obtain the sample size using the Spearman correlation coefficient: two tails, an error alfa of 0.05 [29] and a power of 0.95 [30], resulting in a sample size requirement of 46 participants.

### 2.5. Statistical analysis

Shapiro-Wilk and Kolmogórov-Smirnov test were used to check normality of clinical scores. Given that the analyzed samples violated the statistical normality, the Spearman correlation coefficients with 95% Confidence Intervals (CI) were used to investigate the relationship between WGS and FAC, BBS, PASS, BI and FIM. Correlation coefficients of .00–.49 were interpreted as poor, those of .50 to .79 as moderate, and those of 0.8 or higher as excellent [31]. We expect a convergent validity (significant correlation) with negative sign between WGS and the other scales.

We have considered the overlapping of the CI to assert that there was a difference in the correlation coefficients between the different times of measure. For that, we have adjusted the IC according to Knol et al. [32] with a level of confidence of 83.4% (formula 11) to arrive at a type 1 error probability of 0.05.

A Bonferroni correction was performed to adjust for multiple testing. With five comparisons, a p-value of $\alpha$ = .05/5 (.01) was considered statistically significant. Statistical analysis was performed using the SPSS statistical software (version 20.0).

## 3. Results

After retrospectively analyzing the data of 375 stroke participants admitted at the facility, information from 61 participants was compiled. 61 patients assessed in acute phase (17.07 days ± 13.21), 61 patients remain in the subacute phase (107.06 days ± 13.25), 58 in the chronic phase after six months (197.08 days ± 13.25) (4.91% patients lost from the initial sample) and 42 patients after twelve months (382.06 days ± 9.8) (31.14% patients lost from the initial sample) (Fig. 1). The main reason of patients lost was the discharge from the hospital. The relevant characteristics of participants are presented in Table 2.

Mean time since stroke and outcome measures scores at the four time points (acute, subacute and chronic stage) are shown in Table 3.

**Table 2**
Characteristics of the study sample (n = 61).

| Variable | Data |
|---|---|
| Age, y | 62.75 (13.31) |
| NIHSS immediately after admission | 13.48 (6.185) |
| Sex (male/female), n | 40/21 |
| Type of stroke (ischemic/hemorrhagic), n | 47/14 |
| Affected hemisphere (right/left/bilateral/subcortical), n | 34/21/3/3 |
| Vascular territory (basilar/middle cerebral artery/anterior cerebral artery/internal carotid artery/ anterior communicating artery/diffused), n | 8/38/3/1/ 1/10 |

NIHSS is National institute of Health Stroke Scale. Age and NIHSS are expressed in mean and standard deviation. Sex, type of stroke, affected hemisphere and vascular territory are frequencies.

**Table 3**
Outcome measures scores after admission and three and six months later.

| | First assessment (acute stage) n = 61 | Second assessment (subacute stage) n = 61 | Third assessment (chronic stage) n = 58 | Fourth assessment (one year) n = 42 |
|---|---|---|---|---|
| WGS | 42 (0) | 42 (16.60) | 28.65 (23.65) | 22 (24.90) |
| FAC | 0 (0) | 1 (4) | 3(4) | 4 (4) |
| BBS | 3 (12) | 16(32) | 30 (42) | 41 (43) |
| PASS | 4 (16) | 18 (22) | 25 (22) | 30 (20) |
| BI | 5 (25) | 45 (55) | 60 (73) | 75 (58) |
| FIM | 42 (35) | 80 (48) | 91 (56) | 103 (50) |

Data are expressed in median and interquartile range.

Median values and interquartile range show that all outcome measures scores improved over time.

The construct validity of the WGS in patients with stroke at acute stage was moderate with the FAC (r = -.773), the BBS (r = -.676), the PASS (r = -.646), the BI (r = -.657), the FIM (r = -.592). At subacute stage, the construct validity of the WGS was excellent with the FAC (r = -878), the BBS (r = -.882), the PASS (r = -.847) and the BI (r = -813). The correlation was moderate with the FIM (r = -.693).

At six and twelve months, the construct validity of WGS with the FAC, the BBS, the PASS, the BI and the FIM was excellent (Table 4). Dispersion graphs are showed in supplemental data.

There is a difference of the adjusted confidence intervals of the correlation coefficients between the different times of measure. Specifically, the adjusted confidence intervals of the correlation coefficients of the WGS and the FAC, the BBS, the PASS and the BI did not overlap between the subacute and chronic stages compared to the acute stage. However, there was an overlapping of the adjusted confidence intervals of the correlation coefficients of the WGS and the FAC, the BBS, the PASS and the BI at subacute and chronic stages.

## 4. Discussion

The aim of this study was to investigate construct validity of the WGS for people in an acute, subacute and chronic stage after stroke. To date, to our knowledge, no construct validity studies of WGS with walking, balance and functionality scales have been published. In addition, patients were monitored at 4 specific time points after stroke for an extended period (up to 365 days after stroke onset) to determinate how appropriate WGS was for use at different recovery phases after stroke in a rehabilitation context.

Our results show a moderate correlation between the WGS and the FAC, the BBS, the PASS, the BI and the FIM in the stroke patients at acute stage. However, the correlation was moderate-excellent when patients were in a subacute and chronic phase after stroke. In an acute stage after stroke, there was more heterogeneity in the functional status in the sample, so there were subjects that presented a properly balance in quiet standing but they were not able to walk independently. However, as the injury stabilized and patients received rehabilitation treatment, the functionality of patients improved. For example, the differences observed in the WGS and BBS scores were higher than the minimal detectable change established for these scales for stroke patients (4.24 and 2.7, respectively) [33,34].

The findings of this study confirmed the validity of the WGS in stroke patients mainly at subacute and chronic stages. In addition, the construct validity demonstrated in this paper for the WGS is convergent with the other domains assessed. Correlation between the WGS and FAC was excellent in stroke patients at subacute and chronic stages. The FAC measure gait ability, which means independency or dependency of personal help to maintain balance during walking [35]. The high correlation with the WGS demonstrates the relationship of walking patterns with the necessity for supervision or physical assistance during

**Table 4**
Construct validity of Wisconsin Gait Scale.

| | First assessment (Admission) n = 61 | | | Second assessment (3 months) n = 61 | | | Third assessment (6 months) n = 58 | | | Fourth assessment (one year) n = 42 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tools | r | Adjusted CI | p | r | Adjusted CI | p | r | Adjusted CI | p | r | Adjusted CI | p |
| FAC | −.773 | −.84 to -.69 | .001 | −.878 | −.91 to -.84 | .001 | −.905 | −.93 to -.86 | .001 | −.888 | −.93 to -.84 | .001 |
| BBS | −.676 | −.75 to -.56 | .001 | −.882 | −.92 to -.83 | .001 | −.817 | −.87 to -.75 | .001 | −.908 | −.94 to -.86 | .001 |
| PASS | −.646 | −.74 to -.52 | .001 | −.847 | −.89 to -.79 | .001 | −.892 | −.92 to -.85 | .001 | −.890 | −.93 to -.83 | .001 |
| BI | −.657 | −.75 to -.54 | .001 | −.842 | −.89 to -.78 | .001 | −.867 | −.91 to -.81 | .001 | −.810 | −.87 to -.75 | .001 |
| FIM | −.592 | −.70 to -.46 | .001 | −.693 | -,77 to -.59 | .001 | −.801 | −.86 to -.72 | .001 | −.821 | −.88 to -.73 | .001 |

R; Critical level of $p < .01$ (after Bonferroni correction) was considered significant. Adjusted CI means confidence interval of 83.4% according to Knoll et al., 2011.

gait in stroke patients. Other researches [16,36] showed that the FAC correlates with walking velocity and step length in stroke patients, but this is the first paper, in our knowledge that study its relationship with WGS over time.

The BBS and the PASS demonstrated an excellent correlation with the WGS in stroke patients at subacute and chronic stages. The BBS provides information about balance tasks during sitting and standing [35] and the PASS assesses balance in lying, sitting and standing positions [37]. Van de Port et al. [38] showed that ability to walk was influenced by several factors, such as balance. Nardone et al. [39] showed that increased asymmetrical weight bearing in the lateral direction in standing was significantly correlated with lower gait velocity in stroke patients. Also, Mizelle et al. [40] reported that stroke patients with greater lateral center of pressure displacement during walking showed higher gait velocity. Therefore, the correlation between the WGS and the balance scales is expected, since walking is an activity that requires a good balance.

Lower correlations were found between WGS and BI and FIM in an acute stage after stroke. However, the correlations with the WGS were excellent in a subacute and chronic stage. Our results are in line with Pizzi et al. [3] that showed a good correlation between the WGS and the BI in chronic stroke patients. However, our correlation values were higher. However, our results were not consistent with Turani et al. [11] as they did not find a correlation between WGS and the FIM in acute and subacute stroke patients. It is reasonable that improvements in gait ability and balance enhance the independency of the patients influencing in patients' perceptive and social status [3].

There is no doubt that computerized systems provide more reliable numerical data on gait parameters to contrast with functional status. However, such systems are not easily available to all rehabilitation clinics and do not give details about patients' walk quality and how the body moves during the different phases of the gait cycle. The WGS assesses the characteristics of hemiplegic gait deviations in detail categorizing these characteristics according to the positions of major body part during each phase of gait cycle. In addition, the WGS considers kinematic items that have been related with a higher risk of falls such as a lower hip extension and a lower toe clearance [41]. Therefore, our results show that the WGS can be used in conjunction with other functional assessment tools when exploring stroke subjects.

### 4.1. Study limitations

Our study presents several limitations. This research is a retrospective construct validity study which implies that some patients were excluded from the analysis for reasons that might alter the study's conclusions. The sample size was not large enough to further analysis of the data according to type or severity of stroke. Because the type of stroke (ischemic or hemorragic) or level of severity (mild, moderate and severe) could affect the results of these measures, further studies with larger sample sizes are necessary to analyze these effects on the psychometric characteristics of the measures. Second, our study shows the construct validity of WGS with other scales related with balance and functionality in stroke patients during a period of time in a rehabilitation context, so results are inferred to inpatient rehabilitation context. Third, it is noticeable that methods used in this study to assess gait, balance and functionality variables needed relatively simple equipment available to any rehabilitation clinic and an acceptable amount of time of analysis. However, only one Spanish version of the scales was used (PASS), so the lack of translation and cross-cultural validation of these tests (WGS, FAC, BBS, BI and FIM) could contribute to increase the variability of the scores. Finally, further studies should investigate the WGS validity with three-dimensional computerized systems.

## 5. Conclusions

The WGS has moderate construct validity with walking, balance and functionality scales in patients before 8 weeks post-stroke. On the other hand, the construct validity is excellent with the FAC, the BBS, the PASS and the BI from 3 to 12 months post-stroke.

## Ethical approval

The study was approved by the Human Ethics Committee of the Rey Juan Carlos University.

## Conflict of interest statement

The authors have no conflict of interest to declare.

1) No funds were received for this study; 2) No financial benefits have or will be derived by the authors from this study; 3) The data from this study have not been presented in any other form.

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