Original Article

The reliability, validity and correlation of two observational gait scales assessed by video tape for Chinese subjects with hemiplegia

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Abstract. [Purpose] To test the reliability of the Wisconsin Gait Scale (WGS) and the Gait Abnormality Rating Scale (GARS) for hemiplegic Chinese subjects, as well as to establish the concurrent validity of these two scales with clinical measurements. [Subjects] Twenty hemiplegic stroke subjects were recruited for this study. [Methods] The subjects walked along a 10-meter walkway and their gait was videotaped from 4 directions. Two physical therapists assessed the subjects' gait using the aforementioned scales by watching the video tape. The Intraclass Correlation Coefficient (ICC) was calculated for the two physiotherapists' scores for each category and the total scores to assess the reliability. Concurrent validity was tested by comparing the total scores to subjects' walking speed, the Fugl-Meyer assessment, the Motricity Index of the lower limb, and the Composite Spasticity Index of the lower limb. [Results] The ICC of WGS was 0.961 for intra-rater reliability, and 0.945 for inter-rater reliability. The ICC of GARS was 0.708 for intra-rater reliability and 0.875 for inter-rater reliability. The correlations of the two scales with walking speed, the Fugl-Meyer assessment and the Motricity Index were statistically significant. [Conclusion] Both the Wisconsin Gait Scale and the Gait Abnormality Rating Scale are reliable and valid protocols for measuring the hemiplegic gait of stroke patients.
Key words: Reliability, Validity, Observational scales

INTRODUCTION

Stroke is one of the leading causes of disability worldwide[1]. Post-stroke impairment of the upper limb function and gait disturbance in hemiplegic patients is common, and the impairment of walking ability is one of the most important causes of disability in adults after stroke[2]. Therefore, the goal of lower limb rehabilitation after stroke is to restore the walking ability and improve patients' independence[3].

Assessment of gait after stroke is of great importance for therapists for the assessment of rehabilitation efficiency. Quantitative measurement is always the most objective assessment method and 3-D kinematic measurement has shown promise in this area. However, this kind of measurement needs expensive instruments and is time-consuming. In addition, it usually needs professionals to perform the measurements, and to explain the terminologies and results[4].

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Therefore, observational gait assessment is more acceptable to clinical professionals such as physical therapists due to its convenience and low cost. Observational gait assessments can also be performed using video recordings which allow slow motion and freeze-frame observation. With this kind of assessment, clinicians can assess subjects' walking pattern through observation of displacement of body parts and estimate the temporospatial elements of gait.

Among the observational gait scales, the Wisconsin Gait Scale and the Gait Abnormality Rating Scale were chosen for this study to assess gait performance. The Wisconsin Gait Scale (WGS) is a 14-item scale customized for assessing hemiplegic gait. It allows observation of joint motions of the lower limb, and lower limb coordination during the stance and swing phases[5]. Good intra-rater and inter-rater reliabilities have been reported for western populations[6–8] but to our knowledge, not for Asian populations. The Gait Abnormality Rating Scale (GARS) was first used to assess fall risks of the community-dwelling elderly[9]. Subsequently, GARS and modified GARS have been used to assess the walking ability of adults with various medical conditions such as dementia[10], and conventional disorders[11], but the validity of this protocol has not yet been established for stroke patients.

Previous studies have used walking speed as the chief outcome for assessing the effectiveness of walking abil-

ity[12, 13] and it has been reported that decreased walking speed is seen in stroke survivors[3]. Therefore, in this study, walking speed was also utilized to investigate the concurrent validity of the two scales.

The objective of this study was to investigate the intra-rater and inter-rater reliabilities of the WGS and GARS of hemiplegic stroke patients by observing videotape recordings as well as to determine the concurrent validity of the two scales with gait speed through their correlations with clinical measurements including the Fugl-Meyer assessment, the Motricity Index (MI), and the Composite Spasticity Index (CSI) of the lower limb.

SUBJECTS AND METHODS

Twenty subjects (18 males and 2 females) with hemiplegia after a single cerebrovascular accident were invited to participate in this study. The average age of the subjects was 54.8±8.5 years old. The inclusion criterion was stroke survivors who could walk independently with or without a walking aid. Subjects were excluded if they had cerebellum or brainstem disorders, uncontrolled medical conditions, lower limb contractures, or orthopedic lower limb problems, or if they were taking drugs which affected their muscle performance, such as on botulinum. All the participants provided their written informed consent to participation. The research protocol was approved by the Ethics Committee of the Chinese People's Liberation Army General Hospital.

Video recording of patients' gait: Subjects were asked to walk independently on a 10-meter walkway closely supervised by a physical therapist who did not support the subjects. Two cameras were used to record patients' gait performance and patients were asked to walk three to four times to allow recording them from the sides, front and back.

Scales assessments: Two qualified physical therapists with master degrees assessed all the videos. One was a novice with only two years' working experience and the other was an experienced PT with 9 years' work experience. Before scoring, they were trained in the scales' scoring instructions, and to make common agreement on each item in one session. To test the intra-rater reliability, the experienced PT was asked to view the videotape once again 7 days later and score the subjects again.

WGS (Table 1) examines the *stance phase of the affected leg* by five items: use of hand-held gait aid, stance time on the impaired side, step length of the unaffected side, weight shift to the affected side, and stance time; *toe-off ability* (guardedness and hip extension of affected side); *swing phase of the affected leg* (external rotation during initial swing, circumduction at mid swing, hip hiking at mid swing, knee flexion from toe-off to mid swing, toe clearance, and pelvic rotation) and *heel strike of the affected leg* (initial foot contact). Except for item 1, "use of hand-held gait aid", which has 4 ordinal scores, the other 13 items were scored from 1 to 3, and higher scores indicate worse gait performance.

GARS also has a 4 point ordinal scale (0=normal, 1=mildly impaired, 2=moderately impaired, 3= severely impaired) and mainly measures gait from 3 aspects: 1) general category; 2) lower limb category; 3) head, shoulder and upper limb category. Table 3 shows the individual items of

Table 1. Descriptive data of the participants

Measurements	Description (mean ± SD)
Age (years)	54.8±8.5
Height (cm)	171.0±4.5
Weight (kg)	74.5±9.7
WGS total score	24.7±7.9
GARS total score	20.6±10.0
Walking speed (m/s)	0.4±0.3
Fugl-Meyer score	27.3±4.3
Motricity Index	70.4±21.5
Composite Spasticity Index	10.3±3.4

each category.

In order to investigate the concurrent validity, clinical measurements were also tested in this study. Subjects' walking velocity was measured by calculating the time that subjects took to walk over the middle 8 meters of the walkway, as provided by highly reliable results in a previous study[14]. The Fugl-Meyer assessment, the Motricity Index, and the Composite Spasticity Index of the lower limb were used by a rehabilitation doctor to assess each participant (for details of the three clinical measurements please refer to reference 15, 16, and 17, respectively).

All the analyses were performed using commercially available software, the Statistical Package for the Social Sciences (SPSS) version 17.0 (SPSS Inc., USA). The inter-rater and intra-rater reliabilities were calculated using the Interclass Correlation Coefficient (ICC). Reliability is considered to be good when ICC was larger than 0.75, fair when it is between 0.40 and 0.75, and poor when it is less than 0.40[18]. The relationships of the total scores of the two scales and motor function, and clinical measurements were established by Pearson's correlation coefficient (gait speed, FM scores) and Spearman's correlation coefficient (CSI, MI). A value of $p<0.05$ was considered to be significant.

RESULTS

Twenty subjects were included in this study. All could walk independently during the testing. The descriptive data of subjects' measurements are presented in Table 1.

The intra-rater reliability and inter-rater reliability (total score and each item) of the two scales' assessments of post-stroke patients are presented in Table 2 and Table 3.

The WGS showed good intra-rater and inter-rater reliabilities for the total score: r=0.961, $p<0.001$ and r=0.945, $p<0.01$, respectively. For the items of WGS, the intra-rater reliabilities of "circumduction at mid-swing," "knee flexion from toe off to mid-swing," and "toe clearance" were fair, and the other 11 items all showed good intra-rater reliabilities (ICC>0.75, $p<0.01$) (Table 2). The inter-rater reliabilities of each item of the WGS were also fair to good, ranged from 0.561 to 1, $p<0.05$, except "hip hiking at mid-swing" and "toe clearance."

For the total score of the GARS assessment of hemiplegic stroke subjects, the intra-rater reliability was fair while the inter-rater reliability was good: ICC=0.708 and 0.875, re-

Table 2. Reliability of the WGS

	ICC of intra-rater reliability	95%CI	ICC of inter-rater reliability	95%CI
Total score	0.961**	0.903–0.984	0.945*	0.777–0.962
1. Use of hand-held gait aid	1.000**	1.000–1.000	1.000*	1.000–1.000
2. Stance phase on impaired side	0.768**	0.500–0.901	0.561*	0.141–0.789
3. Step length of the unaffected side	0.858**	0.631–0.932	0.894*	0.737–0.954
4. Weight shift to the affected side with or without gait aid	0.856**	0.661–0.938	0.699*	0.381–0.869
5. Stance width	0.871**	0.702–0.947	0.624*	0.249–0.828
6. Guardedness	0.832**	0.618–0.929	0.795*	0.550–0.913
7. Hip extension of the affected leg	0.837**	0.632–0.932	0.729*	0.391–0.872
8. External rotation during initial swing	0.824**	0.586–0.739	0.583*	0.198–0.810
9. Circumduction at mid-swing	0.569**	0.178–0.803	0.633*	0.269–0.834
10. Hip hiking at mid-swing	0.783**	0.529–0.908	0.327	−0.130–0.662
11. Knee flexion from toe off to mid-swing	0.713**	0.364–0.864	0.718*	0.411–0.877
12. Toe clearance	0.644**	0.276–0.873	0.414	−0.260–0.717
13. Pelvic rotation at terminal swing	0.961**	0.903–0.984	0.861*	0.639–0.933
14. Initial foot contact	1.000**	1.000–1.000	0.750*	0.404–0.875

*indicates p<0.05, **indicates p<0.01

Table 3. Reliability of the GARS

	ICC1	95%CI	ICC2	95%CI
Total score	0.708**	0.380–0.875	0.875**	0.483–0.896
A) General Categories	0.608**	0.175–0.802	0.736**	0.441–0.885
a1) Variability - measure of inconsistency and arrhythmicity of stepping and of arm movements	0.660**	0.250–0.828	0.584*	0.187–0.806
a2) Guardedness - hesitancy, slowness, diminished propulsion and lack of commitment in stepping and arm swing	0.743**	0.436–0.884	0.796**	0.542–0.911
a3) Weaving - an irregular and wavering line of progression	0.203	−0.253–0.584	0.173	−0.281–0.563
a4) Waddling - a broad-based gait characterized by excessive truncal crossing of the midline and side-bending	0.682**	0.334–0.855	0.618**	0.212–0.815
a5) Staggering - sudden and unexpected laterally directed partial losses of balance	0.648**	0.122–0.782	0.546*	0.114–0.779
B) Lower extremity category	0.711**	0.402–0.875	0.730**	0.203–0.812
b1) %time in swing - a loss in the percentage of the gait cycle constituted by the swing phase	0.589**	0.207–0.813	0.723**	0.362–0.863
b2) Foot contact - the degree to which heel strikes the ground before the forefoot	0.511*	0.097–0.772	0.506*	−0.053–0.703
b3) Hip ROM - the degree of loss of hip range of motion seen during a gait cycle	0.722**	0.419–0.880	0.535*	0.089–0.768
b4) Knee ROM - the degree of loss of knee range of motion seen during a gait cycle	0.654**	0.307–0.847	0.000	−0.433–0.433
C) Trunk, Head, and UE categories	0.822**	0.604–0.925	0.652**	0.080–0.764
c1) Elbow extension - a measure of the decrease of elbow range of motion	0.754**	0.464–0.891	0.800**	0.491–0.898
c2) Shoulder extension - a measure of the decrease of shoulder range of motion	0.659**	0.314–0.849	0.479*	0.031–0.734
c3) Shoulder abduction - a measure of pathological increase in shoulder range of motion laterally	0.597**	0.207–0.813	0.693**	0.370–0.866
c4) Arm-heel strike synchrony - the extent to which the contralateral movements of an arm and leg are out of phase	0.435	−0.07–0.726	0.247	−0.218–0.607
c5) Head held forward - a measure of the pathological forward projection of the head relative to the trunk	0.734**	0.428–0.882	0.449*	−0.114–0.671
c6) Shoulder held elevated - the degree to which the scapular girdle is held higher than normal	0.860**	0.680–0.942	0.000	−0.433–0.433
c7) Upper trunk flexed forward - a measure of kyphotic involvement of the trunk	0.569**	0.180–0.804	0.438	0.005–0.731

*indicates p<0.05, **indicates p<0.01; ICC1 indicates intra-rater, ICC2 indicates inter-rater

spectively, both p<0.05 (Table 3). The intra-rater reliabilities of the items were fair to good, ICC ranging from 0.569 to 0.860, p<0.05, except the "weaving," "arm-heel strike synchrony." The inter-rater reliabilities of each item were also fair to good, ranging from 0.449 to 0.796, p<0.05, except "weaving," "knee ROM," "arm-heel strike synchrony," "shoulder held elevated."

The walking speed negatively correlated with the total score of WGS (r=−0.813, p<0.001) and GARS (r=−0.641, p=0.004). In the comparison of the two scales, the correlation of the total score was found to be strong (r=0.872, p<0.001). The correlations of the two scales with clinical measurements are shown in Table 3. There were fair to strong correlations between the two scales and FMA and MI of the lower limb (Table 4), but no significant correlation with the CSI (all p>0.05).

DISCUSSION

The present study was the first study to investigate both the reliability and validity of the Wisconsin Gait Scale and Gait Abnormality Rating Scale, and their correlations with each other and with clinical measurements.

The intra- and inter-rater reliability of the WGS in the present study was satisfactory, a result which was consistent with a previous study of a Turkish population[8]. In that study, the mean total score of the WGS was 23.21, while in the present study, the score was 24.66 a bit higher. For each item of the WGS, the intra-rater reliability was also satisfactory (Table 2), a result which was also comparable to the results of previous studies[6–8]. For the inter-rater reliability, the present study found weaker ICCs than those reported by previous studies for "hip hiking at mid-swing" and "toe clearance," and this may be due to the unfamiliarity of the novice physical therapist with observational gait measurement. These two items are related to typical hemiplegic gait after stroke, and the novice PT may not have been experienced in analyzing subjects' performances. However, the overall scores were still acceptable because of their statistical significance. The poor inter-rater reliability of these two items indicates that when this scale is used in different settings, results from different raters should be compared with especial care.

The Gait Abnormality Rating Scale was designed to observe the gait pattern of older adults with increased fall risk[9]. This scale examines the interaction of the trunk, and upper and lower limb movements during walking. It also includes items that reflect the walking speed and stride length, traditional temporospatial gait parameters, which are shown in Table 3. The GARS scale puts more emphasis on assessing overall functional performance. For the elderly, this scale sensitively indicates their deficits during walking and is related to increased fall risk[10, 19]. In the present study, the target sample was stroke subjects. Some studies have reported that gait speed and cadence decrease in stroke survivors[3], and that altered temporospatial coordination between the head, trunk and pelvis are also observed[3, 20]. This alteration is similar to that seen in the elderly with fall risk, however, the intra-rater and inter-rater reliabilities of the total GARS score of stroke patients were 0.708 and 0.875, respectively, which was just acceptable. In a study of elderly adults, the

Table 4. Correlation of WGS and GARS with clinical measurements

Correlation	FMA	MI	CSI
WGS	−0.677**	−0.687**	0.305
GARS	−0.742**	−0.742**	0.389

**indicates p<0.01

intra-rater reliability of GARS was 0.945[9] and the inter-rater reliability ranged from 0.61–0.95[9]. This indicates that when this scale is used to assess the hemiplegic gait, the results should be treated with caution.

Walking speed is a simple but important parameter which may be used as an index of quality of life, and could be a landmark of physical function in a diversified population[21, 22]. It has also been found to be a crucial parameter of walking performance in hemiplegia[23, 24], since increased walking speed is one of the indications of improvement in hemiplegic gait performance, and it is clinical meaningful for patients after stroke[25]. Both the WGS and GARS showed significant correlations with walking speed (r=−0.813 and −0.641, respectively, p<0.001). The correlation of the WGS to walking speed was consistent with a previous study[7], which concluded that WGS could be used as a sensitive gait measurement protocol for clinical use. GARS also showed a negative correlation with walking speed (r=−0.641) for this group of participants, and a previous study of the community-dwelling elderly which found that the correlation of GARS and walking speed was −0.679[19]. GARS has some items that are related to walking speed such as "guardedness" and "lack of propulsion", and they may contribute to the correlation of the GARS scores of the hemiplegic stroke patients and walking speed.

There was a strong correlation (r=0.872) between the two scales. The two scales have some items that are similar such as: "6). guardedness" in WGS and "a3). guardedness" in GARS; "11). knee flexion from toe off to mid-swing" in WGS and "b4). knee ROM"; and "12). toe clearance" in WGS and "b2) foot contact" in GARS. Both scales had strong relationships with FMA and MI of the lower limb (Table 4), but the correlations of WGS to these two measures were weaker than those of GARS. This may be due to WGS laying particular stress on assessing the gait quality during walking, while GARS measures the overall functional performance of gait. WGS measures hemiplegic gait change by observing the weight-bearing and weight shift in the swing and stance phases as well as the hip, knee and ankle kinematics, inter-limb movement symmetry, balance/guardedness, and assistive device use[7]. With the exception of item 1 "use of gait assistance," the other 13 items of WGS are directly related to the hemiplegic gait of the affected leg as described from the front. On the other hand, in GARS, based on the scale design aims, the three categories of the scale are mainly functionally dependent, rather than characteristic gait descriptions. Both FMA and MI of the lower limb are measurements of the functional performance of the lower limb[15, 16]. And this may explain why GARS had higher correlations with these two functional measures than WGS. Neither of the two scales showed a significant cor-

relation with the CSI of the lower limb. The CSI of the lower limb is an index measuring spasticity which assesses the ankle joint clonus, reflex, and muscle tones[17]. Spasticity is a classic symptom of upper motor neuron injury. After stroke, subjects may exhibit upper neuron injury symptoms like spasticity[26], but in this group of subjects, spasticity may not be the main impediment of gait and functional performance. Besides, in these two scales there are no items that directly point to spasticity. These two reasons may explain the lack of relationships between the two scales and CSI.

In conclusion, both the Wisconsin Gait Scale and the Gait Abnormality Rating Scale were reliable and valid assessments of post-stroke hemiplegic gait in this Chinese population. Furthermore both scales have close relationships with FMA and MI of the lower limb, but show no correlation with CSI of the lower limb.

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