Reliability of a Road Test After Stroke

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ABSTRACT. Akinwuntan AE, DeWeerdt W, Feys H, Baten G, Arno P, Kiekens C. Reliability of a road test after stroke. Arch Phys Med Rehabil 2003;84:1792-6.

Objective: To determine the reliability of the road test performed by stroke patients.

Design: Prospective study of a 6-month predriving evaluation.

Setting: Driving safety center in Belgium.

Participants: Thirty patients with sequelae of stroke.

Interventions: Not applicable.

Main Outcome Measures: Results of driving performance as judged by 2 assessors from the Center for Determination of Fitness to Drive and Car Adaptations (CARA), in a car fitted with a video camera. A third assessor also evaluated all the video recordings. Interrater reliability was evaluated by comparing results from real-life performance and video recording, as judged by the CARA assessors and video judgments between CARA assessors and the third assessor.

Results: Most subitems of the road test showed more than 80% scoring agreement between the various evaluations. Intraclass correlation coefficients (ICCs) of the items varied from −.08 to 1.0. The ICC of the overall performance was .62 when real-life scores were compared with video evaluations and .80 in video versus video comparison.

Conclusion: The reliability of assessing overall performance of stroke patients in the road test is moderately high and better when assessed using the same evidence. Yet, the reliability of some items needs further attention.

Key Words: Automobile driving; Cerebrovascular accident; Rehabilitation; Reliability and validity; Stroke.

OUR SOCIETY HAS A HIGH demand for mobility; thus, returning to driving after brain injury has become more of a necessity than a luxury. Stroke is among the most common forms of brain injury, and it affects driving.[1,2] The inability to drive again after stroke could contribute to loss of social activities leading to increased depression.[3] Several studies[2-10] have shown that stroke survivors show cognitive, perceptual, visual, and motor deficits, which eventually affect their driving performance. Studies[11-16] have also indicated that well-planned and well-administered predriving assessments are helpful to identify stroke survivors who could resume safe driving. One of the responsibilities of experts assessing people with brain injury who wish to resume driving should be the reliable assessment of driving competence.[17]

The road test is universally acclaimed as a valid test of evaluating driving ability. It was described as the most accurate test of driving performance after brain injuries leading to progressive motor disabilities.[18] In most studies on driving after stroke,[7,12,19-22] the criterion of driving ability was based on the road test. However, very few predriving assessment centers for persons with brain injury use standardized and reliable road tests.

In the study by Kewman et al,[23] the test-retest reliability of a 9.6-km road test was evaluated by an experimenter sitting in the back of the car and scores given by a driver educator sitting in front. The experimenter evaluated the driving performance by using a 3-point nominal classification on lane position change every 30 seconds and on 17 items of the fixed course, among other assessments. The driver educator gave a global assessment of the driving performance, by using a 6-point ordinal scale, at the end of the test. Both assessors evaluated 13 patients with severe brain injury twice, 3 weeks apart. Results showed a test-retest correlation of r equal to .89 between experimenter scores and r equal to .97 between driver educator scores.

In another study,[24] 2 trained raters simultaneously assessed driving performance of 30 elderly subjects with a pass or fail score on 75 items of a checklist. The road test consisted of a closed course and an in-traffic section and was performed on a 16-km road that took approximately 45 minutes to complete. The interrater reliability, using Pearson correlation coefficients, was .84 and .74, for the closed course and for the in-traffic section, respectively.

Fitten et al[25] studied the reliability of a road test by using subjects with Alzheimer's disease, vascular dementia and diabetes, and healthy old or young drivers. An on-board driving instructor scored driving performance on a 4.4-km road network while being audio- and videotaped simultaneously. The interrater reliability was determined by comparing the scores of 2 "blind" external consultants (A, B) who evaluated 25 randomly selected audioless videotapes, with scores given by the on-board driving instructor. Pearson correlation coefficients were .91 between consultants A and B, .65 between consultant A and the driving instructor, and .64 between consultant B and the driving instructor.

In a recent study[26] that included 65 subjects with dementia of the Alzheimer type and 58 controls, the reliability of a road test conducted on a 9.6-km course was determined. Driving performance of a subset of 63 subjects was evaluated by a driving instructor and the study investigator by using a global rating scored on a 3-point ordinal scale. Two other investigators also made global judgments of the driving performance of 10 subjects, again simultaneously assessed by the study investigator. A κ value of .85 was reported for judgments between the driving instructor and the study investigator. Interrater reliabil-

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ity for assessment of driving performance between the other investigators and the study investigator was .96.

In the recent study on predicting the determinants of driving after stroke in Belgium,[27] the road test was shown to be the most important predictor of the outcome of a predriving assessment. To the best of our knowledge, the road test included in the predriving assessment has never been assessed for its reliability. Furthermore, no study was found that specifically evaluated the reliability of any road test used in stroke patients. In the few reliability studies available, in other patient populations, only the reliability coefficients of the global outcome of the road tests were reported. The reliability of the several items whose scores add up to give the global outcome was not reported. The aim of our study was therefore to evaluate the reliability of the road test performed by stroke patients in Belgium and the reliability of the items that constitute the road test.

METHODS

Participants and Procedure

According to Belgian law,[28] persons who have neurologic or physical impairments after stroke may not resume driving until 6 months after the onset. The authority to resume driving after the 6-month period can only be given by the Center for Determination of Fitness to Drive and Car Adaptations (CARA) unit of the Belgian Road Safety Institute[29] (BRSI), after a predriving assessment. Referrals to CARA for the predriving assessment are usually given by medical doctors or by car insurance companies.

During a period of 6 months, persons with the diagnosis of stroke who visited CARA for the predriving assessment were selected for inclusion in the study. All subjects freely and willingly agreed to have their road test driving performance videotaped and the results used for the purpose of our study. Thirty subjects were originally included in the study, but data from only 27 subjects were used because of technical problems with 3 video recordings.

The road test was developed on the basis of extensive discussions, expertise, and advice of certified road safety experts in Belgium. It contained a closed course and an in-traffic section. The closed course consisted of 4 maneuvers performed within the premises of the BRSI in Brussels. The in-traffic section was performed on a standardized 20-km road in the vicinity of Brussels. It started from a neighborhood with very low to moderate traffic and progressed to areas with higher traffic, on a 6- and 8-lane 2-way highway, before terminating in the BRSI.

The road test was performed at a specified time of day in an Opel Kadet car with an automatic transmission system. During the road test, each subject was accompanied by an assessor from CARA who could take control of the car in difficult circumstances using a second set of controls. A Sony Video Hi8 camera,[a] containing a 90-minute Hi8 cassette labeled with the name of the subject, was mounted in the back of the car during each test, for recording the driving performance.

Two assessors (A, B) from CARA, experienced in assessing patients with brain injury during road tests, and an external assessor without experience were involved in the study. One of the assessors from CARA usually accompanied subjects during the road test and completed the checklist at the end of the test. When assessor A evaluated the real-life driving performance of a subject, assessor B scored the video recording of the same subject and vice versa. The external assessor, however, scored the video recording of all the subjects.

A checklist adapted from the Test Ride for Investigating Practical Fitness to Drive: Belgian Version,[30] developed in the Netherlands in cooperation with CARA, was used to assess performance in the road test. A total of 17 items of driving performance, including 4 closed-course and 13 in-traffic items, were evaluated during the road test. Each item consisted of subitems that were scored using clearly predefined criteria on a 4-point scale (poor, 1; fair, 2; sufficient, 3; good, 4). A maximum of 220 points from a total of 55 subitems was obtainable.

Data Analysis

Descriptive statistics were used to document the general characteristics of the subject population. To determine the interrater reliability of the road test, its items, and its subitems, 3 data pools were generated from the real-life and the video evaluations. Pool 1 contained 27 scores from the real-life road test performance, as evaluated by the accompanying assessor from CARA (A, n=17; B, n=10). Pool 2 consisted of the results from the 27 video recordings, as scored by the nonaccompanying assessor from CARA (A, n=10; B, n=17). Pool 3 contained the results from the video recordings, as scored by the external assessor (n=27). Subsequently, evaluations during the real-life road test were compared with evaluations of video recordings by the CARA assessors (pool 1 vs pool 2) and between the video judgments by the CARA assessors and the external assessor (pool 2 vs pool 3). Interrater agreement in scoring the subitems was explored by using weighted percentage agreement, because of the skewed distribution of scores. Values of agreement higher than 80% were considered sufficient. Interrater reliability of the items and overall performance (total score) were determined by using the intraclass correlation coefficient (ICC). ICC values of less than .40 were considered low, .40 to .59 were considered moderate, .60 to .79 were considered moderately high, and values above .80 were considered very high.[31] All statistical procedures were performed with the SAS system.[32,b]

RESULTS

The general characteristics of the subject population showed that the average age of the 27 subjects (22 men) was 60.0 ± 13.6 years. Twelve subjects had a right-sided brain lesion; 15 had a left-sided brain lesion. Subjects included 9 patients with ischemic and 18 with hemorrhagic stroke. Sixteen subjects had binocular acuity values that corresponded to 20/20. Nine subjects had values that corresponded to 20/25. Two subjects had binocular acuity values that corresponded to 20/30. All subjects who required correction lenses to drive performed the visual acuity test using the appropriate lenses. Two subjects had quadrianopia and none had hemineglect. Driving experience, which was a measure of the number of years subjects had been driving before the onset of stroke, ranged between 17 and 61 years.

The average interval between onset of stroke and the road test was 14 ± 8.5 months. Most subjects completed the test in less than 1 hour. Whenever the test lasted more than 60 minutes, subjects were more likely to have a poor performance. Some reasons for poor performance were faulty maneuvers during the closed course, slower driving speed as a result of reduced confidence levels, and difficulty in coping with the traffic situation during the in-traffic section of the road test.

All 55 subitems contained in the checklist showed weighted agreements higher than 80%, with the exception of 5 subitems in real-life performance versus the video. The 5 subitems included the lateral positioning on the road at a speed above 50km/h (1) with and (2) without distraction and regular use of the (3) inside, (4) outside left, and (5) outside right mirrors

Table 1: ICCs and 95% Confidence Intervals (CIs) for the 17 Items of the Road Test

Item	Real-Life Performance vs Video ICC	Real-Life Performance vs Video 95% CI	Video vs Video ICC	Video vs Video 95% CI
1. Positioning between 2 cars	.69	.42–.84	.68	.41–.84
2. Reversing into a narrow lane	.72	.48–.86	.59	.29–.79
3. Driving in and out of a garage	−.03	−.39–.35	.00	−.36–.37
4. Turning around in a restricted space	.85	.70–.93	.69	.42–.84
5. Position on the road (<50km/h)	.49	.15–.73	.29	−.08–.60
6. Lane changing	.66	.39–.83	.52	.18–.75
7. Distance from car ahead at <50km/h	.33	−.04–.62	1.00	1.0
8. Speed in areas with limit (<50km/h)	.22	−.16–.55	.79	.60–.90
9. Anticipation and perception of signs	.44	.09–.70	.55	.22–.76
10. Mechanical operations	.39	.02–.66	.18	−.20–.52
11. Joining the traffic stream	−.08	−.43–.30	.50	.15–.73
12. Position on the road (>50km/h)	.28	−.11–.59	.53	.19–.75
13. Distance from car ahead at >50km/h	.42	.06–.68	.66	.38–.82
14. Speed in areas with limit (>50km/h)	.18	−.20–.52	.42	.06–.69
15. Turning left on a major road	.51	.18–.74	.70	.45–.85
16. Visual behavior and communication	−.01	−.04–.04	−.01	−.03–.03
17. Quality of traffic participation	.53	.20–.75	.55	.23–.77

during the entire course of the road test. Three subitems in the video versus video comparisons also showed weighted agreement values of less than 80%. Again, the regular use of the (1) inside, (2) outside left, and (3) outside right mirrors during the course of the road test were shown to be difficult subitems to reliably assess with the video evidence. The 2 subitems contained in item 7, which were keeping of proper distance from other cars inside city areas with (1) low and (2) heavy traffic, showed 100% agreement between the video and the video comparison.

Nine of the 17 items (table 1) had moderate to very high reliability coefficients (.42–.85) when real-life scores were compared with scores from the video evidence (pool 1 vs pool 2). Comparison of evaluations of video recordings by CARA assessors and the external assessor (pool 2 vs pool 3) showed that 13 items also had moderate to very high reliability coefficients (.42–1.0). Items 3, 11, and 16 were not at all reliable in the real-life performance versus the video comparison. The same was found for items 3 and 16 in the video versus video comparison. Item 10 showed low ICC values in both comparisons.

ICC values of the closed-course items (items 1–4), with the exception of item 3, were higher in the real-life versus video comparison than for the video versus video comparison. However, higher ICC values were observed for 9 of the 13 items of the in-traffic section in the video versus video comparison. The ICC value for item 16 remained unchanged in both circumstances.

Consequently, results presented in table 2 show a higher reliability coefficient (.70) for the closed-course section than for the in-traffic section (.56) in the real-life versus video comparison. Video versus video comparison revealed a higher reliability value (.77) for the in-traffic section when compared with the closed-course section (.58).

The ICCs of the overall performance (total score) in the road test were .62 (moderately high) and .80 (very high) for the real-life versus video and for the video versus video comparisons, respectively. When items 3 and 16 (which had shown no reliability) were excluded, the coefficients in both circumstances increased to .64 and .84.

In most cases, large confidence intervals (CIs) were observed for many of the ICCs (tables 1, 2), especially those with values lower than .60.

DISCUSSION

In our study, the closed-course section and 3 of its items were more reliably assessed during the real-life versus video comparison than in the video versus video comparison, as shown in tables 2 and 1, respectively. The closed-course section of the road test involved specific maneuvers performed in an area with defined borders for each maneuver and at very slow speed. The borders were marked out with metal barriers and plastic cones. Contact with the metal barriers or driving over the cones constituted a faulty performance. It was, however, difficult to accurately evaluate this section of the road test by using video evidence. Assessors who scored the video recordings had to rely on the metal clanking sound produced during contact between the body of the test car and the metal barriers, to judge a performance as faulty. In cases in which the contacts were slight, the sounds were not clearly heard on the video recordings. Drives over the cones were also not seen and could not be appreciated from the video recordings. Judgments of faulty performances in these situations were thus subjective.

The in-traffic section, in contrast to the closed course, involved assessments of driving skills performed in dynamic, nonrestricted spaces, over a longer distance and at different speed limits. It was also dependent on the traffic situation and

Table 2: ICC and 95% CIs for Section and Overall Performances in the Road Test

Section/Overall Performance	Real-Life Performance vs Video ICC	Real-Life Performance vs Video 95% CI	Video vs Video ICC	Video vs Video 95% CI
Closed course (items 1–4)	.70	.45–.85	.58	.25–.78
Closed course without item 3	.84	.68–.93	.66	.38–.83
In-traffic (items 5–17)	.56	.23–.77	.77	.56–.89
In-traffic without item 16	.58	.27–.78	.79	.59–.90
Overall (all 17 items)	.62	.31–.81	.80	.61–.90
Overall without items 3 and 16	.64	.36–.82	.84	.67–.92

the driving actions of the other road users. This section of the road test offers a higher potential for collisions. Hence, assessors of real-life driving performance were saddled with the responsibility of ensuring safety, in addition to evaluating the subjects. When evaluating driving performance from video recordings, the assessor did not have to bother with safety and therefore had better concentration. Video recording also served as an important source of information that was reviewed for certainty and clarity in difficult and controversial situations. This may explain why the in-traffic section and most of its items (9/13) showed better reliability coefficients in the video versus video comparison than in the real-life versus video comparison.

No plausible explanation can be offered for the poor showing of item 3, the ability to drive in and out of a garage without violations. From the maneuver description, definition of the scoring criteria, and outcome of the pilot study, this item was expected to be reliably assessable. The only advice that can be offered is a redescription of the test procedure and probably a redefinition of the scoring criteria.

Item 16 involved visual behavior of subjects as well as visual communication with other road users. This item proved difficult to evaluate. The assessors and the subjects had to concentrate fully on the traffic situation and demands during each test, which left the assessors with very little time to look at subjects' faces. The video recordings would have been very useful in assessing this item, but the recorder was mounted in the back of the car. Consequently, it was difficult to see the driver's face at most times during the test.

Despite the methodologic and procedural limitations, the reliability of the overall performance in the road test was .62 in the real-life versus video comparison and even higher (.80) when evaluations from video recordings were compared. This finding is in agreement with the study by Fitten et al,[25] in which a higher interrater reliability coefficient was reported when 2 video evaluations were compared than between the real-life and video comparison.

Use of a video recording as a means of data collection in studies[25,33,34] involving persons with brain injury is not uncommon, because of its inherent advantages. However, video recording of performance alone may not be sufficient in the evaluation of road tests. This is evident in the closed-course section as well as in positioning on the road at speeds below 50km/h, lane changing, and mechanical operations during the in-traffic section of the road test. In future studies on the interrater reliability of the road test, a setup, which enables 2 assessors to accompany and assess the driving performance of the subjects, is advised. The driving performance is also simultaneously videotaped during the real-life assessment and is evaluated after the road test.

Interrater reliability values of between .64 and .96 have been reported for other road tests performed by either elderly, young, diabetic, or Alzheimer's disease subjects.[24-26] Although the procedures involved in these studies may be different in some ways from ours, the outcome of our study (.62 and .80) is encouraging.

However, some very low or only moderate reliability coefficients for items of the road test were obtained despite substantial agreements (>80%) between assessors for most subitems. This may be explained in part by the poor intersubject variation, which may also be reflected in the large CIs. A population that lacks or has very low intersubject variation has been shown to produce low reliability values despite high agreement.[35] Subjects included in this study were, on average, 14 months after onset of stroke and performed the predriving assessment because of personal desire to resume driving. Such subjects would have had several hours of rehabilitation and would have attained some amount of driving proficiency before going for the predriving assessment. Most subjects, consequently, were likely to have performed well in the road test; therefore, the population lacked appreciable intersubject variation. Road test evaluations after brain injury, as seen in previous studies,[1,2,9,16,19,21] are usually performed in populations such as the one in this study. It is therefore advised that, in future reliability studies of road tests, a more diverse selection of the subject population should be made.

One of the limitations of this study was the inclusion of stroke patients only, and so the generalization of the outcome to patient groups with other types of brain injuries and medical conditions is not advised. Some subjects had difficulties with the automatic transmission of the test car, mostly because it was their first experience in such a car. This may have affected the driving performance of those subjects, especially in item 10 (mechanical operations), which concerned the effective and correct use of the accelerator and brake pedals.

CONCLUSION

The reliability of assessing overall performance of stroke patients in the road test is moderately high and is better when assessed by using the same evidence. The reliability of assessing most of the items in real life and from video evidence varied between moderate and very high. Still, the reliability of some items needs further attention.

To our knowledge, this is the first study on the reliability of the road test specifically in stroke patients. The item-per-item reliability evaluation further provides a unique contribution to knowing how easy or difficult each item is reliably judged and its influence on the overall performance. This study, therefore, provides a basis on which future similar studies can compare their results and findings.

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