Original Article

Adaptation of The Stroke Driver Screening Assessment (SDSA) to Malaysian Version (MySDSA) and its Validation for Fitness to Drive after Stroke

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ABSTRACT

Objectives: To adapt the Stroke Drivers Screening Assessment (SDSA) to the Malaysian version (MySDSA) and to establish its criterion validity and predictive ability in assessing fitness to drive after a stroke in Malaysia.
Study design: A universal sampling method.
Setting: A tertiary hospital in an urban setting in Malaysia.
Subjects: Stroke survivors referred for assessment of fitness to drive.
Methods: The MySDSA was adapted from the original SDSA. An expert panel of doctors, occupational therapists, and representatives from the Malaysia Road Transport Department and the Malaysia Institute of Road Safety Research was formed and a consensus decision was made to substitute all road signs in the SDSA Road Sign Recognition section with the Malaysian equivalent. No further changes to the SDSA were made, and the original English language was maintained. After that, stroke patients who had been referred for driving fitness assessment were recruited. The patients were tested using MySDSA and were classified as pass or fail using a discriminant equation. The patient's performance on the MySDSA was then compared with their performance on a computerised driving simulator using Receiver Operating Characteristic (ROC) analysis. The assessor for the driving simulator was blinded from the MySDSA results.
Results: Twenty stroke survivors (mean age 50 years ±10) of the initial 35 stroke survivors recruited completed both the MySDSA and the driving simulator assessment. There was no statistically significant association between either demographic or stroke characteristics and MySDSA performance. MySDSA predicted driving performance on the simulator with 74% adjusted accuracy and above moderate effect size (Cohen's d=0.661).
Conclusions: MySDSA has acceptable accuracy for predicting driving performance on the driving simulator test after a stroke, but it is not recommended to be used alone as a replacement for a driving simulator.

Keywords: driving, rehabilitation, stroke, assessment

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Introduction

In Malaysia, the stroke incidence rate has been increasing among the younger adult population in recent years, both globally and locally.[1,2] This increases the socioeconomic burden because stroke survivors still have immense social responsibilities and obligations at such an age range. As the patients gradually recover and return to premorbid function, return to driving becomes an important goal. The ability to drive represents independence and facilitates social reintegration.[3]

In Malaysia, a valid driving license duration ranges from 1 to 5 years, and the license must be renewed before the expiry date. Per sections 30.1 and 30.2 of the Road Transport Act 1987 (Laws of Malaysia - Act 333, 2013), physicians have the overall legal responsibility to certify if a person with significant medical conditions is fit to drive. For example, a stroke patient with a valid driving license is required to obtain a physician's certificate to confirm his fitness to drive and if any car modifications are required. However, there is no policy to officially withdraw the existing driving license after someone is diagnosed with a stroke.

Returning to driving after a stroke is not without any risk. It has been reported to have an increased risk of serious traffic injuries regardless of the laterality of vascular lesions.[4] This may be explained by Groeger's cognitive theory, which states that driving involves multilevel cognitive and psychological processes.[5] Fitness to drive after stroke may be compromised by stroke consequences such as visual field deficit, inattention, memory deficits, motor sensory impairments, apraxia, and language difficulties. Stroke survivors returning to driving without clinician evaluation is not uncommon.[6] However, to ensure the safety of all road users, an objective assessment of driving fitness is essential.

An on-road driving assessment is considered a gold standard evaluation and is available in most developed countries.

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However, it is not done routinely in Malaysia due to the lack of resources and expertise. This problem is also actual with a computerised driving simulator test. Unfortunately, there are less than five healthcare centres with a computerised driving simulator in the country, and only two centres performed the on-road driving assessment for a minimal population. In addition, the waiting time for these tests is highly long. Coupled with a lack of a registered policy for compulsory testing, most stroke survivors started driving despite the advice from their physicians. For this reason, we need a portable, easily administered, and valid screening assessment tool to determine driving fitness after a stroke. This tool is hoped to ensure the patient's best interest and, at the same time, safeguard road users by identifying unsafe drivers.

One of the established assessment batteries for predicting stroke survivors' driving performance with high accuracy is the Stroke Drivers Screening Assessment (SDSA).[7-9] It is available in the European, United States, and Nordic versions, with accuracy ranging from 62% to 87%.[10-13] SDSA seems to measure predominantly attention and executive abilities,[14] of which have previously been shown to be essential determinants of safe driving.[15] Therefore, in this study, we aimed to adapt the SDSA for use in the Malaysian population and to determine whether it is a suitable screening instrument for stroke patients to return to driving. This adaptation is intended for healthcare professionals already involved with return-to-drive assessment and training.

Methods

This study was approved by the Medical Research and Ethics Committee in UMMC (ID No. 201944-7291) and the Malaysia Ministry of Health (NMRR-20-593-53696). All subjects have given their written informed consent for the study.

Participants

Stroke patients who were referred for driving assessment in the Department of Rehabilitation Medicine, University Malaya Medical Center (UMMC) from May to October 2020 were screened. Using the G power calculator, the desired sample size for the correlation point biserial model with a moderate effect size is 21 patients.

The inclusion criteria were diagnosis of haemorrhagic or ischemic stroke verified by a physician or neuroimaging, having a full driving license, actively driving for at least three times a week; 3 months prior to the stroke, no significant cognitive impairments (Mini-Mental State Examination [MMSE] ≥ 24 or Montreal Cognitive Assessment [MOCA] ≥ 18), and independent or mildly independent in basic activities of daily living (Modified Barthel Index [MBI] ≥ 75). In addition, those aged ≤ 18 and ≥ 70 or with a history of any other neurological conditions like Parkinson's disease, psychiatric disorder, or conditions that legally preclude driving conditions according to Malaysia Ministry of Health guidelines were excluded, such as epilepsy and any form of visual field defect.

Materials

The data was collected using a self-constructed questionnaire specifically designed based on the objectives of this study. The questionnaire has four sections: the first three consist of patients' demographic data, disease-specific characteristics, and driving exposure, respectively, while the fourth section explores the return to the driving experience.

Development of MySDSA

The development of MySDSA was done via adaptation of the original SDSA. An expert panel was formed for this purpose, which comprised relevant healthcare professionals from a few hospitals in Malaysia, including doctors and occupational therapists involved in return to driving assessments and representatives from the Malaysia Road Transport Department and Malaysia Institute of Road Safety Research.

The original SDSA consists of 4 subtests - Dot's cancellation test, Square Matrix Direction, Square Matrix Compass, and Road Sign Recognition. A consensus was achieved among the expert panels to retain all three subtests as the original version except for Road Sign Recognition. The Road Sign Recognition test was modified, in which all the road signs were changed to Malaysia equivalents (Figure 1).

For the language medium, the panel members agreed to maintain the English language for MySDSA, and no translation is needed. The reasons are: English on the SDSA was only used in the instruction guide the healthcare professionals, whereas the patients do not have to read any statement or sentences in English. All healthcare professionals in Malaysia use English as the medium of academic study and communication. They have also been using the original SDSA for the past few years.

Study protocol

This protocol involves a few steps: the index test and the reference test. For the index test, the clinicians tested every subject referred for the driving assessment using MySDSA. The total duration to complete the assessment was about 30 minutes. In order to determine the subject's performance with MySDSA, the discriminant equation of the original SDSA battery was used. Using this formula, two scores - pass score, (a), and fail score, (b), were obtained for each subject. Finally, the MySDSA total score was derived by subtracting the fail score (b) from the passing score (a). With zero as the cut-off point, a positive MySDSA score indicated that the subject passed the MySDSA test. Meanwhile, a negative MySDSA score indicated that the subject failed the MySDSA test.

(a) Pass score = (Dot's Cancellation time x 0.012 + Dot's Cancellation false positive x 0.216 + Square Matrices Direction x 0.409 + Road Sign Recognition x 1.168) - 13.79

(b) Fail score = (Dot's Cancellation time x 0.017 + Dot's Cancellation false positive x 0.035 + Square Matrices Direction x 0.185 + Road Sign Recognition x 0.813) - 10.042

(c) MySDSA total score = (a) - (b)

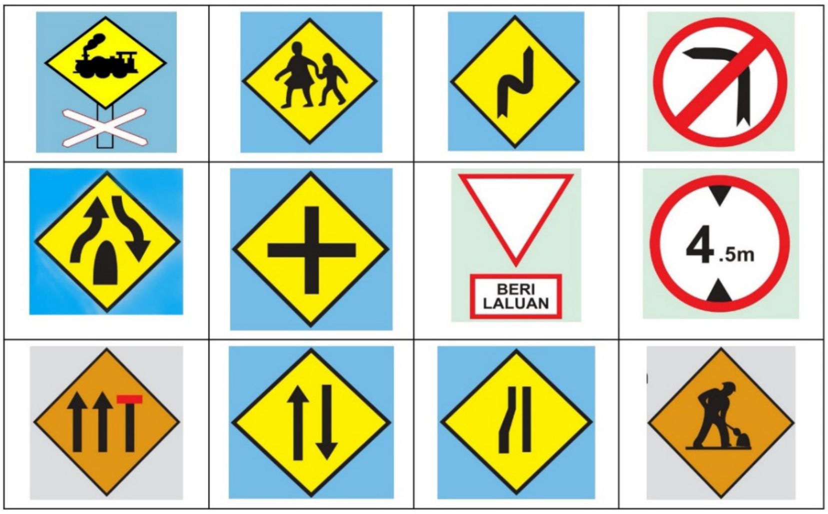

Figure 1. The Road Sign Recognition test has been substituted with the Malaysian equivalent.

For the reference test, all subjects who have been tested with MySDSA were then evaluated on a computerised driving simulator (Jayonik SIMULASIA-SA-3500-R) as the standard criterion. This test was conducted by an occupational therapist trained in the simulator, and subjects were categorised as pass or fail. The previous study has shown that adapting to an unfamiliar car is associated with an increased cognitive load which could affect the assessment validity.[16] Thus, four sessions of free driving practice were allowed to get the subject accustomed to the simulator.

The final session (the fifth) consisted of a basic driving course and a defensive driving course. The basic driving course mainly assessed the driver's behaviour for safety measure compliance, for example, wearing a seat belt, maintaining driving in the same lane, giving a signal, and maintaining safe distance from another car. The defensive driving course assessed the driver's brake reaction speed and brake distance when they encountered sudden obstacles for example, an animal crossing the road or another car blocking the road. Each session was one hour long. The assessor was blinded from the subject's MySDSA outcome.

Statistical analysis

In view of the small sample size, Shapiro-Wilk was used for the normality test. Subjects' demographic and stroke characteristics were compared using Independent t-tests or the Mann-Whitney U test and Chi-square or Fisher's exact tests as applicable. For statistical analysis purposes and due to the small sample size, the MOCA score is converted to MMSE scores using the validated conversion by Roalf et al.[17] to enable us to get one uniform score.

The correlation between the MySDSA score (MySDSA total score, which was calculated using the formula explained under the Methods section - index test) and the continuous variable was measured using Spearman and Pearson test. The agreement between MySDSA and driving simulator performance was measured using MedCalc Receiver Operating Characteristic (ROC) analysis.

Results

Thirty-five stroke survivors were initially recruited with a mean age of 52 ± 10.9 years and a mean stroke duration of 6.9 ± 9.08 months. Fifteen subjects (43%) dropped out of the study due to a sudden lockdown in the country; thus, they could not complete the driving simulator assessment. As a result, only 20 subjects (57%) completed the driving simulator assessment (Table 1).

The average interval between MySDSA and driving simulator assessment was 19.7±12.4 weeks. There was no significant association between the demographic or stroke characteristics and MySDSA performance. Spearman test showed a moderate positive correlation ($p = 0.552$, $p = 0.001$).

Those who completed both MySDSA and driving simulator assessment (n = 20) were included in the ROC analysis. For ROC analysis, the positive test and 'disease present' referred to subjects who were unfit to drive based on MySDSA and computerised driving simulator performance, respectively (Table 2).

Fourteen and six subjects were correctly and incorrectly categorized by MySDSA, respectively. No significant differences

Table 1. Demographic data and stroke characteristics (n = 20)

Variables	
Sex[1] (male/female)	15 (75) / 5 (25)
Race[1] (Malay/Indian/Chinese)	9 (45) /2(10) / 9 (45)
Stroke Event[1] (first/recurrent)	18 (90)/ 2 (10)
Stroke Type[1] (ischemic/hemorrhagic)	15 (75)/5 (25)
Stroke Side[1] (dominant/non-dominant)	12 (60) /8 (40)
Employment Status[1] (yes/no)	6 (30) /14 (70)
Education[1] (primary/secondary/tertiary)	1 (5) /8 (40) /11 (55)
Age (years)[2]	50 (10.17)
Stroke duration (months)[2]	6.9 (9.08)
MMSE[2]	28.40 (1.73)
MBI[2]	90.10 (9.49)
Daily Driving Distance (km)[2]	34.81 (17.07)
MySDSA-simulator interval (weeks)	19.65 (12.37)

[1]Number (%), [2]mean (standard deviation, SD)

Table 2. MySDSA versus driving simulator performance

	Driving simulator		Total
MySDSA	Fail	Pass	
Fail[1]	True positive = 5 (25)	False positive = 3 (15)	8
Pass[1]	False negative = 3 (15)	True negative = 9 (45)	12
Total	8	12	20

[1]Number (%)

Table 3. Demographic and stroke characteristics of the stroke survivors in the "True" and "False" groups

Variables	True (n = 14)	False (n = 6)	*p*-value
Age[1]	49 (10.4)	53 (9.9)	0.45[a]
Gender[2] (male/female)	11/3	4/2	0.62[b]
Ethnicity (Malay/Chinese/Indian)	7/6/1	2/3/1	0.71
Education level (primary/secondary/tertiary)	1/6/7	0/2/4	0.69
Employment status Yes/No	3/11	3/3	0.30
Daily driving distance (km)[1]	37 (15)	30 (21)	0.40
First/recurrent stroke	13/1	5/1	0.52
Stroke type (ischemic/hemorrhagic)	10/4	5/1	1.00
Stroke location (subcortical/cortical)	9/5	4/2	1.00
Stroke side (dominant/non-dominant)	8/6	4/2	1.00
Stroke duration (months)[3]	2 (0.7-6.5)	10 (0.8-14.8)	0.28
MMSE[3]	29 (27-30)	28.5 (26.8-30)	0.89
MBI[3]	93 (82.3-97.8)	93.5 (80-97.8)	0.97
MySDSA-simulator interval (weeks)[3]	26 (7.8-32.5) 2.1	12 (6.8-24.8)	0.41
MySDSA sum score[3]	(-0.4-3.9)	0.2 (-4.3-1.5)	0.08

[1]Mean (standard deviation, SD), [2]number, [3]median (interquartile range, IQR)
[a]independent t test, [b]Fisher's exact test, cChi-square test, dMann-Whitney U test
MMSE, Mini Mental State Examination; MBI, Modified Barthel Index; MySDSA, Malaysian version of Stroke Driver Screening Assessment

between the true and false groups were found in the demographic or stroke characteristics (Table 3). In addition, the differences in the MySDSA-driving simulator assessment interval and MySDSA sum score between both groups were also not statistically significant.

By computing this disease prevalence into the ROC analysis, the adjusted accuracy of MySDSA to predict driving performance on the driving simulator was 74%. This adjustment method is applicable when the sample sizes in the positive and the negative groups do not reflect the actual prevalence of the disease.[18]

MySDSA sensitivity was 62.5%, indicating that the proportion of probability for MySDSA to detect a subject who was unfit to drive is 62.5%. MySDSA specificity was 75%, indicating that the proportion of probability for MySDSA to detect a subject who was fit to drive is 75%. The negative predictive value (NPV) and positive predictive value (PPV) for MySDSA were 96.4% and 15.6%, respectively. The area under the ROC curve (AUC) is 0.688 (p = 0.095) (Figure 2).

Discussion

The best determinant of fitness to drive are Road Sign Recognition, Square Matrices Compass, and Trail Making Test Part B with 84%, 85%, and 80% accuracy, respectively.[15] In stroke survivors, only visual-cognitive skills have typically been identified as predictors of fitness-to-drive of stroke survivors because of the typical pattern of motor impairment involving only one side of the body.[15] Thus, it is possible for them to drive with some modification to accommodate their weaknesses. One test battery that was previously developed for this purpose is the SDSA.[7,8]

In the present study, we adapted the UK version of SDSA to make our Malaysian version (MySDSA). MySDSA showed a superior result in its specificity compared to its sensitivity

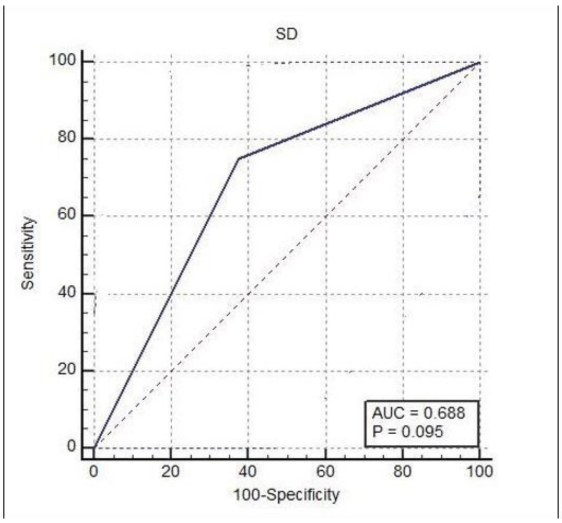

Figure 2. Receiver operating characteristic curve
AUC = Area under the curve

(75% versus 62.5%). It also has NPV of 96.4%, which signifies the probability of a subject being truly fit to drive if he passes MySDSA assessment. However, although sensitivity and specificity measure the intrinsic accuracy and do not depend on the prevalence rate, they do not provide information on the diagnostic accuracy of a particular patient.[18] To obtain this information, we used positive predictive value (PPV) and negative predictive value (NPV), which depend on the disease prevalence.[19,20] The disease prevalence was 6.9%, which was derived by measuring the proportion of stroke survivors who was deemed unfit to drive from driving assessments conducted in UMMC and the total stroke cases referred for driving assessment.

The overall accuracy of MySDSA in predicting the driving performance of stroke patients referred for driving assessment is 74%, comparable to previous studies involving SDSA adaptation.[11-13] The area under the ROC curve (AUC) is 0.688 (0.7) with *p*-value of 0.095, which is not statistically significant at a five percent type I error. Again, this can be due to the small sample size of this current study. However, it is statistically significant when we set the alpha level (α) at 10%, which means the result is generalisable with 90% confidence. In general, an AUC of 0.5 suggests no discrimination, 0.7 to 0.8 is considered acceptable, 0.8 to 0.9 is considered excellent, and more than 0.9 is considered outstanding.[21,22] In this study, the AUC value is acceptable with the above medium effect size (d = 0.661).

Another study using a driving simulator as a reference test was Akinwuntan et al.[13] They tested the US version of the SDSA battery and reported a high accuracy rate (87%) in predicting the driving performance of stroke patients. The Nordic version of SDSA (NorSDSA) was tested with on-road driving performance. The result was similar to MySDSA, with specificity being superior to sensitivity. However, it has a lower discriminant analysis which can only correctly classify 62% of the stroke patients to pass.[12]

The parameters found in this study indicate that MySDSA tends to identify safe rather than unsafe post-stroke drivers with a specificity of 75% vs. a sensitivity of 62.5%. This finding implies that MySDSA is not suitable as a stand-alone test to substitute driving simulator assessment as it may risk inaccurate approval for fitness to drive, especially for those with a MySDSA sum score closer to zero. Our advice is for clinicians to use it with other cognitive tests, for example, Trail Making Test Part A and the Snellgrove Maze Task if the clinician does not have access to a computerised driving simulator. This combination was shown to be a good predictive model for on-road test failure after a stroke.[23]

Overall, MySDSA is a valid screening tool that has the potential to be used widely in Malaysia. Similarly, as SDSA, it can be used by any clinician and does not need extensive training.[24] The two major drawbacks of this study are the small sample size due to the high dropout rate and the long interval between MySDSA and the driving simulator test, which can affect accuracy since neurological recovery may occur over such a prolonged duration. During the COVID-19 pandemic, this study was halted for three months due to the local government movement control order, explaining the long interval between MySDSA and the driving simulator assessment. Moreover, the centre involved in this study was designated as one of the COVID-19 hospitals during the pandemic, rendering further recruitment impossible within the set time frame.

Another limitation is using a local computerised driving simulator as a reference standard compared to on-road assessment. Despite the lower face validity than on-road assessment, it enables repeatable assessment in various controlled driving environments. It has established relative validity.[25,26] The simulator in this study is the best contextual driving assessment available in the country and has been acknowledged by the National Road Transport Department. It uses a virtual reality concept that simulates the local traffic and weather. The demerit marking system is also similar to the system used for on-road driving test in Malaysia.

Conclusions

This study showed that MySDSA has an acceptable accuracy for predicting driving performance on the driving simulator test. In clinical practice, MySDSA can serve as a screening assessment prior to sending the stroke patients to the driving simulator test. Due to the slightly higher sensitivity, MySDSA should not be used as a stand-alone battery in the decision making on fitness to drive without a driving simulator. The decision should be made collectively from results of multiple established cognitive tests, experience of the driver and judgment of the clinicians. Larger studies are needed to further establish the criterion validity of MySDSA in predicting driving performance.

Disclosure

The authors declare no conflict of interest of any kind.

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