Effect of Simulator Training on Driving After Stroke: A Randomized Controlled Trial

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Abstract

Objective: There is no convincing evidence to show that neurologically impaired persons seem to benefit from driving training programs. This study investigated the effect of simulator-based training on driving after stroke.
Methods: 83 first ever sub-acute stroke patients entered a 5-week 15-hour training program in which they were randomly allocated to either an experimental (simulator-based training) or control (driving-related cognitive tasks) group. Performance in off-road evaluations and an on-road test were used to assess the driving ability of subjects pre- and posttraining. Outcome of an official predriving assessment administered 6 to 9 months post stroke were also considered (follow-up).
Results: Both groups significantly improved in many off-road evaluations and in the on-road test after training. There were no significant differences between both groups in improvements from pre- to posttraining except in the ‘road sign recognition test’ in favor of the experimental subjects. Significant improvements in a three-class decision (‘fit to drive’, ‘temporarily unfit to drive’ and ‘unfit to drive’) were also found in favor of the experimental group post training. Academic qualification and overall disability together determined subjects that benefited most from the simulator-based driving training. At follow-up, significantly more experimental subjects (73%) than controls (42%) passed an official predriving assessment and could legally resume driving.
Conclusion: Simulator-based driving training was better especially for well educated and less disabled stroke patients. However, the findings of the study may have been modified as a result of the large number of dropouts and the possibility of some neurological recovery unrelated to training.

INTRODUCTION

Driving performance is impaired by motor, visual, cognitive and perceptual deficits that are commonly experienced after stroke.[1,2] Though some studies evaluated the effect of driving training after brain injury,[3,4] there is no convincing evidence on the efficacy of this practice. This study therefore sought to establish the effect of driving training after stroke by investigating the immediate and long term effect of a simulator-based program on the on-road performance and overall driving fitness in stroke patients.

DESIGN

A randomized controlled trial that included 83 first ever stroke patients on admission in a rehabilitation hospital, not older than 75 years and were legally driving prior to stroke onset. All subjects were neurologically assessed before training and randomly allocated to either an experimental or a control group. Subjects in the experimental group received driving training in a full bodied car simulator powered on a STISIM Drive System, Version 1.03. The high fidelity system contained a 'Scenario Definition Language' with which several short and interactive driving scenarios used for training different driving skills were developed. A 13.5-km scenario that took about 25 minutes to drive through and used specifically for driving assessments in the simulator was also developed. The 13.5-km driving scenario started on a two-lane road with urban-like traffic and progressed to a four-lane highway with 120 km/h speed restriction and possibilities to overtake other cars before terminating on a two-lane road in a rural setting. Life-size computer generated images were projected on to a screen (approximately 2.30m by 1.70m) with a visual angle of 45°. Adaptive aids such as left-sided accelerator pedal, right-sided indicator stick and steering spinner were coupled to the simulator when required.

Controls received standardized driving-related training by performing cognitive tasks such as route finding on a paper or road map, memory training with numbers and forming different patterns using tiles. Recognition of road and traffic signs was also trained using 40 cards with pictures of different traffic situations.

In addition to regular hospital rehabilitation programs, each subject, irrespective of group membership, received a total of 15 hours training spread over 5 weeks at one hour a day, 3 times a week. All subjects were between 6 - 9 weeks post stroke at inclusion in the trial and were evaluated for their fitness to drive in real life before training (pretraining assessment) and immediately after training (posttraining assessment) during which subjects were between 11 - 14 weeks post stroke. Subjects' performances in a mandatory and official predriving assessment six months after stroke, which they were all encouraged to perform, were obtained (follow-up assessment). Following each assessment of driving fitness, subjects were judged either as 'fit to drive', 'temporarily unfit to drive' or 'unfit to drive'. In reality only those judged 'fit to drive' based on performance in the official (follow-up) assessment are legally allowed to resume driving.

Consequently, ‘fit to drive’ was further classified as ‘pass’ and the other two classes of judgments as ‘fail’.

RESULTS

From pre- to posttraining

There were no significant differences between the experimental and control groups for all variables of the pretraining neurological evaluations and the pretraining predriving assessment, which included visual and neuropsychological evaluations and an on-road test. There were significant improvements within both groups in one visual test (kinetic vision) and many variables of the neuropsychological evaluations from pre- to posttraining. Only performance in a neuropsychological test (road sign recognition) was significantly different between the experimental and control groups after training in favour of the former. Performances in the on-road test, which is a primary outcome measure, also significantly improved from pre- to posttraining in both groups. However, the difference between groups after completion of training was not significant due to the large variability in the subject population. Between groups differences in the three-class decision on fitness to drive, which was the other primary outcome measure, was clearly not significant ($p = 1.00$) at pretraining. However, the difference between the groups tended towards significance at posttraining ($p = 0.09$). When the ‘changes in decision’ such as from ‘unfit to drive’ to ‘fit to drive’ due to improvement from pre- to posttraining were analyzed (table 1), there was significant difference between the groups ($p = 0.05$) in favor of the experimental group.

Table 1: Frequencies of the changes in the fitness to drive decision at pre- and posttraining for the 73 subjects that completed training

Levels of improvement	Experimental (N = 37)	Control (N = 36)
Two levels (*‘unfit to drive’ to ‘fit to drive’*)	10	2
One level (*‘unfit to drive’ to ‘temporarily unfit to drive’ or ‘temporarily unfit to drive’ to ‘fit to* drive’)	10	12
Zero level (*no change in fitness to drive decision*)	17	22
	Chi-square = 6.14, p = 0.05	

At follow-up

Results showed that the differences between the experimental and control groups in the official on-road test ($p = 0.08$) and the three-class decision ($p = 0.10$) at follow-up were not significant. However, a comparison of the pass/fail ratio between both groups as seen in table 2 revealed a significant difference ($p = 0.03$). Nineteen (73%) of the 26 experimental subjects that performed the follow-up assessments passed and legally could resume driving as compared to only 11 (42%) of the 26 control subjects.

Table 2: Frequencies and comparison of pass and fail classifications derived from the three-class decisions of fitness to drive at follow-up between experimental and control groups

	Experimental (N = 26)	Control (N = 26)	**Test-statistic**	**p - value**
Pass (*fit to drive*)	19 (*19*)	11 (*11*)	X = 5.04	0.03
Fail (*temporarily unfit to drive + unfit to drive*)	7 (*4* + *3*)	15 (*9* + *6*)		

X = Chi-square test

Benefit from the interventions

Outcome of univariate logistic regression analyses to identify subgroups of subjects in both groups that benefited more from the training programs, revealed academic qualification ($p = 0.026$), side of lesion ($p = 0.048$) and the Barthel Index ($p = 0.043$) scores as individual predictors of marked improvement in the experimental group. Multivariate logistic regression analyses produced a combination of academic qualification and Barthel Index score as the best predictive model of improvement in the experimental group. Barthel Index, with a possible score range of 0 to 100, is a measure of the ability to perform major activities of daily living. A higher score indicates better functional ability. Data exploration showed that 8 out of the 10 experimental subjects that improved from 'unfit to drive' decision at pretraining to 'fit to drive' at posttraining (two-level improvement) had both high academic qualification (tertiary education) and high Barthel Index scores (≥75). No neurological evaluation or predriving assessment variable was retained as a significant predictor of improvements in the control group.

DISCUSSION

In agreement with findings in other studies,[3, 4] subjects in both the experimental and control groups improved in many variables of the predriving assessment from pre- to posttraining. In this study, only improvements in the road sign recognition test showed significant difference in favor of the experimental group when both groups were compared. This is in spite of the fact that skills required to perform the road sign recognition task were specifically trained in both groups. This finding reinforces a motor learning principle, which states that "there is greater amount of positive transfer of learning when a skill is trained in a similar context in which it is performed". Training of the task in the simulator involved responding to traffic signals and signs in a context similar to real life driving while controls were trained the same task by matching traffic signal and signs cards to different traffic situations also depicted on cards.

The other predriving assessment variables were not significantly different between groups probably because the training programs received by subjects in both groups were driving related. A control group that received non-driving related (placebo) training would have been ideal but the study was so designed in order to ensure that both groups were equally motivated since subjects were on admission at the same tine in the same rehabilitation hospital. It is also difficult to attribute all observed improvements solely to the effect of training since subjects were all included in the trial during a period that is associated with the possibility of spontaneous recovery after stroke. The dropout rate during the study was rather high, which could mean that some patients were recruited too early post stroke and may have underestimated the difficulty in driving again. It is recommended that patients with severe post-stroke deficits should be allowed more time to physically recover before being included in such training programs. However, the fact that the improvement levels immediately after training were retained through to the follow-up period demonstrates the long term effect of training. This important finding suggests the usefulness of implementing a driving training program in the active rehabilitation phase after stroke. A preference for simulator based driving training is justified by the finding of this study.

CONCLUSION

Simulator-based driving training showed to be a better driving training method especially for well educated and less disabled stroke patients. The findings of the study may have been modified as a result of the large number of dropouts and the possibility of some neurological recovery unrelated to training.

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