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The effects of below-elbow immobilization on driving performance☆

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ABSTRACT

Introduction: There is limited research to guide physicians and patients in deciding whether it is safe to drive while wearing various forms of upper extremity immobilization. The purpose of this study is to evaluate the effect of below-elbow removable splints and fiberglass casts on automobile driving performance.

Methods: 20 healthy subjects completed 10 runs through a closed, cone-marked driving course while wearing a randomized sequence of four different types of immobilization on each extremity (short arm thumb spica fiberglass cast, short arm fiberglass cast, short arm thumb spica splint, and short arm wrist splint). The first and last driving runs were without immobilization and served as controls. Performance was measured based on evaluation by a certified driving instructor (pass/fail scoring), cones hit, run time, and subject-perceived driving difficulty (1–10 analogue scoring).

Results: The greatest number of instructor-scored failures occurred while immobilized in right arm spica casts ($n = 6$; $p = 0.02$) and left arm spica casts ($n = 5$; $p = 0.049$). The right arm spica cast had the highest subject-perceived difficulty (5.2 ± 1.9; $p < 0.001$). All forms of immobilization had significantly increased perceived difficulty compared to control, except for the left short arm splint (2.5 ± 1.6; $p > 0.05$). There was no significant difference in number of cones hit or driving time between control runs and runs with any type of immobilization.

Conclusions: Drivers should use caution when wearing any of the forms of upper extremity immobilization tested in this study. All forms of immobilization, with exception of the left short arm splint significantly increased perceived driving difficulty. However, only the fiberglass spica casts (both left and right arm), significantly increased drive run failures due to loss of vehicle control. We recommend against driving when wearing a below-elbow fiberglass spica cast on either extremity.

Introduction

Providing recommendations to patients about driving while being treated in an upper extremity immobilization device is a frequent dilemma for physicians that potentially has both safety and legal implications [1,2]. To date there have only been a handful of studies that have evaluated the effect of upper extremity immobilization on driving performance [3–5]. Results of these studies have indicated that driving performance may be impaired by a variety of rigid (i.e. fiberglass or plaster) immobilization devices, including: below-elbow, above-elbow, and devices that incorporate the thumb [6–8]. One recent review concluded that "immobilization of either arm in a splint or sling significantly impairs driving ability" [9]. However, no study to date has evaluated the effect of less rigid, prefabricated splints that are commonly used to immobilize the wrist.

The purpose of this study was to evaluate the driving performance of healthy subjects with upper extremity below-elbow immobilization, and to elucidate a difference between prefabricated splints and fiberglass casts, both with and without a thumb spica component. We hypothesized that the thumb spica component for both the prefabricated splints and below-elbow casts would afford a negative effect on driving performance. This information will provide further insight into developing safe return-to-drive criteria, which physicians may use to counsel their patients with upper extremity conditions requiring immobilization.

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Materials and methods

After approval by our institutional investigational review board, participants were recruited from among hospital personnel at our institution as well as the local community. Inclusion criteria included an age of eighteen years of age or older, possession of a current driver's license, vehicle insurance, and full range of motion of both upper extremities. Exclusion criteria included any recent injury or surgery to either upper extremity which may contribute to driving impairment, current extremity immobilization, or any medical condition that may lead to driving impairment (i.e. vision deficit). All participants gave written informed consent prior to participation in the study.

Testing was conducted on a closed driving course designed by professional driving instructors. The course consisted of traffic cone obstacles and barriers and was designed to simulate an urban driving experience. This required drivers to maneuver within a limited space, brake, reverse, park, and steer around turns and corners. Two identical four-door, sedan-style vehicles with a left-sided steering wheel were used. Each was equipped with automatic transmission and passenger-side brakes for instructor use in the event that the driver performed an unsafe maneuver. A certified driving instructor accompanied the driver in the passenger seat during each drive to evaluate performance as well as to ensure driver safety. Prior to testing, all participants were given a safety briefing by the instructors and familiarized with the course during a practice drive.

Participants served as their own controls by first driving the course without being immobilized in order to obtain a performance baseline. Each driver repeated the course with four types of below-elbow immobilization on each extremity (thumb spica fiberglass cast, short arm fiberglass cast, thumb spica splint, and short arm wrist splint) (Figs. 1–4). Drivers were randomized to the laterality and order of immobilization using a random number generator. We anticipated some degree of performance improvement with subsequent drives due to increasing familiarity with the course. Therefore, we had each subject perform a final drive without immobilization to establish an "experienced driver" control. Testing was completed for each subject in a single day. Three testing sessions were held on separate days with no significant variations in weather conditions to impact driving performance.

As previously mentioned, a certified instructor accompanied the subject during each drive through the course. Besides focusing on safety, they also evaluated the driver's ability to maintain control of the vehicle. If the instructor felt the driver lost control or deviated significantly from the intended course at any time, they were given an automatic failing score for that particular drive. Conversely, passing scores were given for a controlled drive within the parameters of the course. The instructor did not provide feedback on performance during testing. Total driving time for the course, as well as number of cones struck by the vehicle during each drive, was recorded by an independent evaluator outside the vehicle. At the completion of each drive, subjects filled out an evaluation form that included a visual analogue scale of perceived driving difficulty, as well as a section for optional comments regarding how the cast/splint affected their driving. During the data analysis process, all comments were placed into one of four categories: difficulty gripping the steering wheel, difficulty maneuvering the steering wheel, alteration in normal driving technique, and difficulty using the gearshift.

Statistical analysis

A pre-hoc power analysis was performed to detect a 4 s difference in driving time. Using this difference and an anticipated standard deviation of 4 s, analysis required the use of 17 subjects to have a power of 0.807 with an alpha of 0.05.

Fig. 1. Short arm thumb spica fiberglass cast.

Baseline driving performance variables (course time, number of cones hit, and subjective evaluations) were compared with the same performance variables from each immobilization drive as well as the final non-immobilized drive using an analysis of variance (ANOVA), followed by post hoc independent sample *t*-tests. Bonferroni correction for multiple comparisons was applied for the course time comparison. Cochran Q test and Fisher's exact tests were also used for comparison of pass/fail performance. Each immobilization drive was also compared to the final drive performance in the same manner.

Results

Patient demographics

Twenty subjects were enrolled (10 male and 10 female). Mean age was 33.4 years (range 18–67 years). Eighteen subjects were