Accessibility of U-Haul rental vehicles

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This study evaluated the capability and limitations of wheelchair users with transfer abilities to safely ingress and egress into and out of vans and trucks as well as operate commonly available hand controls in rental vehicles. Participants included 28 manual wheelchair users who underwent a standardized physical abilities and transfer assessment. The physical assessment of these movement behaviors was evaluated during ingress/egress/operations procedures for five rental vehicles. After these evaluations were completed, participants were asked to rate their experiences. Baseline ingress/egress evaluations were also carried out for the participant's personal vehicles. Wheelchair users in this study exhibited above-average physical abilities as compared to previously reported values for individuals that use wheelchairs. Despite a clear willingness to attempt transfers for ingress/egress of the trucks and vans, only 1.5% of the participants were able to conduct such transfers safely and successfully for all observations. For those instances in which participants were able to transfer into a vehicle, the adequacy of the hand controls was examined and deemed adequate and safe for normal driving activities. Based on the limited access to these large vehicles, a need exists for additional work in the design and redesign of such vehicles to provide more accessibility for wheelchair users.

Keywords: accessibility; driver behavior; vehicle design; wheelchair; transfer

Introduction

The Americans with Disabilities Act (ADA) dictates that owners and operators of places of "public accommodation" must remove barriers to the accessibility of their goods and services for individuals with a disability (e.g., provide hand controls in rental vehicles), if removal is "readily achievable" (i.e., easily accomplishable and can be carried out without much difficulty or expense). In order to help remove these barriers, many vehicles have implemented modifications

such as hand controls, wheelchair access and securement, and steering control devices to help individuals with disabilities (NHTSA, 2004). However, several factors must be considered when assessing the safety of a vehicle for use by individuals with disabilities: provisions enabling the individual to operate the vehicle systems, adequacy of occupant protection systems, body positioning and access to controls, and provision of safe ingress into and egress out of vehicles (e.g., Di Stefano & Stuckley, 2015; Koppa, 1990). While the extant data regarding driving with hand controls indicate that such adaptive measures are generally adequate for safe operation of vehicles, a comprehensive evaluation of the safety of an adapted vehicle must also include consideration of other factors such as vehicle ingress and egress, wheelchair transfers, and the particular physical characteristics of the individual. Also, in-depth accident analyses of driver, vehicle, and environmental factors involved in traffic incidents have found that driver error (e.g., vehicle handling, inattention, pedal error, shifting error) is a primary contributor to vehicular accidents (Treat, 1980; Young et al. 2011; Lococo et al. 2012; NHTSA, 2018); database analyses have shown that adapted vehicles are also associated with similar types of driver errors (Benoit et al., 2009). Yet, there are voids in the literature with respect to how well individuals with disabilities use this adaptive equipment and how effective these accommodations are at mitigating barriers while allowing disabled individuals to safely access and operate such vehicles. Therefore, the goal of this study was to report on the ability of wheelchair-dependent individuals to safely ingress, operate, and egress rental vehicles, including vehicles that have been modified with hand controls.

Methods

Participants: Twenty-eight participants were recruited through a local recruiting agency and pre-screened to meet the following inclusion criteria, established a priori: aged 18 to 65, dependent on a manual wheelchair for mobility, able to independently transfer, have a valid driver's license, and at least one year of experience operating vehicles with adaptive hand controls.

Procedures: Participants answered demographics and driving-experience questions, and had their physical abilities (e.g., strength, flexibility, and pain; Sprigle et al. 1995; Greve et al. 2015) and transfer abilities assessed by a licensed Doctor of Physical Therapy. Additionally, participants examined several rental vehicles to evaluate their potential to safely transfer into and out of the driver's seat and operate the test vehicles. Participants then reported perceived injury risk associated with independently transferring, likelihood of attempting to do so, and likelihood of renting the vehicles for independent use. The researchers also evaluated the participants' abilities to independently and safely conduct such transfers into and out of their personal vehicles (baseline) and rental vehicles, as well as operate the rental vehicle with adaptive hand controls. The participants were observed controlling the vehicle in the following ways: (1) releasing and engaging the parking brake before and after the driving task, by leaning down and pressing on the brake with their hands; (2) using the hand control to accelerate and decelerate while pulling forward and/or backing in and/or out of the garage, stopping at a stop sign, driving at a slow speed over gravel terrain, driving 30-40 mph around the test track, and stopping at a traffic light; and (3) steering through turns, curves, and straight-aways. Transfer capability was assessed using the Transfer Assessment Instrument (TAI) as described by McClure et al. 2011, the only validated and reliable outcome measure of transfer quality (McClure et al. 2011). The vast

majority of participants (25 of 26) attempted to transfer into and out of the rental vehicles. A "safe transfer" was defined as the participant's ability to ingress and egress without assistance and abnormal risk. Finally, for those who operated the vehicles, participants rated their driving experience.

Test Vehicles: Several types of large vehicles were utilized to reflect the range of vehicles commonly available for rent at vehicle rental companies. Specifically, the vehicles selected were models that were commonly rented through a nationwide American moving equipment rental company (U-Haul), and included a GMC pick-up truck, a GMC van, Ford van, Ford truck, and a Ford F-650. Ingress and egress dimensions and characteristics varied among the vehicles. Vehicle characteristics related to the distance wheelchair users would have to move to transfer into the vehicle included whether there is a running board or step at the driver's side door, presence and location of handles, seat height from the ground, the horizontal distance from the outermost point of entry to the seat edge, door opening width, horizontal space from the seat front to the dashboard, and vertical space from the seat to the steering wheel; see Table 1. The hand controls utilized, MPS Monarch Mark 1A and Wells Enberg Push/Right Angle, were mechanical lever systems that engaged the pedals to control vehicle speed and were located to the left of the steering wheel. Prior to the onset of the study, approval was provided by Exponent's Institutional Review Board.

Results

Based on the clinical assessment, and comparison with extant data regarding typical physical characteristics and capabilities, the participants demonstrated better musculoskeletal health relative to typical wheelchair dependent individuals, as shown in Table 2. The TAI scores for the

vast majority of participants indicated the participant population examined was largely able to safely conduct independent transfers (including their wheelchairs) into and out of personal vehicles, as demonstrated by a mean TAI score of 9.6±0.8, more than 1.5 standard deviations above the mean for the average wheelchair user (McClure et al. 2011). Findings related to transfer ratings for ingress/egress for rental vehicles are provided in Table 3, including the percentage of participants who indicated they were more likely than not to: (1) experience pain/harm when transferring, (2) attempt to transfer, (3) rent the vehicle, and (4) drive the vehicle. Comments by the participants indicated some of the factors that they considered in evaluating their capability to safely enter the vehicles, including: the height of the seat, the horizontal distance of the seat edge from the door edge, the presence of a running board, door opening width, how close they can get their chair to the seat, available features to grasp onto, and their capability to bring their wheelchair into the vehicle. Despite the above-average strength and physical capabilities of the participants, they rated all of the vehicles as more likely than not to cause pain or harm when transferring in or out of the vehicle, with the exception of the GMC Pick-Up, which had the lowest seat height and one of the lowest horizontal distances to the seat of all the test vehicles. Although 62% of the examined wheelchair users indicated that they might attempt to transfer into and rent (42%) the smallest available vehicle (the GMC Pick-up), the majority reported that they would not be likely rent any of the other vehicles independently. With the exception of the GMC Pick-Up, less than 40% of the participants stated they were likely to attempt transfer to the GMC Van, Ford Van, Ford Truck, or Ford F-650. During the assessment of ingress/egress for rental vehicles, the authors observed only two safe transfers out of 130 to the U-Haul trucks (specifically, the GMC Pick-Up), resulting in a success rate of 1.5%. Considering the inability of most of the study participants to safely transfer into and out of the

smallest vehicle tested, despite their above-average physical characteristics, it would likely be unsafe for an average wheelchair-dependent individual to transfer into and out of the examined vehicles. However, none of the participants rate the GMC Pick-Up as difficult or uncomfortable to drive. Similarly, the participants unanimously indicated the controls were not difficult to learn to use, felt that the vehicle behaved as expected, and the controls allowed them to maintain control of the vehicle. Therefore, based upon our observations of wheelchair-dependent drivers operating the GMC Pick-Up with the adaptive hand controls, as well as the ratings supplied by the drivers, the provided hand controls in the GMC Pick-Up were adequate and safe for normal driving activities by wheelchair-dependent users experienced in driving with hand controls.

Discussion

All participants could safely transfer independently into and out of their personal vehicles. However, only *two* of the examined wheelchair-dependent individuals could safely transfer independently into the GMC Pick-Up. Further, *none* of the examined wheelchair-dependent individuals could safely transfer independently into the GMC Van, Ford Van, Ford Truck, or Ford E-650, most likely due to the physical characteristics of the vehicles. Specifically, the inclusion of a running board provided an additional physical 'barrier' between the wheelchair used and the vehicle body, which therefore increased the distance the participant needed to negotiate during transfer. The presence of a running board may also introduce further reaching, and more complex grappling, providing for additional difficulty in the transfer. In addition, the presence and location of handles and the height differential between the ground and driver's seat also adversely effected the wheelchair users' ability to transfer efficiently and safely. Importantly, the study population is characterized by above-average upper body physical

capability. For the average wheelchair-dependent individual, who would likely possess reduced upper body strength and flexibility, the risk of a fall and/or injury would likely be greater. Although nearly 93% of wheelchair users were willing to attempt to transfer into a test vehicle independently, this intent is not indicative of a safe or successful completion of this complex behavioral sequence. Finally, the hand controls in the GMC Pick-Up were adequate and safe for the normal driving activities participants who could transfer into the vehicle and have substantial experience with such controls. Findings from this study indicate the need for additional work in the design and redesign of such large-sized vehicles to provide more accessibility for wheelchair users should they need to safely ingress/egress before they can operate such a vehicle using the modified hand controls.

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Declaration of Interest

The authors have declared that no competing interests exist.

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Table 1. Test vehicle characteristics related to transfer.

	Running board/Step	Location of handles on driver's side	Floor/running board/step height from ground (in)[+]	Seat height from ground (in)	Horizontal distance, seat edge from vehicle exterior (in)[++]	Door opening width (in) [+++]	Horizontal space between dashboard and seat front (in)	Vertical space from seat steering wheel (in)
GMC Pick-up	Absent	Roof	22	37	7	29	10	10
GMC Van	Present	None	14	42.5	12.5	26	14	9.5
Ford Van	Present	None	14.75	43.5	13.25	26	14	10
Ford Truck	Absent	A-Pillar	20.5	41.5	6	27	10	8
Ford F-650	Present	A-Pillar, B-Pillar, exterior	13.5	54	21.25	27	12	6

[+] to first step/running board surface if present, otherwise to cab floor
[++] to farthest step/running board edge if present, otherwise to door edge
[+++] dashboard to seat back or rear door edge, whichever is closest

Table 2. Average (and standard deviations) shoulder, elbow, and wrist strength along with overall push force measurements (in kilogram-force).

	Strength Measurements (kgf)							
	Shoulder Abduction	**Shoulder Flexion**	**Shoulder Extension**	**Elbow Flexion**	**Elbow Extension**	**Wrist Flexion**	**Wrist Extension**	**Push Force**
Mean ± SD	16.8±5.4	16.9±5.4	15.1±4.2	17.4±5.2	14.7±5.4	10.5±3.8	9.2±3.7	19.0±3.9

Table 3. Summary of participant transfer ratings for rental vehicles. Mean ratings greater than 3 indicate that the participant evaluated the likelihood as more likely than not. An asterisk (*) indicates that the observed ratings are statistically significant ($p<0.05$), according to the chi-square statistic.

	Likelihood of Pain/Harm		**Likelihood of Transferring**		**Likelihood of Renting**		**Likelihood of Driving**	
	% of Ratings >3	**Mean ± SD**	**% of Ratings >3**	**Mean ± SD**	**% of Ratings >3**	**Mean ± SD**	**% of Ratings >3**	**Mean ± SD**
GMC Pick-Up	35%	2.8±1.4	62%*	3.6±1.7	42%*	2.8±1.8	50%*	3.2±1.9
GMC Van	58%	3.5±1.4	31%*	2.4±1.7	19%*	2.1±1.6	38%*	2.6±1.94
Ford Van	54%	3.6±1.2	35%*	2.4±1.7	19%*	1.9±1.5	31%*	2.3±1.8
Ford Truck	54%	3.5±1.4	38%*	2.8±1.8	27%*	2.1±1.6	31%*	2.4±1.8
Ford F-650	73%*	4.1±1.4	15%*	1.8±1.3	4%*	1.5±0.9	19%*	2.0±1.6