A DYNAMIC TEST METHOD FOR SIMULATING SCOOTER-SEATED PASSENGER INJURY SCENARIOS ON TRANSIT BUSES

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ABSTRACT

The purpose of this project was to design a simple test method that is able to simulate low-level accelerations that occur in large accessible transit vehicles (LATV) to better understand scooter and occupant kinematics and injury scenarios during low acceleration conditions.

A rotating test platform was designed to accommodate an unsecured scooter occupied by a modified midsize male Hybrid II Anthropomorphic Test Device (ATD). Two wheelchair motors and a wheelchair controller were used to respectively drive and control the rotational speed of the test platform. A tri-axial accelerometer was mounted onto the platform at the scooter center of gravity and used to record accelerations during testing.

When exposed to conditions simulating deceleration, acceleration and lateral deceleration of an LATV equal to or less than 0.4g, an occupied scooter slid forward, tipped rearward, and tipped sideways, respectively. During exposure to a vehicle deceleration of approximately 0.6g, an unrestrained ATD fell from a fixed scooter and onto the floor. These preliminary results demonstrate that this test method can produce low accelerations and replicate occupied scooter kinematics (sliding and tipping) observed during low acceleration in-vehicle testing.

INTRODUCTION

Since the introduction of ADA in 1990, there has been an increase in the number of people with disabilities who use their wheeled mobility devices as seats in public transit vehicles [1]. The Department of Transportation (DOT) ADA regulations require that transit providers accommodate passengers who use "common wheelchairs" when traveling in a motor vehicle [2]. This requires the installation of 4-point strap type tiedown systems to secure the wheelchair and vehicle-mounted pelvic and shoulder belt restraints to provide occupant protection to wheelchair users traveling in LATVs. Various studies have indicated that wheelchair-seated passengers rarely use these wheelchair tiedown and occupant restraint systems (WTORS) due mostly to the fact that they are uncomfortable and operator-dependent [3-6].

A recent study indicated that forces resulting from sudden vehicle braking (0.8g), sharp turning (0.75g) and accelerating (0.3g) on an LATV remain below 1*g* [7]. However, insufficient research has been done to pinpoint at which levels of acceleration a wheeled mobility device starts tipping or sliding, and when an ATD looses contact with the seat. This study developed a test method that can evaluate the kinematics of an occupied wheeled mobility device under low acceleration conditions.

STUDY OBJECTIVE

The objective of this study was to build and evaluate a test device to simulate forces commonly experienced by passengers seated in wheeled mobility devices in LATVs during vehicle braking, accelerating and turning maneuvers.

METHODS

A literature review was initially conducted to find a suitable dynamic test method that could produce low accelerations and could be performed in a laboratory. Many of the existing methods are difficult to replicate in a small laboratory. After consultation with Q'Straint (Ft Lauderdale, FL) it was determined that using rotation to create low-level accelerations was a feasible laboratory method. An 8-ft radius spinning platform was constructed to create a centrifugal force that simulates vehicle deceleration (braking) when a scooter is placed facing away from the center of rotation, lateral deceleration (turning) when a scooter is placed tangentially, and acceleration when a scooter is placed facing the center of rotation (Fig. 1). The test device was built using a 6in x 6in x16ft support beam, a rotary table, a 4ft x 8ft test platform, two 1HP drive motors, a speed controller (Pride Mobility) and a tether post mounted at the center of rotation. The test platform was covered with a commercial grade ribbed vinyl and rubber floor surface (Koroseal, RJF Int. Corp., Fairlawn, OH).

An Amigo tri-wheeled scooter and a 50th percentile male Hybrid II ATD representing an average male occupant were placed onto the test platform. The abdominal sac of the ATD was removed for this test to better represent the hip-to-torso flexibility of a scooter-seated occupant in a non-impact condition. The ATD was placed onto the scooter seat with the hands placed on the scooter tiller. The tether strap, attaching the scooter to the test platform, allowed the scooter to slide or tip, but prevented it from excessive movement resulting in falling off the platform during the test.

To record accelerations during testing one tri-axial accelerometer was mounted on the test platform below the combined scooter and ATD center of gravity. The accelerometer was wired to a laptop also secured to the platform. The laptop was monitored wirelessly using remote desktop software. A video camera was positioned away from the test platform to record scooter and occupant kinematics throughout the test.

The following scenarios were tested:

1. Acceleration with scooter loosely tethered and ATD not tethered
2. Lateral acceleration with scooter and ATD loosely tethered
3. Deceleration with scooter and ATD loosely tethered
4. Deceleration with scooter tightly tethered and ATD not tethered

To bring the test platform with the occupied scooter up to speed, an investigator would activate the controller, increasing the speed by approximately 0.6 mph for each trial. A second investigator monitored the maximum acceleration level achieved for each controller setting and observed scooter and ATD movement. If during testing of scenario #1 through #3 excessive scooter movement was observed such as tipping or tightening of tether straps, the test was stopped. To conduct test #4 the platform speed was incrementally increased until the (non-tethered) ATD fell from the platform.

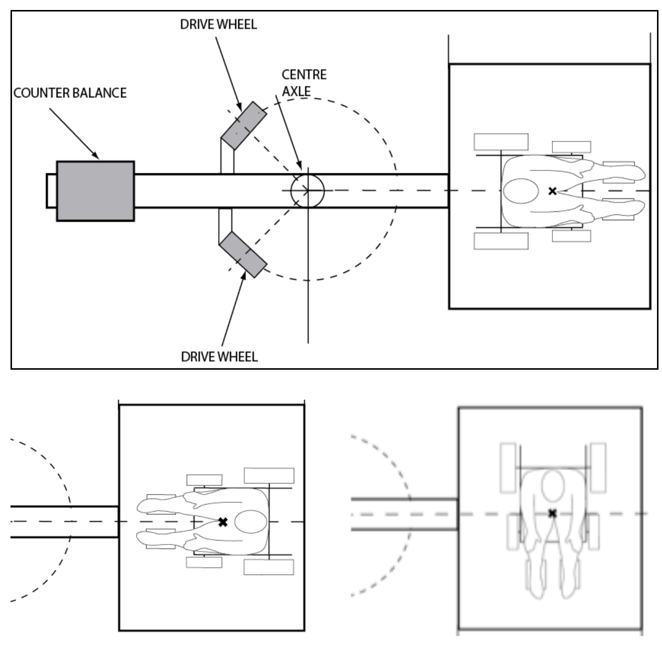

Figure 1: Test setup to simulate an occupied mobility device exposed to deceleration (top), acceleration (bottom left), and lateral deceleration (bottom right)

RESULTS

Acceleration data was collected at a sampling rate of 100Hz and exported to Microsoft Excel. Data was filtered using a moving average of 20 points (0.2-second window). Figure 2 depicts the acceleration-time plots for the trials in which scooter movement was observed for each test scenario. Scooter movement was observed at an approximate control speed setting of 2.5 mph for the first 3 test scenarios. The observed scooter and ATD movements in Figure 2 are associated with the acceleration curve, the lateral acceleration curve and the deceleration curve (scooter fixed) of Figure 3.

During the acceleration test (#1), the platform reached 0.25g at approximately 15 seconds, at this acceleration level, the scooter started tipping rearward after which the tether strap was taut. During the lateral acceleration (turning) test (#2), the scooter was exposed to 0.4g approximately 15 seconds into the test followed by the scooter tipping sideways and the ATD leaning sideways until the tether strap was taut on both scooter and ATD. During the deceleration (braking) test (#3), the scooter was exposed to 0.35g (after approximately 13 seconds) after which the scooter slid forward. During the deceleration test (#4) where the scooter was tightly tethered, the ATD started to lean forward at 23 seconds (0.38g) and was fully ejected from the scooter at about 28 seconds (0.55g).

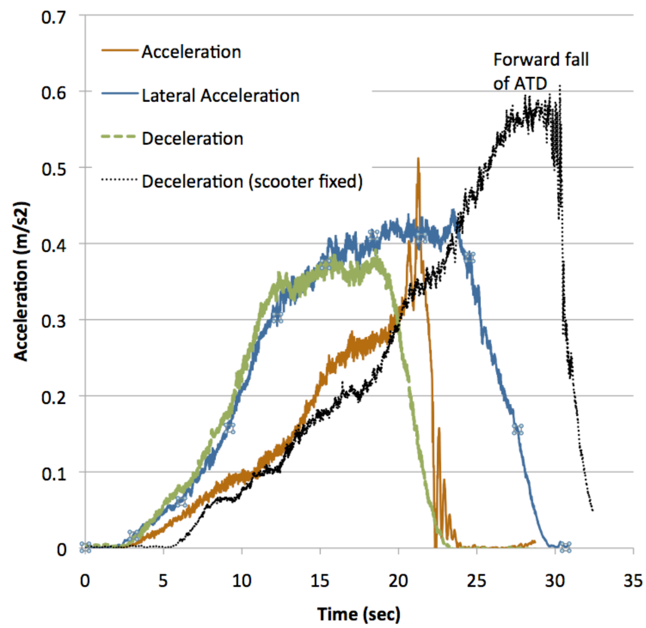

Figure 3: Accelerations measured during testing.

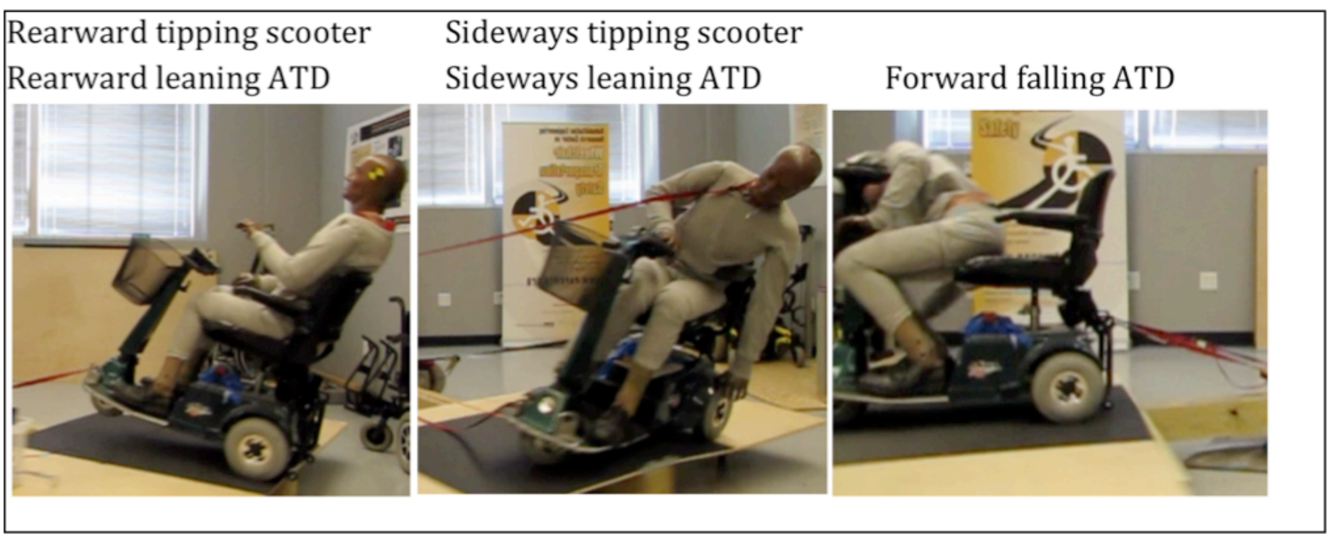

Figure 2: Occupied scooter kinematics observed during tests simulating vehicle acceleration (left), lateral acceleration (center) and deceleration with a fixed scooter (right).

DISCUSSION AND CONCLUSION

The test apparatus was capable of simulating low-level ccelerations associated with vehicle braking, accelerating and turning. Preliminary test data show that an occupied scooter may tip over sideways at a lateral acceleration of about 0.4g (vehicle turning) and may tip backwards at about 0.25g (vehicle acceleration). An occupied scooter may slide forward at a deceleration of 0.35g. And a scooter occupant seated on a secured scooter may be ejected from the scooter seat during a vehicle deceleration of 0.55g.

This test method proved feasible for studying the affects of long duration forces generated at low accelerations. The test setup can be enhanced with a means to better quantify wheeled mobility device movement during testing. This test method can be used to evaluate effectiveness of postural supports in preventing occupant falls from a wheeled mobility device, and vehicle mounted safety systems designed to contain wheeled mobility devices and retain their occupants while traveling in LATVs.

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