Driving with a Disability

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Outline

- Amy Lane:
  - Driver Assessment and Evaluation
  - Vehicle Setup
- Linda van Roosmalen:
  - Wheelchair Driver Safety
  - System Usability

Driving-what's the big deal?

- Driving is an Instrumental Activity of Daily Living- a cornerstone for independence in our society
- Rite of passage, symbol of autonomy and independence
- Almost all productive roles require us to be mobile individuals
- After an injury, illness or due to a medical condition, safe community mobility or driving skills can be impaired
- Lack of ability to safely move in the community can lead to isolation, depression*, loss of function

*Fonda SJ, Wallace RB, Herzog AR. Changes in driving patterns and worsening depressive symptoms among older adults. J Gerontol B Psych Sci soc Sci. 2001 Nov; 56(6): S343-51.

Driver Rehabilitation

Rehabilitation service that assists individuals in the attainment of skills for safe and independent driving and transportation

All rehabilitation practitioners should consider driving as an important aspect in the rehabilitation continuum of care

Driver Rehabilitation Specialist-the person responsible for planning, coordinating and possibly implementing the driving rehabilitation services

- Driver educators
- Occupational Therapists
- Other health care professionals

ADED- Association for Driver Rehabilitation Specialists

- CDRS- Certified Driving Rehab Specialist
- www.aded.net

Driver Rehabilitation Process

- **Interview and history**
- **Clinical assessment (pre-drivers)**
- **Behind the wheel evaluation (client, vehicle and equipment)**
- Training
- **Adaptive Equipment and Vehicle Modifications**
- Transport as passenger
- Vehicle modification/Final inspection

Interview and History

- Client goals
- Medical history
- Medications
- Driving history
- Licensure status
- Client vehicle

Medical Restrictions

- Department of Transportation criteria
- Seizure history
- Vision restrictions
  - Corrected vision (acuity)
  - Peripheral vision
- Brittle, unstable diabetes
- Periodic loss of consciousness or attention
- Drug or alcohol disorder

Clinical assessment (pre-drivers)

- Vision Screen
- Visual-Perceptual Assessment
- Cognition
- Communication and Behavior
- Motor and Mobility Skills
- Knowledge of Driving

Behind the wheel evaluation

- Best measure of a person's ability to drive
- Assess transfer skills/management of mobility device
- Determine ability to operate vehicle with or without adaptive equipment
- Assess driving performance (traffic safety, vehicle control, reaction time, attentiveness etc…)

Communication of Results

- No concerns, may resume driving
- May resume driving with recommendations or restrictions
- Additional training
- Other therapeutic interventions
- Re-evaluation
- State re-test
- Should not drive, provide counseling and alternative forms of transportation options

Adaptive Driving Equipment

It is the responsibility of the CDRS to evaluate all aspects of the client's functional ability, and desires in conjunction with the client's vehicle and equipment needs.

This requires a well designed cost effective plan based on client interviews and comprehensive assessments to ensure client satisfaction.

Adaptive Equipment-Primary Controls

Adaptive Equipment-Primary Controls

Adaptive Equipment-Secondary Controls

Adaptive Equipment-Secondary Controls

Special considerations- loading of mobility device

- Determine the client's ability to safely and independently:
- Transfer in/out vehicle
- Stow mobility aid
- Properly secure mobility device
- Apply and use seatbelts

- The fit between client, their mobility device, mobility lift and the vehicle storage area is critical in the evaluation process

Wheelchair Loading


Wheelchair Loading

Wheelchair Loading

Vehicle Options
ATRS-Freedom Sciences

Vehicle Options

Vehicle Options

Vehicle Options

Ford F150

Freedom Motors
Honda Element

Freedom Motors
Toyota Scion

Freedom Motors
PT-Cruiser

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Facts

- Total number of wheelchair users to reach 4.3 million by 2010 [LaPlante 2003]
- Lack of access to transportation is one of the most frequently cited problems for rural residents [RTC 1999]
- Transportation is the key to community participation for individuals with mobility limitations [Gray 2006]

Components of a Safe System

- Vehicle
  - Boarding/exiting
  - Driving
- Wheelchair and seating system
- Vehicle Safety System
  - Wheelchair securement system
  - Occupant restraint system
    - Shoulder belt (upper torso belt)
    - Pelvic belt (lap belt)
- Driving support systems

Boarding Accidents

Vehicle type	% of individuals injured
Private Vehicle	56.6%
Para-transit	31.3%
Public bus	9.8%
School bus	2.4%

(Rotko et al, 2005)

Loading type	% of individuals injured
Loading by lift	27.1%
Unloading by lift	31.4%
Loading by ramp	17.4%
Unloading by ramp:	8.1%
Other:	15.1%

Vehicle Impact Direction

Car/van impact direction frequency:

Front	48.3%
Side Impact	28.5%
Rear Impact	3.3%
Other	19.9%

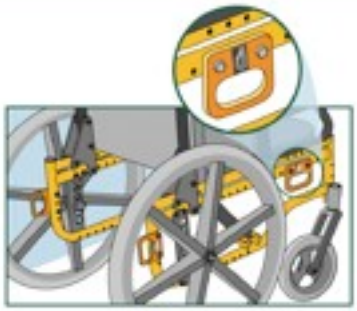
NHTSA, FARS Database

Wheelchair and Seating System

- Wheelchairs and seating systems are not generally designed to withstand crash level loading
  - Postural belts are NOT designed to be crash safe!
- Wheelchairs that comply with ANSI/RESNA WC19 standards have been crash tested at a pulse of 30mph/20g using a 4-point tiedown for wheelchair securement
  - Seating system withstands crash level loading
  - Wheelchair integrated pelvic anchor points

ANSI/RESNA WC19

- Compliant wheelchairs have four, crash tested and marked securement points
- Easy attachment for tie-downs
- Wheelchair has provision for a crash tested pelvic belt



ANSI/RESNA WC19

- Wheelchairs may also include, and be dynamically tested with, a fully integrated belt restraint system
  - Both pelvic and upper torso anchor to the wheelchair
  - Often used for pediatric wheelchairs

Invacare TDX-SP is WC19 compliant with an integrated pelvic belt

ANSI/RESNA WC19

- Wheelchair must pass a 30mph-20g crash test

Where to find a WC19 wheelchair?

www.rercwts.org

Click on "WC19"

Wheelchair Name and Model	Occupant Weight Limit (lb)	A WC19 Compliant Wheelcl Anchored Lap Belt is availa
Allegro	250	No
Orbit	150	No
Solara 2G (tilt-in-space)	250	Yes
Spree GT	200	Yes
Spree XT	150	Yes
Spree XT Ltd	150	Yes

Wheelchair Securement

- 4-point tiedown systems are NOT designed for independent use
- Automated docking systems allow independent securement for wheelchair-seated drivers
  - EZ-Lock
  - Permolock
  - QLK
  - Dock 'N Lock

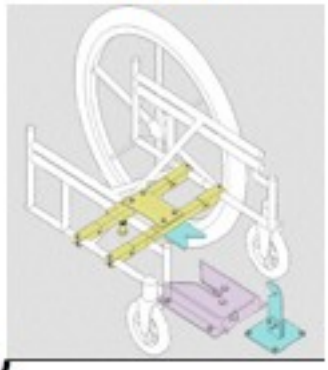
Automatic Docking

Q'Straint: QLK

Sure-Lok: Dock 'N Lock

Automatic Docking

EZ-Lock



Permobil: Permolock

About Docking

- Manufacturers provide special docking hardware for a list of (newer) wheelchairs
- Crash testing of devices according to ISO10542
- EZ-Lock Patent expired, causing an infusion of other docking products onto market
- Permobil has a retractable bolt option for their wheelchairs
  - works with the Permolock

Need for Restraint

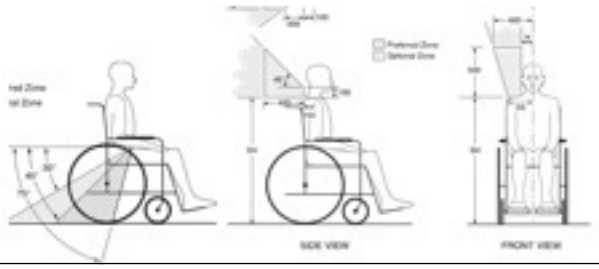
Shoulder Belt only

Need for Restraint

Pelvic Belt Only

Occupant Restraints

- SAE J2249 (1996): Recommended Practice
  - Use of an upper torso restraint (shoulder belt)
    - Placed over bony parts of the shoulder and sternum
  - Use of a pelvic restraint (lap belt)
    - Placed over the Illiac Crests



Occupant Restraints

- Ensure snug belt fit
- Run pelvic belt low over the hip bones
  - Avoid belt sub-marining: When belt is routed too high over the abdomen belt slides onto the abdominal area causing internal injury
- Use postural supports in addition to safety restraints not instead of safety restraints
- WC19 wheelchairs do have a wheelchair integrated pelvic restraint that can be used for occupant protection

What happens in the real world?

RERC-WTS: Research Study

- Project Leaders: L. van Roosmalen, L. Schneider
  Investigators: N. Ritchie,, M. Manary, N. Madura
  Students: I. Jongh, S. Felahi, M. Turkovih

- Part 1 (completed): Document and quantify the issues and problems of wheelchair securement, seatbelt use/fit for wheelchair-seated drivers and front-row passengers in vans and minivans
- Part 2 (ongoing): Design/develop/evaluate innovative solutions for improving occupant protection

Study Setup

- 21 wheelchair-seated drivers and 8 front-row wheelchair-seated passengers were evaluated while:
  - entering/exiting their personal vehicle
  - maneuvering in and out of the wheelchair securement system
  - donning/doffing the belt restraint system
- User input was collected regarding personal perception of safety and usability issues
- Digital and manual measurements were taken of wheelchair-seated driver, vehicle interior and occupant restraint geometry
  - Create map of wheelchair seated drivers

Wheelchair Observations

Of 29 participants:

- 25 subjects used a power wheelchair
- 4 used a manual wheelchair
- 12 wheelchairs had a wheelchair - mounted headrest
- 19 wheelchairs had an armrest with a closed front design, causing the occupants to route the lap belt around the front, over the top or through the opening in the armrests (usually resulting in less than optimal or poor lap belt fit)

Wheelchair Docking Concerns

- subjects mentioned that the docking device bolt on the bottom of the WC was too low to the ground and often catches on door lips or carpets inside and outside of vehicle
- Subjects mentioned that it often requires several tries to align and engage the WC with docking device
- All drivers were unable to manually release their docking system in case an emergency evacuation is needed

Restraint Observations

Of 29 participants:

- 10 are able to actively don their occupant restraint
- 14 require a passive belt system or the assistance of an attendant to don the occupant restraint, which often resulted in improper belt routing and slack in the belt system
- 5 don't use an occupant restraint system due to difficulty reaching and handling the buckle and difficulty routing the belt around wheelchair components

Restraint Observations

Reported Problems

- WC joystick interferes
- Joystick must be swung away or route belt over armrest
- WC armrests interfere with ORS placement on hips

Reported Problems

- Inboard buckle on webbing falls to floor
- Buckle hard to reach because of WC armrest and joystick
- Floor in vehicle makes maneuvering difficult, wheels slip on carpet or fall into empty floor pockets

Reported Problems

- Can't rely on shoulder belt for postural support during turning
- Loose belt adds to driver instability
- Shoulder belt not tight enough or too tight
- Home-made solutions

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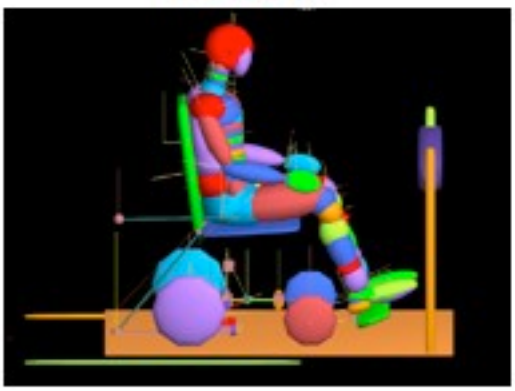
Simulating Drivers

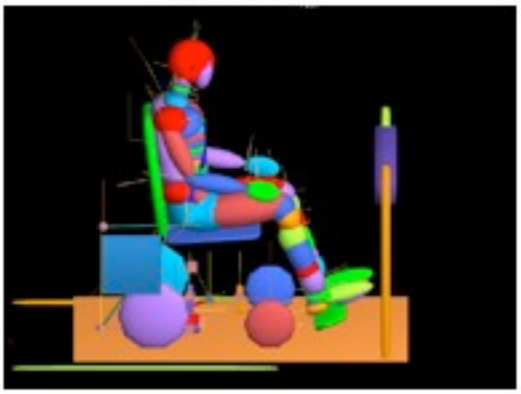
No shoulder belt



[Turkovich 2009]

Simulating Drivers

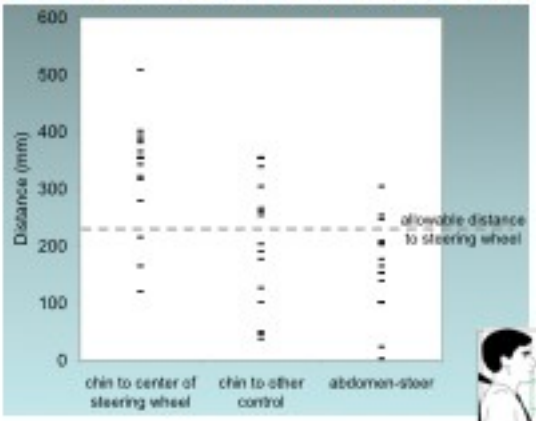
Shoulder belt



[Turkovich 2009]

Safe distance to controls?

Distances measured between driver and control device



Do drivers feel safe?

- Although most participants were using improperly and poorly positioned safety belts, or no safety belts at all, and most could not independently exit their vehicle in an emergency situation:

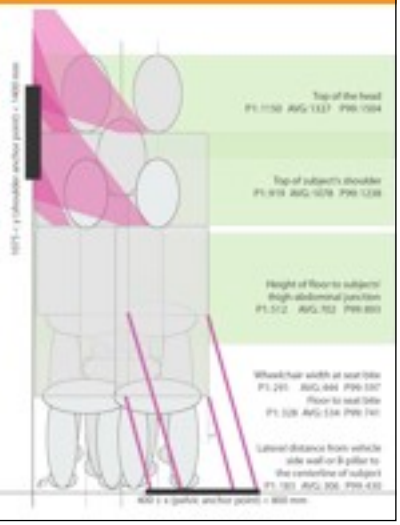
Most reported feeling **safe or very safe** when driving or riding in their personal vehicles!!

Risk Factors

- Non-use and misuse of belts
- Belt anchor positions in vehicle
- Poor fit of belts
- Loose belts
- Poor usability of belts → non use!
- Disconnected airbags
- Improperly positioned energy absorbers (airbags, padded interior)
- Insecure/unstable wheelchair seat
- Poor head/neck/back restraint

Driver Anthropometrics

- Need for adjustable restraints
- Need for alternative location of energy absorbers



[Ilona de Jongh 2008]

Need for Improvement

- Open armrest design for better belt fit
- Accessible passive restraint
- Adjustable belt tension
- Provide better postural support with shoulder belt (or harness)
- Head/neck/back restraint
- Alternative passive restraint systems

Open armrest

[van Roosmalen, Schneider, Ritchie & de Jongh, 2006]

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Open armrest

[van Roosmalen, Schneider, Ritchie & de Jongh, 2006]

Driver Support Systems

Carnegie Mellon University and the University of Pittsburgh
Quality of Life Technology Engineering Research Center

Sponsored by the National Science Foundation

Safety and information systems

- Automatic Crash Notification
- Adaptive Cruise Control
- Navigation systems
- Collision Warning Systems
  - Lane keeping assistance
- Proximity sensors/Obstacle avoidance
  - Parking aid
  - Parking collision avoidance
- Driving monitor
  - Behavior and feedback
- Information presentation
  - Windshield/dashboard

Cluttered Uncluttered

Driving Simulator

- Driver assessment and evaluation
- Ability to track driver learning
- On the fly adjustment to instrumentation
- Road driving remains a key component in driver training

Driving simulator at the University of South Florida (Tampa, FL)

Recommendations & Resources

Safe driving: A team approach

- Driver Rehab Specialist
- Mobility equipment dealer
- Van modifier
- Client
- Family members
- Caregivers

Resources

- Wheelchair Transportation Safety www.rercwts.pitt.edu
- National Mobility and Equipment Dealer Association (NMEDA) www.nmeda.org
- Association for Driver Rehabilitation Specialists (ADED) www.aded.net
- American Occupational Therapy Association www.aota.org

Resources

- www.creativecontrolsinc.com 800-539-7237
- www.ezlock.net; 225-214-4620
- www.orthosafe.com; 609-587-9444
- www.qstraint.com; 800-987-9987
- www.sure-lok.com; 866-787-3565
- www.immi.com

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UMTRI

Sponsored by: NIDRR

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- Linda van Roosmalen has a background in industrial design engineering and rehabilitation science
- As Visiting Assistant Professor in the Department of Rehabilitation Science and Technology at the University of Pittsburgh, she is involved in research, development and training in the area of wheelchair transportation safety
- Other interests include telerehabilitation, product safety, product usability and design for all