Advances in Wheeled Mobility: From Manual Wheelchairs to Intelligent Systems

Ben Mortenson
PhD, Occupational Therapist, Assistant Professor, UBC

Jaimie Borisoff
PhD, BASc, Canada Research Chair, Rehabilitation Engineering Design, British Columbia Institute of Technology

Emma Smith
MScOT, Occupational Therapist, Doctoral Student, UBC
PI: Dr. Bill Miller, PhD, FCAOT

www.canwheel.ca
Canadian Disability Participation Project

• Dr. Martin Ginis, Project Director
• Employment, Sports, and Mobility

• ICORD’s Miller, Mortenson, Borisoff
• Looking at Sam Sullivan’s BCMOS
Wheelchair Facts

• Worldwide: 65 million people need wheelchairs (WHO, 2008)

• Over 200,000 Canadians require a wheeled mobility device (Smith, 2014)

• Long history of wheelchair use.
  • 525 A.D. (China)
The Wheels of LIFE
Benefits of Wheelchairs

• Wheelchairs are the only means of mobility for some people

• They are essential for enabling social participation
What We Know

• Wheelchair training significantly improves manual wheelchair skills (Kirby research group)

• Provision by expert clinicians causes increased wheelchair use (Hoenig et al., 2005)
Wheelchair Concerns

• 50% to 80% of persons with SCI will develop a pressure ulcer (Brienza & Karg 1998)

• 25% to 80% of wheelchair users experience wrist, elbow and shoulder injuries (Cooper et al. 2001)
Wheelchair Concerns

• 59% of individuals in 11 residential care facilities had inappropriate seating in the Greater Vancouver Area (Giesbrecht, Mortenson, & Miller, 2012)

• Among 2213 people with SCI, within a 6-month period, 45% of full-time wheelchair users completed a repair, and 9% had an adverse consequence occur (McClure et al 2009)
Wheelchair Concerns

• Out of 150 wheelchair users in Italy (out-patients), 68% of wheelchairs had unsuitable wheelchairs (Cherubini & Melchiorri, 2012)
Wheelchair-Related Issues

• Accessibility problems (McClain et al. 2000; Meyers et al.; 2002; Mortenson et al., 2005)

• Home adaptation may be expensive

• Safety is a serious concern (Mortenson et al., 2005; 2006)
Wheelchair-Related Injuries

• 50-70 deaths/year in US (Calder & Kirby, 1990)

• 100,000 injuries to ER/year in US (Xiang et al, 2006)

• 5-18% of community wheelchair users injured/year (Kirby et al, 1994; Berg et al, 2002; Nelson et al, 2010)
Wheelchair Accidents: Cause

- Tips & Falls: 73.2%
- Environment: 41.4%
- Transfers: 16.9%
- Collisions: 1.7%
Dilemma

SAFETY

PERFORMANCE
EVERY CHOICE IS A COMPROMISE

Changing Centre of Gravity
Solutions

Accessibility, Wheelchair Design and Training
Manual Wheelchairs to Exoskeletons

Jaimie Borisoff,
PhD, BASc, Canadian Research Chair, Rehabilitation Engineering Design, British Columbia Institute of Technology
History of Manual Wheelchairs
Types of Manual Wheelchairs
Active People Use “Ultra”Light Wheelchairs

More than light, they are stiff and responsive = easy to push
Wheelchairs for Older Adults?
Wheelchairs for Older Adults
Manual Wheelchair Concerns

• Moving / Propulsion
• Transfers (e.g. Sit to Stand)
• Activities of Daily Living
• Comfort & Stability
MOVING IN A WHEELCHAIR
Power Add-On Systems
SmartDrive
Power-Assist Wheels
TRANSFERS: SIT TO STAND
Footrest Retraction
Sit to Stand from a Wheelchair: Elevation
Chairs can Usually be Adjusted
“ELEVATION”: an Ultra-light Wheelchair With Dynamic Seating
Dynamic Seat Height
Dynamic recline
Dynamic Wheeled Mobility Using Dynamic Reconfiguration on Slopes
(NEAR) FUTURE OF WHEELCHAIRS FOR OLDER ADULTS?

• Light
• Easy to propel (stiff and responsive)
• Transfers (e.g. Sit to Stand)
• Activities of Daily Living
• Comfort & Stability
Future of mobility?

Wheelchairs or Exoskeletons?
Integrated or Attached Exoskeleton-Wheelchair
Scooters – Use and Research

Ben Mortenson
PhD, Occupational Therapist,
Assistant Professor, UBC
Police crack down on mobility scooter mayhem as drunk and drug-driving pensioners become 8 mph menace to society

By REBECCA CAMBER FOR THE DAILY MAIL
UPDATED: 09:35 GMT, 13 August 2010

A police force facing savage budget cuts has announced a crackdown on the menace of the mobility scooter driver.

Officers have launched a course to combat the scourge of the lawless silver-haired scooter rider as the number of accidents on the roads rise.

They may not be joyriding teenagers any more, but officers say pensioners on mobility scooters can be just as dangerous with many being caught drunk or high on prescription drugs behind the wheel.

Norfolk Police are calling for a nationwide testing scheme because people are able to drive mobility scooters at the top speed of 8 mph without any
A mobility scooter menace?

By Nick Holland

A number of high-profile accidents involving mobility scooters have raised concern that drivers cannot be prosecuted and caused some to float the idea of testing users.
# Scooters Versus Power Wheelchairs

<table>
<thead>
<tr>
<th></th>
<th>Scooters</th>
<th>Power Chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheels</td>
<td>3-4</td>
<td>4</td>
</tr>
<tr>
<td>Drive wheels</td>
<td>Rear</td>
<td>Forward/Mid/Rear</td>
</tr>
<tr>
<td>Control</td>
<td>Tiller</td>
<td>Joystick, Head Array</td>
</tr>
<tr>
<td>Price</td>
<td>$3000-5000</td>
<td>$6000-50000</td>
</tr>
<tr>
<td>Centre of Gravity</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Stigma</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Seating</td>
<td>Captains Seat</td>
<td>Specialized</td>
</tr>
</tbody>
</table>
Prevalence

• Estimated 60,000 users in Canada 2006 (Stats Can, 2008)

• Estimated 142,000 in US in 1998 (Kaye et al., 2000)

• Estimated 232,000 scooter users (i.e., 13 out of every 1000 adults owned a scooter) (ACCC) et al., 2012).
Question

• A scoping review was conducted to identify empirical research on mobility scooters.
Methods

• Reviewed electronic data bases
• Searched conference proceedings
• Reviewed reference lists of relevant studies and papers citing them
Results

756 records identified excluding duplicates

710 excluded following review of title or

46 full articles retrieved and screened

18 excluded:
1. 7 combined scooter user data with other mobility user data
2. 11 had less than 75% of the sample as scooter users
3. 1 was a literature

28 studies met inclusion criteria

Three studies identified from reference list.

31 studies were included in the final
## Results

<table>
<thead>
<tr>
<th>Topic</th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative description users/activities</td>
<td>7</td>
</tr>
<tr>
<td>Accidents and safety</td>
<td>7</td>
</tr>
<tr>
<td>Prescription/service delivery/provision</td>
<td>6</td>
</tr>
<tr>
<td>User Qualitative Experiences</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Issues</td>
<td>2</td>
</tr>
<tr>
<td>Scooter Training</td>
<td>3</td>
</tr>
<tr>
<td>Intervention</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
</tr>
</tbody>
</table>
Results

• Accident rates varied 1.54 per person per year (Hoenig et al., 2007) to 15 per person per year (ACCC et al., 2012).

• Scooter provision to individuals with arthritis did not cause deconditioning (Hoenig, Pieper, Branch & Cohen, 2007).
Results

• Provision is associated with:
  • A yearly cost savings of $8460 per person per year (decreased caregiving) (Samuelsson & Wressle, 2014)

• A significant decrease of 67% in transport costs and a decrease of 72% in caregiver time requirements (Hagberg et al, 2015)

• A significant increase in the frequency of shopping for groceries going for a walk/ride (Sund et al, 2015)
Results

• Training studies demonstrated mixed results

• Survey research emphasized the importance of scooter training to build skills and increase confidence while driving (Mortenson et al., 2014).
Results

• Mobility scooters are not accommodated by US and Canadian building standards (King, Dutta, Gorski, Holliday, & Fernie, 2011)

• Qualitative studies emphasize benefits of scooter use and physical and social barriers (Fomiatti et al. 2014; May et al., 2010)
Discussion

• Limited research in this area

• Appears to be increasing.
  • 7 were published from 2000-2007
  • 24 were published from 2008-2015
Discussion

• Research using representative samples needed to identify those who not only use scooters (which is funding dependent) but also those who might benefit from them
Discussion

• More experimental studies are needed to look at the outcomes of training, not only on skills, but also on outcomes like safety and social participation
Discussion

- Policies and practices around scooter funding, accessibility, prescription and training need to be improved.
Discussion

• Currently, I am completing a study on the measurement properties of a variety of scooter related measures to make sure they are reliable and valid.
Discussion

• I am conducting a study with VCH occupational therapists Richelle Emery and Linda Smith to look at the outcomes associated with customary care.
Discussion

• I have submitted for funding to conduct an experimental study to determine the outcomes of scooter training more conclusively.
From Powered Wheelchairs to Intelligent Cars

Emma Smith
MScOT, Assistive Technology Professional/Seating and Mobility Specialist, Doctoral Student, UBC
Why Powered Wheelchairs?

- Difficulty with a manual wheelchair
- Low energy or strength
- Need mobility indoors
- Need help sitting up
Powered Wheelchairs
Where’s the Drive Wheel?

• Front, Rear, or Mid
• Impacts
  • Driving experience
  • Turning radius
• Manoeuverability
• Obstacle climbing
Powered Wheelchair Options
Powered Wheelchair Controls
Issues with Powered Wheelchairs

• Safety
  • New powered wheelchair users
  • Declining cognition and memory
• Breakdowns
• Accessibility
• Cost/Access
Advances in Powered Mobility
It can do that?
What About Training?
Powered Wheelchair Research
Intelligent Powered Wheelchairs
Automatic Parking / Obstacle Avoidance
... and more!
References

References cont’d


• Sund, T., Iwarsson, S., Anttila, H., & Brandt, Å. (2015). Effectiveness of Powered Mobility Devices in Enabling Community Mobility-Related Participation: A Prospective Study Among People With Mobility Restrictions. *PM&R.*


Questions??