Manual Wheelchair Configuration and Training: An Update on the Evidence

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Introductions: Who are these guys anyway?

- Carmen
  - Dr. DiGiovine is the most organized of the group; always the serious one….but is able to put up with Tina, Theresa and Wendy!
- Theresa
  - The OT who always has a smile on her face and is always willing to volunteer for another year of literature review! Really, the calm and organized one in the group.
- Tina
  - The PT who works for a manufacturer…she's gone to the dark side! Always putting the final touches on the presentation the in the nick of time.
- Wendy
  - Welcome Wendy to the group – not sure she knows what she is getting into! Provides hands-on, day-to-day application of EBP.

Presenters

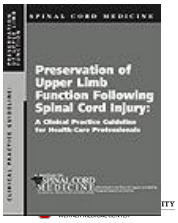
- Carmen P. DiGiovine, PhD ATP/SMS RET
  - Clinical Assistant Professor and Program Director
    - Assistive Technology Center – OSU Wexner Medical Center
    - Occupational Therapy Division - The Ohio State University
    - Biomedical Engineering Department - The Ohio State University
- Theresa F. Berner, MOT,OTR/L, ATP
  - Rehab Manger and Clinical Instructor
    - Assistive Technology Center - The Ohio State University Wexner Medical Center
    - Occupational Therapy Division - The Ohio State University
- Tina Roesler, PT, MS, ABDA
  - Director, International Sales and Education, TiLite
- Wendy Koesters, PT ATP/SMS
  - Rehabilitation Team Member – OSU Wexner Medical Center

Objectives

- Identify five topical areas related to wheelchair configuration and training.
- Implement at least 5 clinically relevant studies, one from each of the five topical areas, into their own clinical practice.
- Describe the 5 steps utilized in collecting and reviewing the scientific literature.
- Recognize the application of evidence based practice in at least one case study.

Clinical Practice Guidelines: Still Relevant?

- Published in 2005
- A consortium of professionals including practitioners, researchers, and educators
- Consolidates research findings and relates them directly to clinical practice
- 35 recommendations in 6 specific categories



What it includes:

- 35 separate guidelines related to:
  - Education
  - Ergonomics
  - Equipment Selection, Training and Environmental Adaptations
  - Exercise
  - Management of Acute and Subacute Upper Limb Injuries and Pain
  - Treatment of Chronic Musculoskeletal Pain to Maintain Function
- Recommendations for Future Research

Clinical Practice Guidelines related to Manual Wheelchair Propulsion.

- Ergonomics (CPG 3-5)
  - Minimize the frequency of repetitive upper limb tasks.
  - Minimize the force required to complete upper limb tasks.
  - Minimize extreme or potentially injurious positions at all joints.
    - Avoid extreme positions of the wrist.
    - Avoid positioning the hand above the shoulder.
    - Avoid potentially injurious or extreme positions at the shoulder, including extreme internal rotation and abduction.

Clinical Practice Guidelines related to Manual Wheelchair Propulsion

- Equipment Selection, Training, and Environmental Adaptations (CPG 6-9)
  - With high-risk patients, evaluate and discuss the pros and cons of changing to a power wheelchair system as a way to prevent repetitive injuries.
  - Provide manual wheelchair users with SCI a high-strength, fully customizable manual wheelchair made of the lightest possible material.
  - Adjust the rear axle as far forward as possible without compromising the stability of the user.
  - Position the rear axle so that when the hand is placed at the top dead-center position on the pushrim, the angle between the upper arm and forearm is between 100 and 120 degrees.

Clinical Practice Guidelines related to Manual Wheelchair Propulsion

- Equipment Selection, Training, and Environmental Adaptations (CPG 10, 14)
  - Educate the patient to:
    - Use long, smooth strokes that limit high impacts on the pushrim.
    - Allow the hand to drift down naturally, keeping it below the pushrim when not in actual contact with that part of the wheelchair.
  - Complete a thorough assessment of the patient's environment, obtain the appropriate equipment, and complete modifications to the home, ideally to Americans with Disabilities Act (ADA) standards.

Clinical Practice Guidelines related to Manual Wheelchair Propulsion

- Exercise (CPG 17, 18)
  - Incorporate flexibility exercises into an overall fitness program sufficient to maintain normal gleno-humeral motion and pectoral muscle mobility.
  - Incorporate resistance training as an integral part of an adult fitness program. The training should be individualized and progressive, should be of sufficient intensity to enhance strength and muscular endurance, and should provide stimulus to exercise all the major muscle groups to pain-free fatigue.

Free Download:

- http://go.osu.edu/PVA_CPG
  - Direct link
- www.pva.org
  - Paralyzed Veterans of America Homepage

Through 2014

- The literature reviewed continues to support the recommendations in the 2005 PVA publication
- Many important areas have emerged as offshoots to the CPG
- Further research indicates a need to update the CPG to include a broader range of disability groups and age ranges

What it comes down to:

- Time
  - Ongoing clinical reviews have been a volunteer effort by a small group of clinicians and researchers
  - Many have dropped off due to time pressures
- Dollars
  - Is there an appropriate avenue to fund the CPG development process?
  - Who takes it on? and what is the time frame?
- Could it be YOU???

In Past We Identified Important Additions to the Research:

- There are other areas we should be paying close attention to:
  - Alternate Drive Mechanisms
  - Activity and Performance
  - Environment
  - Service Provision
  - Outcomes
  - Evaluation
  - Caregiver training/handling
  - Wheelchair Skills

Wheelchair Skills Training

- Should it be a separate CPG?
  - Large body of evidence
  - Success directly related to wheelchair configuration
  - Does not directly show impact on the UE
- Where do we find more information?
  - Dalhousie University, Halifax, Nova Scotia, Canada (Dr. Lee Kirby)
  - www.wheelchairskillsprogram.ca

Don't Forget the Basics

- Reviewing Important Parameters of the Guidelines
- Impact on individual, caregiver and clinician scientist

Education and Training Three Distinct Segments

1. **Clinician Training**
   - Expectation of core tools that allow them to practice in their profession as a general practitioner
   - Try to incorporate AT/Wheelchair training into entry level academic education at the university level
   - Self directed training: web resources, conferences, review of current literature
   - Implementation of evidence based practice

2. Caregiver Education

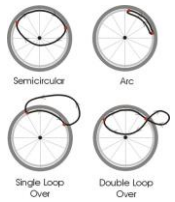
- United States: 80% of home care is provided by unpaid caregivers
- Set up realistic expectations
  - Operation and maintenance of equipment
  - Transport/storage of equipment
  - Repair/warranty information
  - Assisted wheelchair skills
- Ensure smooth community integration
  - Early discharge
  - Away from "safety" of rehabilitation facility

3. Client Education

- Usual and accepted training related to ADLs and specific diagnosis (based on standard facility protocol)
- Begin at introduction of manual mobility:
  - Risk factors for UE injury
  - Configuration
  - Functional considerations: transfers, weight shifts, etc.
  - Wheelchair maintenance
  - Wheelchair skills training**
  - Propulsion training**

Propulsion Training: Key to Long-Term Success

- PVA Guidelines: teach long, smooth strokes that limit forces at the handrim; look for distinct propulsion patterns
- Pre-post intervention assessment:
  - Key functional parameters:
    - Velocity ≥ 1.2 m/s
    - Stroke length: 100 degrees
    - Stroke frequency: ≤ 1 stroke/second
    - Force?
  - Smartwheel protocol?
  - Not using the Smartwheel
- Establishment of normative values?
- Multifaceted intervention:
  - Propulsion pattern instruction
  - Wheelchair configuration changes
  - Specificity of exercise and strength training



Cowan RE, et al. "Preliminary Outcomes of the SmartWheel Users' Group Database: a Proposed Framework for Clinicians to Objectively Evaluate Manual Wheelchair Propulsion," *Arch Phys Med Rehabil*, vol. 89, no. 2, pp. 260–8, 2007.

Boninger ML, et al. "Push mechanics and injury prevention in spinal cord injury: Recommendations based on CULP-SCI investigations," *J Rehabil Res Dev*, vol. 42, no. 3 Suppl 1, pp. 9–20, 2005.

The journey

- ISS 2009: An update on the evidence
- ISS 2010: An update on the evidence
- PMG: International Consensus on Best Practice; suggested updates to the UECPG
- ISS 2012: Another update on the evidence
- ISS 2014: A new update!

ISS 2014

- Over **62** new references to published research since completion of the 2012 review conducted at ISS
- Over **300** new references to published research since completion of the clinical practice guidelines in 2005
- Continue to have countless other non peer reviewed articles in industry publications and conference proceedings

Categories reviewed in 2014

- Clinical Practice Guide Recommendations
  - Ergonomics
  - Education and Training
  - Equipment Selection and Configuration
    - Impact on Rolling Resistance
    - Alternate Drive Mechanisms
  - Exercise
- Areas of interest to clinician scientists
  - Pediatrics
  - Older Adults
  - Outcomes

What this isn't

- An exhaustive literature review with well defined parameters.
- Trying to define clinical practice

What this is?

- Review of current literature related to wheelchair selection, set up, training and propulsion
- Provide basis for facilitating EBP

Our Literature Search: An Update to the Evidence

- A convenience sample from 2004 through December 2013.
- An update alerting service for PubMed (http://pubcrawler.gen.tcd.ie) to provide daily email updates on any journal articles that matched the keyword search for "wheelchair".
- Furthermore, the convenience sample includes relevant conference proceedings and as well as other journal articles which relate to the subject, but do not included the keyword "wheelchair"

Continuing to look at the literature

- What new information can we take away?

Clinical Practice Guidelines related to Manual Wheelchair Propulsion.

- Ergonomics (CPG 3-5)
  - Minimize the frequency of repetitive upper limb tasks.
  - Minimize the force required to complete upper limb tasks.
  - Minimize extreme or potentially injurious positions at all joints.
    - Avoid extreme positions of the wrist.
    - Avoid positioning the hand above the shoulder.
    - Avoid potentially injurious or extreme positions at the shoulder, including extreme internal rotation and abduction.

Ergonomics

- Jonathan S. Slowik, Richard R. Neptune; *"A theoretical analysis of the influence of wheelchair seat position on upper extremity demand."* Clinical Biomechanics, 28 (2013) 378-385
  - Modeled various upper extremity positions relative to the wheel during propulsion
  - Supported the information regarding importance of wheel position that is documented in the CPG.
  - Additional information on the fore and aft position of the wheel dictates that an elbow angle between 110 and 120 degrees, and a hub-shoulder angle between -10 and -2.5 degrees is most optimal; CPG says "..as far forward as possible without compromising the stability of the user..."
  - More rearward axle position increases muscle demand and metabolic costs

Clinical Practice Guidelines related to Manual Wheelchair Propulsion

- Equipment Selection, **Training**, and Environmental Adaptations (CPG 10)
  - Educate the patient to:
    - Use long, smooth strokes that limit high impacts on the pushrim.
    - Allow the hand to drift down naturally, keeping it below the pushrim when not in actual contact with that part of the wheelchair.

Education & Training

I. M. Rice, R. T. Pohlig, J. D. Gallagher, and M. L. Boninger, "Handrim wheelchair propulsion training effect on overground propulsion using biomechanical real-time visual feedback," *Arch. Phys. Med. Rehabil.*, vol. 94, no. 2, pp. 256–263, Feb. 2013.

- Intervention groups demonstrated improvements in Contact Angle and Stroke Frequency compared with control group.
- Contact angle feedback is a more intuitive training variable.
- Reduction in peak rate of rise of force may be a result of increased contact angle.

Clinical Practice Guidelines related to Manual Wheelchair Propulsion

- **Equipment Selection**, Training, and Environmental Adaptations (CPG 6)
  - With high-risk patients, evaluate and discuss the pros and cons of changing to a power wheelchair system as a way to prevent repetitive injuries.

Alternate Drive Mechanisms

- Alternative to manual or power mobility
  - Not *just* PAPAW
    - Power assist wheels
    - Power add on systems
      - Joystick based
      - Wheel input based technology
    - Lever drive systems
    - Unique mechanical assists (Freewheel)
  - Can often be interchanged standard manual propulsion
- Has participation benefits
  - Clients with significant UE injury
  - Weakness/fatigue issues
  - Children
- Must consider the limitations
  - Maintenance
  - Transportability

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Equipment Selection and Training

Lisa A. Zukowski, Jaimie A. Roper, Orit Shechtman, Dana M. Otzel, Jason Bouwkamp, Mark D. Tillman, *"Comparison of Metabolic Cost, Performance, and Efficiency of Propulsion Using an Ergonomic Hand Drive Mechanism and a Conventional Manual Wheelchair."* Archives of Physical Medicine and Rehabilitation, 2014;95:546-51

- Examined possible differences between lever drive system and standard propulsion
- Using a prototype device; there are commercial products available that have gained popularity
- Metabolic costs did not change; performance and efficiency *decreased* with use of the the hand drive mechanism
- Need to look at new products critically and review evidence regarding claims.

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Pediatrics

- Development/Diagnosis
- Physical Capacity
- Learning style based on:
  - Cognitive ability
  - Age
- Pain and injury with children is not as prevalent*
  - Different behaviors?
  - Muscular development?
  - Remodeling?

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Pediatric

- C. Maher, "Anaerobic tests for wheelchair-using children with cerebral palsy: the 'scroll saw' of the exercise test toolbox?," *Dev. Med. Child Neurol.*, Jul. 2013.
- This study reviews the reliability, validity, and sensitivity of anaerobic tests for wheelchair-using young people with CP
- The 2 field based tests studies include Muscle Power Sprint Test and the 10 x 5m sprint test
- Provides a method to measure physical fitness and activity measuring anaerobic fitness using minimal equipment in the field.

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Older Adults

- Overlooked population
- Unique considerations:
  - Caregiver involvement
  - Facility vs. community location
  - Anatomical /physiological changes
  - Fatigue/muscle strength
- Same rules should apply:
  - Education/Training
  - Set up and configuration
    - Look at propulsion method
    - Mobility should be functional in their given environment

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Older Adults

- W. B. Mortenson, W. C. Miller, C. L. Backman, and J. L. Oliffe, "Association Between Mobility, Participation, and Wheelchair-Related Factors in Long-Term Care Residents Who Use Wheelchairs as Their Primary Means of Mobility," *J. Am. Geriatr. Soc.*, vol. 60, no. 7, pp. 1310–1315, Jul. 2012.
  - Wheelchair related factors were associated with participation frequency through relationship with mobility
  - Wheelchair skills were important predictors of life-space mobility and frequency of participation, and life space mobility was a significant predictor of frequency of participation.
  - Depression was associated with poorer wheelchair skills and mobility and less-frequent participation

Outcomes

- S. Askari, R. L. Kirby, K. Parker, K. Thompson, and J. O'Neill, "Wheelchair propulsion test: development and measurement properties of a new test for manual wheelchair users," *Arch. Phys. Med. Rehabil.*, vol. 94, no. 9, pp. 1690–1698, Sep. 2013.
  - Develop and assess a simple and inexpensive test to evaluate the manual wheelchair propulsion
  - Recorded Data
    - Completion of 10m, Direction of travel, Number of cycles, Time, Propulsion Method, Propulsion Technique
  - Derived Data
    - Velocity, Push Frequency, Effectiveness
  - Main advantages
    - Simplicity, low cost, and usability for both hand and foot propellers
    - Distances greater than 10m and on a variety of surfaces (eg, rough ground and inclines).

Evidence Based Practice

"It's about integrating individual clinical expertise and the best external evidence!"

– Sackett, et al. 1996

Facets of EBP

- The proficiency and judgment that individual clinicians acquire through **clinical experience** and clinical practice.
- Published **research** papers in peer reviewed journals (Archives of Physical Medicine)
- Published Magazine articles (PT Magazine)
- Proceedings of Conferences (ISS)
- Text books

Case Studies:

Using data with clients for equipment recommendation, justification, establishment of baseline function, and education.

#1 - Set-up and Education

- 36 year old male with CP; spastic diplegia
- Problem:
  - Disrepair of current wheelchair
  - Lack of postural support

- Current Equipment
  - Tilite Aero Z with 3" front wheels
  - Custom Jay 2 cushion (asymmetric length)
  - Jay 2 solid back support.
- Client goals
  - Better postural support
  - Leg protection through doorways and while playing wheelchair basketball.
  - Assist at legs to prevent tonal extension pattern; results in loss of balance and feet coming off footplate

Trial Equipment

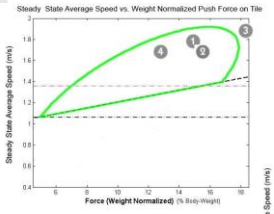
- Increased seat slope
  - Able to maintain independent swing through transfers
  - Tighter knee angle
- More forward COG
- Ride Evaluator cushion

Propulsion Analysis - Tile

- Significant increase in push length
- Opportunities for education
  - Decrease push frequency
  - Further increase push length
  - Decrease force

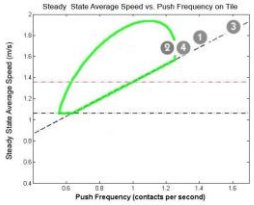
	Current	Current	Trial	Trial	Database Average	Database Top 25%
Speed [m/s]	1.8	1.7	1.9	1.7	1.29	1.73
Push Freq [1/s]	1.4	1.2	1.6	1.3	0.91	1.05
Push Angle [degree]	42.4	40.9	52.9	48.5	74.48	82.90
Force (%)	14.6	15.2	18.2	12.5	11.32	12.95

Propulsion Analysis – Opportunities for Education



Current Wheelchair – 1 & 2

Evaluation Wheelchair – 3 & 4



#2 - Marginal Propeller

- Complex medical history: Scleroderma Progressive, chronic pain disorder, etc.
- Propels with upper extremities and lower extremities
- Current equipment
  - Lightweight wheelchair (K004)
  - Roho high profile quarto cushion
  - Sling back and seat
  - Elevating leg rests
- Problems
  - Back too high; not supportive for kyphosis
  - Unable to propel over doorway thresholds
  - Home mostly carpet

Outcome Measures – Determine Client Goals

- QUEST:
  - "Device is not very comfortable"
  - "Very hard to push on carpet and make turns. Can't push on uneven roads"
  - Priorities with new equipment: adjustments, easy to use, comfort
- FMA

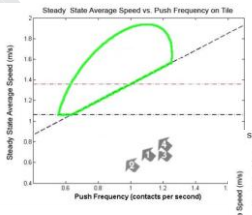
  "Too hard to push, makes my hands and shoulders hurt"

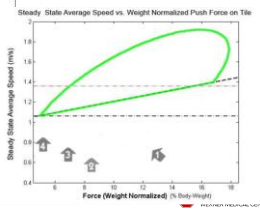
Propulsion Analysis - Tile

- Significant decrease in force
- Opportunities for education
  - Decrease push frequency
  - Increase push length
- Opportunities for strength training to increase force and functional velocity

	Current	Current	Trial	Trial	Database Average	Database Top 25%
Speed [m/s]	0.7	0.6	0.7	0.8	1.29	1.73
Push Freq [1/s]	1.1	1.0	1.2	1.2	0.91	1.05
Push Angle [degree]	50.0	53.0	40.9	25.1	74.48	82.90
Force (%)	12.7	8.2	6.6	4.4	11.32	12.95

Propulsion Analysis - Tile





Current Wheelchair (Lightweight) – 1 & 2

Evaluation Wheelchair (Ultralight) – 3 & 4

Opportunities for Education and Training

Propulsion Analysis - Carpet

- Opportunities for education
  - Increase functional velocity
  - Increase push length
- Opportunities for strength training to increase functional velocity.

	Current	Current	Trial	Trial	Database Average	Database Top 25%
Speed [m/s]	0.4	0.4	0.5	0.5	1.29	1.73
Push Freq [1/s]	0.9	0.8	1.0	1.0	0.91	1.05
Push Angle [degree]	48.0	48.5	43.8	49.6	74.48	82.90
Force (%)	13.1	12.8	10.4	12.1	11.32	12.95

Manual Wheelchair Skills Test

- Castor distribution of weight affected turning on carpet as well as ramps
- Use of % with documentation on G codes
- Establish baseline
- Determine where to focus training

Weight Distribution: 26%/74% (Front/Rear)

MWC Skills Test Score – 38/64

Implementation: "Worth the wait!

- Plan for follow up 1 month post delivery
- Propulsion analysis (SmartWheel)
- Wheelchair Skills Test
- Outcomes
  - Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST)
  - Functional Mobility Assessment (FMA)

#3 - Education, Education, Education!!!

- Background
  - 57 year old woman
  - Thoracic SCI
  - 18 years post injury
  - Chronic shoulder pain
  - Ultralight manual wheelchair with gel cushion and solid back support
- Goals
  - New wheelchair for continued independent function at home an work

Assessment

- Propulsion Analysis – SmartWheel
- Pressure Mapping
- Wheelchair Skills Test
- Shoulder orthopedic screen
- Measures of current seating configuration

Original Manual wheelchair skills test

Goal at implementation/follow-up for score to be equal to or greater than baseline

Smartwheel- education on wheel access affecting speed and force (COG)

Trial 1

Trial 2

- Client's frame with original set up vs. moving COG 1.5" anterior
- Result: decreased repetition of braking at initial push, decrease in average force, and push frequency decreased

Resources to access literature

- Pubcrawler – Alerting service for PubMed
  - http://pubcrawler.gen.tcd.ie/
- Pubmed
  - http://www.pubmed.gov
- Google Scholar
  - http://scholar.google.com
- NIH Public Access
  - http://publicaccess.nih.gov
  - http://www.pubmedcentral.nih.gov
- Professional Organizations
- Manufacturers' Websites / Journal Clubs / Local and University Libraries

More resources

- www.herlpitt.org (Human Engineering Research Laboratories)
- www.wheelchairnet.org
- www.icord.org/scire (Spinal Cord Injury Rehabilitation Evidence)
- www.mobilityrerc.catea.org (Rehabilitation Engineering Research Center)
- www.RESNA.org (Rehabilitation Engineering and Assistive Technology Society of North America)
- www.pva.org (Paralyzed Veterans of America)
- www.guideline.gov (National Guideline Clearinghouse)
- www.ahrq.gov (Agency for Healthcare Research and Quality)

Find Creative Ways to Keep Up

- Collaborate and Communicate:
  - Attend conferences
  - Talk with colleagues
  - Start a journal group
  - Ask manufacturers/suppliers for help
- Review what you can – scan journals and magazines for basic content
- Document, document, document!

Thanks for Coming!

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