- If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.

- This handout is for reference only. Non-essential images have been removed for your convenience. Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date.

Technical issues with the Recording?

- Clear browser cache using these instructions
- Switch to another browser
- Use a hardwired Internet connection
- Restart your computer/device

Still having issues?

- Call 866-782-9924 (M-F, 8 AM-8 PM ET)
- Email customerservice@OccupationalTherapy.com

Wheelchair Mobility: Ultralight Configuration And Propulsion

Michelle L. Lange, OTR/L, ABDA, ATP/SMS

Quickie 7

1

Learning Outcomes

The participant will be able to:

1. Define an ultralight manual wheelchair.
2. Describe ultralight configuration considerations.
3. Define the most efficient self-propulsion technique.

2

continuED

What we will be covering:

- What is a ultralight manual wheelchair?
- Clinical Guidelines
  - Configuration
  - Propulsion techniques
- Case Study

Ki Mobility Ethos

3

continuED

SMS Series

- This is part of a series of webinars designed to prepare the participant for the Seating and Mobility Specialist examination.
- And… develop more advanced seating and wheeled mobility skills

ATP | SMS ASSISTIVE TECHNOLOGY PROFESSIONAL SEATING AND MOBILITY SPECIALIST RESNA CERTIFIED

4

continuED

Manual Wheelchairs

- A manual wheelchair is designed to provide dependent or independent mobility to a client, as well as support an appropriate seating system.

continuED

ATP RESNA CERTIFIED ASSISTIVE TECHNOLOGY PROFESSIONAL

Assessment

- Assessment is typical done with a wheelchair supplier.
- Lightweight, Ultra Lightweight and Pediatric manual wheelchairs are considered Complex Rehab equipment.
- Complex Rehab is typically recommended by a professional who is a certified:
  - ATP: Assistive Technology Professional
  - SMS: Seating and Mobility Specialist
  - These are obtained through RESNA
    - Rehab Engineering and Assistive Technology Society of North America

continued

Assessment

- Considerations include:
  - Strength, range of motion, muscle tone and orthopedic status
  - Cardiopulmonary status and fatigue
  - Potential for change in function or size
  - Positioning needs
  - Environmental needs

continued

Manual Wheelchair Types

- Standard Wheelchair (K0001)
- Standard Hemi Wheelchair (K0002)
- Lightweight Wheelchair (K0003)
- Lightweight Wheelchair (K0004)
- Custom Lightweight and Ultra Lightweight Wheelchair (K0005)
- Pediatric
- Bariatric
- Specialty

Custom Lightweight & Ultra Lightweight

- Medicare K0005
- Weigh less than 30 pounds, as low as 17 to 18 pounds
- Greatest degree of options:
  - Size
  - Frame adjustments
  - Suspension
  - Casters
  - Designed to maximize self-propulsion efficiency and reduce RSI risk

Quickie QRi

Custom Lightweight & Ultra Lightweight

- Appropriate Client:
  - Any client who is self-propelling using both arms for a significant time period

Quickie Xenon

CONTINUED

Custom Lightweight & Ultra Lightweight

- Ultralights vs. standard wheelchairs
  - Improved push speeds
  - Improved distance
  - Decreased energy expenditure
    - Beekman, C. E., Miller-Porter, L., & Schoneberger, M. (1999). Energy cost of propulsion in standard and ultralight wheelchairs in people with spinal cord injuries. *Physical therapy*, *79*(2), 146-158.

CONTINUED

Custom Lightweight & Ultra Lightweight

- Folding and Rigid frame options
  - Folding is easy to transport and often has more growth or other frame options.
  - Rigid frames are lighter, more durable and more energy efficient.

Ti Lite TR

continuED

Rigid vs. Folding

- Rigid frames are more efficient to propel
- Why?
  - Fewer moving parts
  - Energy is transferred into the ground instead of into moving frame.
  - Cross braces can twist and move when crossing uneven surfaces, resulting in energy loss.

13

continuED

Rigid vs. Folding

- Folding frame improvements
  - Some folding frames now ‘lock’ in place to minimize movement and loss of efficiency.
  - Some movement remains

TiLite TX2

14

continuED

Rigid vs. Folding

- Folding options
  - ‘Folding’ frames generally fold side to side
    - Cushions and backs need to be removed
  - Rigid frames typically fold into a ‘box’
    - Back canes fold down
    - Rear wheels can be removed
    - Footrests are typically incorporated into the frame

Quickie QRi

15

Rigid vs. Folding

Quickie QX

- Transfers
  - Folding frames offer swing away footrest hangers for transfers.
  - Rigid frames incorporate the footplate into the frame.
    - Client transfers side to side or in front of these
    - This style saves weight, increases the strength of the frame and keeps the knees at 90 degrees without caster interference.
      - Small footprint

Quickie Q7

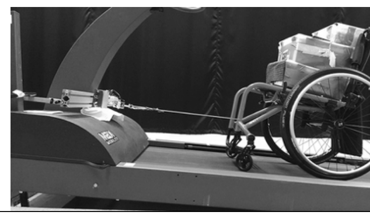
16

continued

Ultra Lightweight

- Durability
  - Research has demonstrated that over the lifetime of the frame, ultra lightweight wheelchairs are more cost-efficient than other less costly frames.
    - Fitzgerald, Shirley G., et al. (2001). Comparison of fatigue life for 3 types of manual wheelchairs. *Archives of physical medicine and rehabilitation 82*(10),1484-1488.

VA



continued

Wheelchair Design

- Weight
- Seat Width
- Seat Depth
- Seat to Footrest Length
- Front Frame Bend
- Seat Height and Vertical Wheel Position
- Seat Slope
- Backrest Height and Angle
- Center of Gravity
- Rear Wheel Camber
- Rear Wheels and Tires
- Casters
- Handrims

18

continued

Weight

- Generally, the lighter the wheelchair, the more efficient it is to propel.
- This includes the weight of components and seating.
- Rigid are generally lighter than folding options,

Seat Width

- As narrow as possible
- At or slightly more than measured hip width
- Too wide – increased shoulder abduction and wrist flexion required
  - More difficult to propel
  - Higher injury risk

20

continued

Seat Depth

- Too Short
  - Increases load on buttocks
  - Shortens frame length and amount of weight on casters which decreases propulsion efficiency
- Too Long
  - Pressure behind knees, may lead to posterior pelvic tilt
- Ideal
  - Maximize weight on the rear wheels to increase propulsion efficiency and maneuverability
  - Ideal is at least 2 inches shorter than measured seat depth

21

continued

Seat to Footrest Length

- Increases height of cushion
- Support thighs and buttocks while supporting feet
- Too high
  - Increased pressure to ITs
- Too low
  - Inadequate support and stability
  - Can also lead to interference with the ground

22

Quickie 7R

Front Frame Bend

- The angle of the front frame to the floor
- Determines position of the footrest relative to the seat
- Larger angle / increased knee flexion
  - Makes the chair shorter and more maneuverable
  - Accommodates tight hamstrings
- Smaller angle / increased knee extension
  - Chair is longer and less maneuverable
  - May pull pelvis into posterior pelvic tilt

23

Seat Height and Vertical Wheel Position

- Front seat height is determined by the length of the lower legs
  - Footplates need to clear, at least 2" off the ground
  - For taller people, this can impact access to work surfaces
- Rear seat height should be where the user's elbow is 120 degrees flexed when hand is resting on the top of the wheel.

Quickie

24

continuED

Seat Slope

- Seat slope is the difference between the front and rear seat heights.
  - Impacts sitting balance, transfers, wheel access
  - Usually a minimum of 2" slope is used
- Larger slope
  - May help someone with less trunk control
  - May make transfers more difficult
  - The user may end up too low in relation to the wheels for effective self-propulsion

25

continuED

Backrest Height and Angle

- Taller back
  - More trunk stability
- Lower back
  - Allows the scapulae to move during propulsion, greater shoulder motion, decreases push frequency
    - Yang, Y. S., Koontz, A. M., Yeh, S. J., & Chang, J. J. (2012). Effect of backrest height on wheelchair propulsion biomechanics for level and uphill conditions. *Archives of physical medicine and rehabilitation*, *93*(4), 654-659.
  - Seat to Back angle
  - Impacts sitting balance and position
  - Anterior pelvic tilt can assist with propulsion

Jay 3 back

26

continuED

Howiroll.com

Center of Gravity

- Adjustment of the rear wheel forward or back affects center of gravity
  - Forward – puts more weight on the rear wheels, less stable
  - Back – puts weight balanced between rear wheel and caster, more stable
- For efficient self-propulsion, the wheel should be as far forward as possible without impacting stability
  - Paralyzed Veteran's of America, 2005
  - Most commonly where middle finger lines up with axle with arm hanging down at side

27

continuED

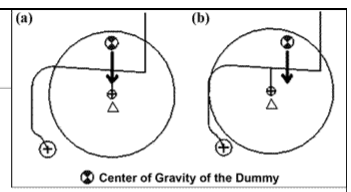


Figure 4.
Position of rear-wheel axle in forward stability tests. **(a)** Midposition of rear-wheel axle was considered least stable setting, since **(b)** wheelchair would tip backward if we moved axle further forward.

Center of Gravity

- Determination
  - Have client sit in MWC and push forward. If casters pop up off the ground, the rear wheel is too far forward
  - The user should still be able to "pop a wheelie"
    - Liu, H. Y. (2008). *Evaluation of titanium ultralight manual wheelchairs using ANSI/RESNA standards* (Doctoral dissertation, University of Pittsburgh).

28

continuED

continuED

Quickie Match Point

Rear Wheel Camber

- Camber brings the top of the wheel closer to the user
  - Improves propulsion as wheel is closer
  - Increases lateral stability
  - Increases overall width of MWC
  - 2-5 degrees is common and doesn't interfere with doorways
  - Often must be determined at order, may not be adjustable in field

29

continuED

TiLite Twist

Rear Wheels and Tires

- Wheel size
  - 18 – 22 inches for pediatric MWCs
  - 24 – 26 for adult MWCs
    - 24" is most common
  - Determined by height required to maintain elbow at 120 degrees while resting hand on wheel
    - Dependent on arm length

30

Rear Wheels and Tires

- Tires
  - Pneumatic
    - Reduce rolling resistance (force required)
    - Increase comfort
    - Can lose pressure or go flat
  - Solid
    - Less maintenance

31

Casters

- Size
  - Small (3-4") improve maneuverability, but increase rolling resistance and can get caught more easily
  - Larger (5-6") better for varied terrain
- Position
  - The shorter the distance between the rear wheel and caster, the less rolling resistance
    - DiGiovine, C., Koontz, A., & Boninger, M. (2006). Advances in manual wheelchair technology. *Topics in Spinal Cord Injury Rehabilitation*, *11*(4), 1-14.
  - Casters placed lateral to the footplates decrease maneuverability as the MWC is wider at this location

32

continuED

Casters

- Loading
  - It is important to not position the client in the wheelchair so that the front casters are "loaded"
  - Impedes turning
  - Increases wear

33

continuED

Handrims

- Standard handrims can be slippery
- Coated handrims may improve propulsion, especially in users with limited hand function, but create friction that can lead to abrasions
  - i.e. going down ramp
- Gloves
- Ergonomic handrims
  - Decrease pain in wrists and hands
    - Koontz, A. M., Yang, Y., Boninger, D. S., Kanaly, J., Cooper, R. A., Boninger, M. L., ... & Ewer, L. (2006). Investigation of the performance of an ergonomic handrim as a pain-relieving intervention for manual wheelchair users. *Assistive Technology*, *18*(2), 123-145.

34

continued

Self-Propulsion Considerations

- Proper configuration of axle and casters:
  - Decreases rolling resistance
    - Decreases force required to propel the MWC
  - Reduces frequency of push stroke to achieve and maintain speed

continued

Optimal Propulsion Technique

- Single loop is most common
- Semicircular is most efficient
  - Hand remains below the handrim during the recovery phase of propulsion
  - Lower push frequency
  - Decreased forces

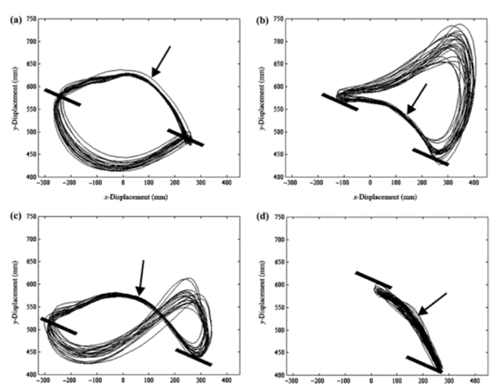


Figure 3.
Plots of *x*- and *y*-coordinates of third metacarpophalangeal marker of over 10 wheelchair propulsion cycles. Each plot represents frequently seen individual pattern: **(a)** semicircular, **(b)** single loop-over propulsion, **(c)** double loop-over propulsion, and **(d)** arcing. Heavy lines in figure indicate contact and end points. Arrow points to period where hand is on pushrim. (Reprinted from *Archives of Physical Medicine and Rehabilitation*, 80(8):910–15, Boninger ML et al.: "Wheelchair Pushrim Kinetics: Body Weight and Median Nerve Function," ©1999 American Congress of Rehabilitation Medicine and American Academy of Physical Medicine and Rehabilitation.)

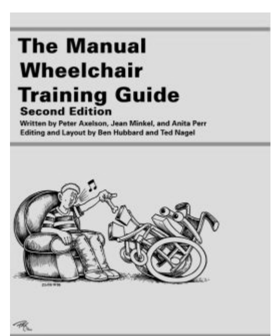
Reducing Pain and Injury

- People who self-propel are at high risk of pain and repetitive stress injuries
  - Carpel tunnel syndrome (49-73%)
  - Pain in upper extremities / rotator cuff tears (59%)
- Pain and injury can lead to:
  - Decreased function
  - Decreased quality of life
  - Increased medical costs

Berner, T. F., DiGiovine, C. P., & Roesler, T. L. (2010). Manual Wheelchair Configuration and Training: An Update on the Evidence. In *26th International Seating Symposium. Vancouver, British Columbia* (pp. 180-5).

Manual Mobility Training

- Training wheelchair skills
  - Transfers
  - Wheelies
  - Getting back into wheelchair from a fall
  - Maintenance
- Manual Wheelchair Training Guide:
  - http://www.beneficialdesigns.com/products/pax-press/manual-wheelchair-training-guide
- Wheelchair Skills Program
  - https://wheelchairskillsprogram.ca/en/



Case Study

- Lori
- Diagnosis: cerebral palsy, arthritis
- Age: 35 years
- Goals:
  - Improve postural support and stability
  - Tone management in a seated posture
  - Optimize self-propulsion
  - Optimize ADLs

39

Case Study

- Current equipment:
  - TiLite TR ultralight MWC
  - Ride Designs custom cushion
  - Jay 3 back
- Posture:
  - Pelvis: mild to moderate posterior pelvic tilt, mild obliquity and rotation – all reducible
  - Trunk: leaning to right side (reducible), kyphosis (non-reducible)
  - LEs: mild windsweep to left, adducted

40

continued

Case Study

- Current configuration:
  - Seat width appropriate
    - Close to wheels
  - Seat depth appears a bit long, but the cushion is beveled

41

continued

Case Study

- Current configuration:
  - Seat to Footrest length
    - Good pressure distribution, adequate footrest clearance
  - Front frame bend
    - Tolerating 90 degrees of knee flexion well
    - Controls her tone and minimizes footprint

42

Case Study

- Current configuration:
  - Rear wheel position:
    - vertical height – she is too high
  - Seat Slope
    - Slightly lower rear seat height
  - Backrest
    - Height – we increased height, though this remained in position in relation to her back. The new back was mounted lower to support the posterior pelvis
    - Angle – open to accommodate kyphosis

43

Case Study

- Current configuration:
  - Center of Gravity
    - When arm was dropped, her middle finger was in line with the axle, but above it
    - She is seated too high, though the relationship between the rear wheel and casters is good

44

Case Study

- Current configuration:
  - Camber
    - She did not appear to have any camber
    - Although this would have brought the wheels in a bit, she was happy with the current configuration and did not have any stability issues

45

Case Study

- Current configuration:
  - Rear Wheels
    - Solid inserts
    - Less maintenance, but increased weight
  - Casters
    - Small, though she is not having issues and is mostly indoors
  - Handrims
    - Light coating for increased friction assisted her grip and propulsion

46

continued

Case Study

- Current self-propulsion:
  - She can self-propel with good control
  - She is unable to efficiently self-propel unless her legs are strapped

47

continued

Case Study

- Recommendations:
  - Trial lower rear seat height to improve relationship to rear wheel to determine if self-propulsion is improved
  - If this is unsuccessful, trial larger rear wheel. The frame will have to be reconfigured to accommodate this.
  - Consider slight camber
  - Consider pneumatic inserts to lessen weight
- Recommended seating changes also improved stability and, as a result, self-propulsion

48

Take Home Message:

- Our main goal is independent mobility, if possible
- Mobility needs to be as efficient as possible and limit repetitive stress injuries
- If a client is not efficient in one category of manual wheelchair, consider the next category
- If a client is not efficient in any category of manual wheelchair, consider power mobility

Resources

- For more information, check out:
  - Rosen, L. (2018). Manual Mobility Applications for the Person Able to Self-Propel. In Seating and Wheeled Mobility: a clinical resource guide, eds M. Lange & J. Minkel, Slack, Thorofare, NJ.
  - Manual Wheelchair Selection Guide:
    - http://www.beneficialdesigns.com/products/pax-press/a-guide-to-wheelchair-selection
  - The National Spinal Cord Injury Association Manual Wheelchair information
    - http://www.spinalcord.org/resource-center/askus/index.php?pg=kb.page&id=1642

Resources

- For more information, check out:
  - RESNA Position Paper on The Application of Ultralight Manual Wheelchairs
    - http://www.resna.org/sites/default/files/legacy/resources/position-papers/UltraLightweightManualWheelchairs.pdf
  - RESNA Wheelchair Service Provision Guide
    - http://www.resna.org/sites/default/files/legacy/resources/position-papers/RESNAWheelchairServiceProvisionGuide.pdf
  - Preservation of Upper Limb Function Following Spinal Cord Injury – a clinical practice guideline for health care professionals, PVA
    - http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1808273/

Resources

- The National Registry of Rehabilitation Technology Suppliers, www.nrrts.org
- Rehabilitation Engineering and Assistive Technology Society of North America, www.resna.org
- The International Seating Symposium, www.iss.pitt.edu

Questions?

- MichelleLange1@outlook.com

Thank You!

Contact Information

- Michelle L. Lange, OTR/L, ABDA, ATP/SMS
- MichelleLange1@outlook.com
- www.atilange.com