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# Wheelchair Mobility: Power Add On Options And Use For Manual Wheelchairs

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

Quickie Xtender

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## Learning Outcomes

The participant will be able to:

1. Define Alternate Drive Mechanisms and provide examples of 3 types.
2. Describe clinical indicators for Alternative Drive Mechanisms.
3. Describe clinical indicators for PAPAWs.

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## What we will be covering:

- Alternate Drive Mechanisms
- Providing assist for self-propulsion of a manual wheelchair
  - Lever drives
  - Arm-crank drives
  - Geared hubs
  - Reverse pushrim drives
  - Push rim-activated power assist drives

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## 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

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## Mobility Hierarchy

- Dependent Manual Wheelchairs

⇩

- Independent Manual Wheelchairs
  - Designed for self-propulsion

⇩

- **Alternate Drive Mechanisms**

⇩

- Power Wheelchairs

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## Alternate Drive Mechanisms

- Goal:
  - Improved mechanical efficiency
  - Maintain transportability, versatility, and aesthetics of a manual wheelchair
    - DiGiovine & Berner, 2018

NuDrive Air

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# Who is this Appropriate For?

- It is well documented that people who self-propel a manual wheelchair, even an appropriately configured ultralightweight MWC, are prone to:
  - Repetitive stress injuries
    - Shoulders, wrists
  - Pain
- This can worsen to the point that mobility is compromised.

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# Who is this Appropriate For?

- A person who can self-propel, but:
  1. Has upper extremity injury and/or pain
  2. Has decreased cardiopulmonary function
  3. Has decreased strength and endurance

Quickie Q7

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## Who is this Appropriate For?

- A person who can self-propel, but:

4. Is less efficient in mobility secondary to aging with a disability or aging in general
5. Is a long-term MWC user who may have lost efficiency
6. Is a MWC user who cannot manage slopes, varied terrain and/or long-distances without assistance

Quickie Q7

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## Non-powered options

- Geared systems
- Lever systems
- Arm-crank systems

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# Geared Systems



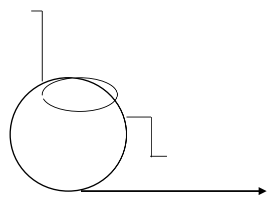
# Geared Systems

- Gear system between the handrim and the wheel
  - Geared hubs
  - Reverse pushrim drives


Intelliwheels
Easy push
wheel

# Geared Systems

- How does it work?
- Standard MWC handrim has a 1:1 ratio
  - 1 push = set distance of movement



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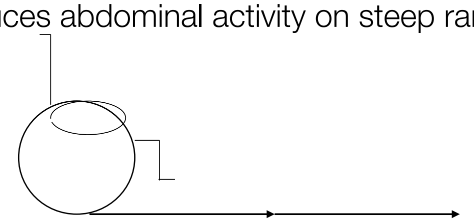
# Geared Systems

- Geared systems
  - Typically 1:1 ratio for standard propulsion
  - 1:2 ratio for propulsion on inclines or high rolling resistance surfaces
    - i.e. carpet
  - Reduces UE effort on all ramps
  - Reduces abdominal activity on steep ramps



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# Geared Systems

- Who is this appropriate for?
  - Users who could not traverse certain environments without this system
  - Users with reduced UE strength

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# Geared Systems

- Reverse propulsion
- Pulling back on the wheel moves the MWC forward

RoWheels Revolution

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## Geared Systems

- Pulling action uses muscles in your upper back and shoulders
  - Larger muscles
  - Encourages better posture
  - Reduced risk of shoulder-related injuries
  - Minimizes impact on handrim

RoWheels Revolution

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## Geared Systems

- The user must recognize the need to change gears
- Adds weight
  - Most weight is by the hub, less impact on propulsion
- Minimizes roll-back on slopes
- Reduces force required to brake when going downhill

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continued

# Lever Systems

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continued

NuDrive Air

# Lever Systems

- Lever arm increases torque compared with traditional handrim
- Typically levers are placed between frame and wheel
- Does not add very much to width of chair
- Gears may also be built-in
- Handle is easier to grasp than the handrim

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continued

# Lever Systems

- Steering
  - Differential motion
    - Pull back on one side, push forward on the other for a turn
  - Dedicated steering mechanism
    - Turn the handle of the lever

GRIT Freedom Chair

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# Lever Systems

- More mechanically efficient than standard handrims
- Speed higher
- Heart rate and $O^2$ consumption less
- Less demanding, less strenuous, more efficient

NuDrive Air

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# Armcrank Systems

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## Armcrank Systems

- Often used in handcycles
- User may be upright or recumbent
- Gears similar to a bicycle
- Cons:
  - Bulky
  - Reduced maneuverability
  - Aesthetics

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# Armcrank Systems

- Most systems are synchronous
  - Arms turn together – more efficient
- Continuous movement is less straining and more efficient than handrims
- Longer distances and higher speeds
- Recumbent position reduces air resistance

Invacare Top End XLT

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# Armcrank Systems

- Typically used for recreational purposes
- Although efficient, these are not practical for everyday use in a variety of environments

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# Justification

- How are these systems justified?
  - Allows a MWC user to be maintain independence in mobility without having to switch to a PWC
  - Increases efficiency while decreasing risk of injury and pain
  - Cost of these systems is typically less than a PWC

Quantum Edge 3

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# Powered Options

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# Powered options

- Pushrim-Activated Power Assist (PAPAW)
  - Motor in hub of the wheel
  - Motor external to the frame

Quickie Xtender

Max Mobility SmartDrive

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# PAPAWs

Quickie Xtender battery

- How does it work?
  - Hybrid system
  - Measures force imparted on pushrim and amplifies force through electromechanical system
  - Amplifies the propulsion phase (faster and increased force)
  - Extends the recovery phase (time before another stroke required)

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# PAPAWs

- So what exactly does that mean?
  - A typical push on the handrim results in more force to propel the MWC further per stroke and with more force up slopes and over varied terrain
  - Cool!



# PAPAWs

- Modes of operation
  - Intermittent
  - Continuous mode

## PAPAWs

- Intermittent mode
  - Motor engages only in response to force on handrim
  - Only used when needed, may be safer for some users

Frank Mobility
E-Motion

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## PAPAWs

- Continuous mode
  - Motor is turned on
    - Via Switch or BT device (i.e. wristband)
  - Handrims only used for course corrections
  - Great for long distances, requires minimal effort
  - Does require attention

Max Mobility
SmartDrive

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# PAPAWs

- Translating handrim forces into direction of movement
  - Some systems react differently to forces on each handrim. User may push with uneven forces. Most similar to typical MWC propulsion.
  - Some systems read forces on both handrims together for smoother propulsion. Smarter electronics.

Frank
Mobility
E-motion

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# PAPAWs

- Uses
  - Client who is not an efficient MWC user, but is reluctant to move to a PWC
  - Injury prevention
  - Energy conservation
  - Increases distance for some users
  - Increases access/control on slopes and varied terrain

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# PAPAWs

- Drawbacks
  - Weight
  - Cost
  - Reduces ability to do wheelies
  - May impact accessibility

Max Mobility
SmartDrive

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# So if these increase efficiency that much…

- Why doesn't everyone use them?
- Good question!
- Research has shown that all these strategies basically compensate for MWC design issues that lead to injury and pain that worsens over time.

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## So if these increase efficiency that much…

- Most users are not aware of these technologies and are often resistant to more technology than they need.
- Most funding sources are not aware of these technologies and are reluctant to pay for more than they believe is necessary.
- Future – hopefully improved design and awareness through education

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## Case Study

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# Case Study

- DeShawn
- Transverse Myelitis
- 13 years old
- Middle School

Quickie 2

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# DeShawn

- DeShawn was using an ultralightweight MWC with customized seating.
- He was able to propel throughout his school, though this was slow and took a lot of energy, especially for longer distances.
  - Moving from class to class
  - Led to fatigue that was impacting school performance

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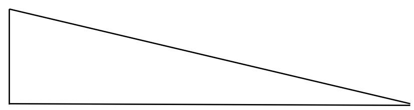
# DeShawn

- He also could not slow his speed when going down a ramp.
- He did not have adequate strength to propel up a ramp.
- As a result, he was dependent for these activities.



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# DeShawn

- Power Wheelchair?
- We considered a power wheelchair, but DeShawn was very reluctant to move to a power wheelchair.
- The family did not have an accessible vehicle, and they needed something they could fold.

Quickie QM-7

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# DeShawn

- We arranged for a trial with some PAPAWs
- We could remove his rear wheels so that he could try the PAPAWs on his own MWC.
- He liked them!

Quickie
Xtender



# DeShawn

- Funding
  - We were concerned about funding, as these were costly
- We measured how long it took DeShawn to move between specific locations before and after the PAPAWs.
- We documented situations he was unable to manage in the current MWC.
  - i.e. up a ramp
- We then documented if he could perform that task with the PAPAWs.

# DeShawn

- Examples of appropriate measures
  - Wheelchair Propulsion Test
  - Wheelchair Skills Test ⟹

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# DeShawn

- His Mom tried to take the MWC apart and put this in her vehicle.
- It was heavier, but she could do it.
- She decided his function was more important and agreed to pursue the PAPAWs.

Public Domain image

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# DeShawn

- Results
  - DeShawn was independent in all of his mobility, including varied terrains and slopes.
  - He no longer had to depend on others or risk becoming ‘stuck’.
  - He was not as fatigued and so was better able to participate at school.



# Take Home Message:

- Many people using a MWC are inefficient in self-propulsion.
- Many people who self-propel develop injuries and pain.
- Options exist which close the gap between MWCs and PWCs.

## References:


- DiGiovine, C. & Berner, T. (2018). In Seating and Wheeled Mobility: a clinical resource guide, eds M. Lange & J. Minkel, Slack, Thorofare, NJ.


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## Questions?

- Email

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## Thank You!

## Contact Information

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