Manual Wheelchair Seating and Mobility

Preserving the Upper Limb and Promoting Function Throughout the Lifespan

Kristen Fiola, PT, DPT
Zachary Staats, OTR
Disclosures

Zachary Staats, OTR and Kristen Fiola, PT, DPT have no financial interest or relationships to disclose.
Meet Your Presenters!
Objectives

• Describe the components of the mat evaluation to better determine a client’s seating and positioning needs related to:
  – Promoting participation in functional activities.
  – Promoting neutral alignment of the pelvis, spine, shoulders, head, and neck.
  – Reducing the risk of future spinal deformities and upper extremity overuse injuries.

• Discuss the differences between standard, lightweight, and ultra-lightweight manual wheelchair frames, and how these differences impact upper limb preservation.

• Describe various wheelchair accessories with respect to impact on seated posture, function, and upper limb preservation.

• Identify optimal wheelchair configuration as defined by the Clinical Practice Guidelines for Preservation of Upper Limb Function Following Spinal Cord Injury.
You Got This One?

Whose Job Is It?
Interdisciplinary Approach

• Ownership of wheelchair seating and positioning varies between facilities.

• Both OT and PT provide valuable input regarding a client’s seating and mobility needs.
What’s the Big Deal?

• Shift in Biomechanics

• Function

• Self-Identity
AND...

The client spends an awful lot of time in that thing.
The Journey Begins…

Don’t forget to bring the client with you.

Educate, educate, educate!
Seating and Positioning

• Every wheelchair user is unique, physically and psychologically.
• Environments vary.
• Needs of the wheelchair users vary.
• Each combination of user and wheelchair is new and, thus, always a challenge.
• This is true for ANY long term wheelchair user.
How Should One Sit?

- Pelvis in neutral or slight anterior pelvic tilt
- Natural spinal curves
- Shoulder girdle above pelvic girdle
- Head balanced and aligned in midline
- Thighs/femurs loaded
- Feet supported and loaded
How Should One Sit?

• Considerations
  – Stability
  – Pressure distribution
  – Ability to lean forward
  – Variation
  – Freedom of the feet
  – Safety and Security

• Which of these considerations impact function?
Client Interview

- Comprehensive Medical and Surgical History
- Cognition
- Visual/perceptual deficits
- Occupational profile
  - Life roles and responsibilities
  - Self-management skills
  - Routines
- Environmental Assessment
- Vocational Demands
- Ability to maintain recommended equipment
The Mat Evaluation

- Observe the patient’s movement.
  - Transfers
  - Transitional movement
- Perform a comprehensive assessment in sitting and supine.
- Attempt to position the client’s pelvis and trunk as close to neutral as possible prior to beginning your assessment.
The Mat Evaluation

- Pelvic Alignment
  - Obliquity
  - Tilt
  - Rotation

- Trunk Alignment
  - Kyphosis
  - Lordosis
  - Scoliosis
  - Trunk rotation
The Mat Evaluation

• Shoulders
  – Rounded
  – Internally rotated

• Scapulae
  – Abduction/adduction
  – Upward/downward rotation
  – Elevation/depression
  – Winging and tipping

• Head Alignment
  – Forward head
  – Rotation
  – Lateral Flexion
The Mat Evaluation

• Lower Extremity ROM
  – Hip flexion
  – Hip abduction
  – Hip internal/external rotation
  – Knee flexion/extension
  – Dorsiflexion/plantar-flexion
  – Inversion/eversion

• Remember that you are examining ROM available for seated posture.
The Mat Evaluation
The Mat Evaluation

- Contractures – fixed vs. flexible
- Trunk stability and mobility
- Hypertonicity
- Pain influenced by seated posture
- Muscle strength in relation to maneuvering a wheelchair and changing position
The Mat Evaluation

• Place the patient at the edge of the mat as close to 90-90-90 as possible.

• Measurements
  – Seat to top of head
  – Seat to top of shoulders
  – Seat to axilla
  – Seat to elbow
  – Seat to inferior angle of scapula
  – Head width
  – Shoulder width
  – Chest width
  – Hip width
  – Back of hip to back of knee
  – Bottom of heel to back of knee
  – Foot length
Wheelchair Frame Selection

“Provide manual wheelchair users with a high-strength, fully customizable manual wheelchair made of the lightest possible material.”

Wheelchair Frame Selection

- Lightweight Wheelchair (K0003)
- High-Strength, Lightweight Wheelchair (K0004)
Wheelchair Frame Selection

The Ultra Lightweight Wheelchair (K0005)

Ultra Lightweight Wheelchair – Titanium (K0009)
Wheelchair Frame Selection

- Aluminum vs. Titanium
  - Weight
  - Durability
  - Flexibility of Material
  - Aesthetics

- Folding Frame vs. Rigid Frame
  - Weight
  - Durability
  - Ease of loading/unloading
  - Foot propulsion vs. upper extremity only
The Cushion
The Cushion

• Consider
  – Positioning
  – Maintenance
  – Impact on functional performance
  – Comfort
  – Pressure distribution
Pressure Mapping
Pressure Mapping
Pressure Mapping
Pressure Mapping
The Foot Support
The Foot Support

• Consider impact on…
  – Position of the pelvis
  – Function
  – Spasticity
  – Skin and joint protection
The Backrest
The Backrest

• Select a backrest that:
  – Aligns the spine in a neutral position
  – Supports the trunk in midline
  – Allows room for the pelvis
  – Allows the arms to be moved behind the trunk easily.
  – Promotes an upright, stable, and functional position
The Backrest

Tension Adjustable Back Upholstery  Custom Solid Backrest
The Backrest

Tension Adjustable Back Upholstery

Custom Solid Backrest
The Backrest

- Other factors to consider:
  - Ease of managing backrest hardware
  - Durability
  - Weight
  - Comfort
  - Adjustability
    - Height
    - Forward/Rearward
    - Angle
The Armrests
The Armrests

Using our arms to stabilize ourselves is something we all do!
The Armrests

• Consider impact on:
  – Performance functional tasks
  – Posture
  – Pressure distribution

• Excluding the armrests can sometimes promote a more functional, active position.
Wheelchair Accessories

- Tires
  - Pneumatic tires
  - Pneumatic tires with flat free inserts
  - Solid tires

- Casters
  - Larger casters increase rolling resistance.
  - Smaller casters decrease ease of negotiating cracks, bumps, and thresholds.
Wheelchair Accessories

- Push-rims
  - Standard aluminum anodized
  - Friction-coated
  - Ergonomic options

- Push Handles
  - Integrated
  - Bolt-on
Wheelchair Accessories

• Armrests
  – Tubular swing-away armrests
  – T-style armrests
  – Flip-back armrests

• Clothing Guards
  – Removable
  – Integrated
  – Fold-down or flip-back
Wheelchair Accessories

- Heel Loops and Calf Straps
  - Keep feet positioned on the footplate
- Anti-tippers
  - Prevent wheelchair from tipping backward
- Seat Belt
  - Padded or non-padded
  - Push button or lever style
Wheelchair Configuration

• Dimensions
  – Seat Width
  – Seat Depth
  – Seat to Back Angle
  – Back Height
Wheelchair Configuration

- Other Adjustments
  - Camber
  - Rear Wheel Spacing
  - Seat to Footrest
  - Front and Rear Seat to Floor Height
  - Center of Gravity
Wheelchair Configuration

To achieve ideal seat height, the elbow angle should be 100 to 120 degrees when the hand is placed at the top, dead-center of the wheel.
Wheelchair Configuration

Most often, when the seat height is adjusted appropriately, the finger tips should be at same level as the axle when the arms are hanging down to the sides.
Wheelchair Configuration

Lower seat position improves propulsion biomechanics...

BUT

If the seat is too low, the user is forced to push with arms abducted and shoulders elevated.

Impingement Syndrome, anyone?
Wheelchair Configuration

- Adjust the rear axle as far forward as possible without compromising the stability of the user.
  - Decreases rolling resistance
  - Increases contact angle
  - Less muscle effort
  - Lower push frequency
  - Smoother joint excursions
Wheelchair Configuration

The wheelchair is NOT a coat rack!

Adding weight can affect stability.
Time To Put Your Thinking Caps On!
Case Study
Case Study
Case Study
Case Study
Case Study
Case Study
Manual Wheelchair Seating and Mobility

Preserving the Upper Limb and Promoting Function Throughout the Lifespan

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Who’s ready for ROUND TWO?
Objectives

• Describe principles of strengthening related to upper limb preservation.

• Identify wheelchair push stroke mechanics and related risks for the development of upper extremity overuse injuries.

• Identify proper technique and body mechanics for performance of advanced wheelchair skills.

• Discuss clinically feasible methods for the objective assessment of manual wheelchair propulsion.
ICF Model: Health Condition

- Overuse injuries are common in wrist, elbow, and shoulder.
- Shoulder
  - Shoulder problems are common in both tetraplegia and paraplegia (between 30% and 60%).
  - Higher percentages in people with tetraplegia.
ICF Model

Health condition
(disorder or disease)

Body Functions & Structure

Activity

Participation

Environmental Factors

Personal Factors

Contextual factors
ICF Model: Health Condition

• Common shoulder conditions include:
  – Impingement syndrome
  – Capsulitis
  – Osteoarthritis
  – Recurrent dislocations
  – Rotator cuff tears
  – Bicipital tendinitis
  – Myofacial pain syndrome involving cervical and thoracic paraspinals
Body Systems

- Any disruption of the dynamic stabilizers will alter the center of rotation of the humeral head, resulting in excessive excursion of the humeral head in the glenoid fossa.
  - Decreased sub-acromial space, due to osseous changes, muscular and/or capsular tightness/laxity.
  - Altered innervation.
  - Disruption of force couples (e.g., rotator cuff muscles depress humeral head and offset deltoids and supraspinatus).
- Worsened by inflammation, fibrosis of tendons/bursae.

Nawoczenski et al, 2009
Body Systems

People with Tetraplegia

– High joint reaction forces with pushrim contact.
– Increased demand on muscles that depress the humeral head.
– Decreased strength/innervation of rotator cuff muscles.

Mulroy et al, 2004
Activity

- Increased daily weight bearing demands on shoulder during:
  - Transfers
  - Weight shifts
  - Self-care/ADLs
  - Wheelchair propulsion

- Often results in pain less than 1 year post injury. (Requejo et al, 2008).
Activity

• Shoulder joint reaction forces during level wheelchair propulsion (Mulroy et al, 2004).
  – Low to Moderate (8-46N).
  – Average muscle response: low to moderate (14-35% max voluntary contraction).
Activity

Repetitive Nature

Muscle Fatigue

Impingement, Musculotendinous injury
Participation

• Pain only factor correlated with lower quality of life scores (Lundqvist et al, 1991)

• Individuals with UE pain (Dalyan et al, 1999)
  • 26% needed help with functional activities
  • 28% reported limited independence
Participation

Individuals with UE pain

• Higher rate of unemployment
  – 21.4% vs 7.1%

• Rate of full-time employment lower
  – 20% vs 45.2%

(Dalyan et al, 1999)
Participation: Sports

• Wheelchair athletes: increased load and repetitive stress
• Fast propulsion $\rightarrow$ greater forces in shoulder than free propulsion.
  – Increased number of push strokes/min
    (wheelchair basketball, racing, etc.)

Mulroy et al, 2004
Conversely, increased strength and endurance of athletes may have protective effect on the shoulder. (Mulroy et al, 2004)
How Can We Help?

• Strengthening and stretching program
• Education
• Assess past medical and social history
  – Job and leisure requirements
• Body habitus
• Wheelchair configuration
Stretch the Front…

- Upper Trap
- Pectoralis (chest)
- Long head of biceps
- Posterior shoulder capsule
…and Strengthen the Back

- Rotator Cuff/Scapular
  - Middle & Lower Traps
  - Serratus Anterior
  - External Rotators
- Shoulder and Elbow
  - Shoulder Extensors
  - Elbow Extensors
  - Elbow Flexors
Education

- Educating client on shoulder preservation
  - ADL
  - Mobility
    - Transfers
    - Push stroke mechanics
  - Personalize recommendations specific to the individual.
    - Past medical history
    - What are their participation level goals?
- Get them to buy in!!!
  - Show them the literature.
How *Should* You Propel?

- Can’t avoid the excessive demands on shoulder.
- Can implement techniques to decrease forces through the upper extremities.
Pushing a Wheelchair

• 4 identified push techniques
  – Single loop over
  – Double loop over
  – Arching
  – Semi-circular

• Most common: single loop over
• Most efficient: semi-circular
Propulsion Technique

Single Loop-Over

Double Loop-Over
Propulsion Technique

Arching

Semi-Circular
Propulsion Technique

- Educate the patient to use long, smooth strokes that limit high impacts on the pushrim.
- Educate the patient to allow that hand to drift down naturally, keeping it below the pushrim when not in actual contact with that part of the wheelchair.
Propulsion Technique

• Semi-circular pattern is associated with
  – Lower stroke frequency
  – Greater time spent in the push phase
  – Less angular joint velocity and acceleration

• Semi-circular pattern decreases abrupt changes in direction and extra hand movements.
Propulsion Technique

• Recommendations:
  – Use the semi-circular pattern!
  – Ride it out, optimize each push.
  – Avoid friction of hands on the wheels.
  – Evaluate wheelchair configuration, check out the shoulder and elbow position.
Pushing a Wheelchair
Wheelchair Configuration

A quick review from Part One…

Seat height and position of rear axle are key to creating an efficient push stroke!
Wheelchair Configuration

- Lower seat position improves propulsion biomechanics
  - Greater upper limb motions
  - Greater contact angle
  - Lower frequency
  - Higher mechanical efficiency

- However, if the seat is too low, the user is forced to push with arms abducted and shoulders elevated.
Wheelchair Configuration

- Adjust the rear axle as far forward as possible without compromising the stability of the user.
  - Decreases rolling resistance
  - Increases contact angle
  - Less muscle effort
  - Lower push frequency
  - Smoother joint excursions
Propulsion Training

• Frequency of propulsion
  – Approximately 1 push per second
  – Decreased frequency = decreased demands on the shoulder joint.

• Contact Angle
  – Approximately 100 degrees from pushrim contact to pushrim release.

• Velocity
  – 1.06 m/s to safely cross an intersection
  – 1.36 m/s is average walking speed
The SmartWheel

- The SmartWheel is a clinical assessment tool used to objectively measure:
  - Velocity
  - Force exerted on the pushrim
  - Push frequency
  - Push angle
The SmartWheel

- The SmartWheel can be used for:
  - Propulsion Training
  - Equipment Selection
  - Equipment Justification
  - Equipment Set-up
  - Comparison to National Database
No SmartWheel? No Problem!!

- So what if my clinic doesn’t have a SmartWheel?
  - Set up a straight path and measure distance.
  - Instruct patient to start propelling when he/she is ready. Begin stop watch as soon as hands contact the pushrim.
  - Count the number of push strokes during the trial.
  - Stop the stop watch when the patient crosses the finish line.
  - Velocity is distance/time.
  - Push frequency is number of pushes/time.
No SmartWheel? No Problem!!

• Be sure to observe the patient’s propulsion style and provide education as needed! Information can be used to
  – Objectively document propulsion style.
  – Compare wheelchair frames.
  – Determine wheelchair set up.
  – Train patients on proper propulsion technique.
Advanced Wheelchair Skills

• Not for everyone!!!
• Considerations:
  – Age
  – Personality
  – Body Habitus
  – Coordination
  – Strength
  – Flexibility
Who is appropriate for advanced level skills?

- Hand function
  - Assists in the maneuverability of the wheelchair.
  - Some patients with tetraplegia are able to perform advanced wheelchair skills – slower to progress.
Who is appropriate for advanced level skills?

• Abdominals
  – Assist with trunk balance.
  – The lower the level of paralysis, the easier the skills should be.
Reminder

Practice in the clinic is important,  
BUT  
mastery can only be achieved with practice outside in the community!
Remember…
Where do we start?

- Static wheelies!!!
- Learn the balance point
- Assess center of gravity
  - Too tippy? Need to adjust rear axle?
Static Wheelies

• Training progression
  – Place patient into the wheelie position
  – Find the balance point
  – Maintain the balance point

• Teach the patient to assume the wheelie position
  – Quick forward stroke to pop-up the casters
Dynamic Wheelies

- Forward
- Backward
- Turns/circles
And now…Apply what you have learned!

- It is usually easier to negotiate rough terrain in a wheelie position.
- Need to perform dynamic wheelies for most advanced skills.
  - Ramps
  - Curbs
  - Stairs
  - Escalators
Ramps: Going Up

- Lean forward into the slope of the ramp
- Steeper slope
  - Shorter, simultaneous strokes.
  - Move hands rapidly between pushes.
Ramps: Going Down

- Control the wheelchair by the resistance of your hands on the pushrims.
- Lean trunk backward into the slope of the ramp.
- May use zig-zag motion to slow momentum.
Curbs: Going Up

- Static start
  - Lower curbs
- Dynamic start
  - Hints
    - Momentum
    - Timing
    - Technique
Curbs: Going Down

• Backward
  – Lean forward and control the back tires to the ground
  – Back off in a wheelie

• Forward
  – Transition to wheelie
  – Maintain the wheelie until on the lower surface
Stairs: Going Up

• Forward or Backward
  – With 1 railing and a hand on 1 tire
  – With 2 railings
Stairs: Going Down

• Backward
  – One or two railings

• Forward
  – Controlled wheelie
    • Easiest when a large horizontal surface and small vertical rise.
    • Easiest when small series of steps rather than a long flight of stairs.
Escalators: Going Up

- Roll forward and place the front casters on the step.
- Grab the handrails and allow the motion to take you up.
- Remember at the top to push off so that the casters do not get stuck.
Escalators: Going Down

- Descend backward
  - Grab the handrails
  - Lean forward and allow the motion to take you down.
Hill: Up and Down
The “Take-Home”

• Assess your client thoroughly.
• Choose the appropriate frame and accessories.
• Consider configuration.
• Provide a thorough exercise program.
• Educate on the correct propulsion technique.
• Teach skills for success in all environments.
The “Take-Home”

Regardless of our specific disciplines, we all play valuable roles in ensuring the needs of the client are thoroughly met.

Together, we can all help to preserve upper limb function and promote functional performance throughout the lifespan of individuals with spinal cord injury.
Questions?
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Obtaining CME Credit

If you would like to obtain CME credit for this activity, please visit:

http://www.pesgce.com/PVAsummit2011/

This information can also be found in the Summit 2011 Program on page 8.


References


