Manual Wheelchairs

Options, Configuration and Propulsion Biomechanics

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Acknowledgements

PVA
PARALYZED VETERANS OF AMERICA

Acknowledgements

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Overview

- K-Classification of manual WCs
- Wheelchair comparison data
- Components and set-up
- Pain and repetitive strain injuries
- Propulsion biomechanics
- Injury prevention

Standard
(K0001)

- Heavy > 36 lbs
- Limited dimensions
- Non-adjustable
- Sling upholstery
- Indoor use
- Multiple-user transport
- Low cost
- Hemi height possible

Invacare Tracer EX2

K0002 and K0003

- Standard Hemi (K0002)
  - Lower seat height (17" to 18")
- Lightweight (K0003)
  - Weight 34-36 lbs
  - Patient cannot self-propel a K0001
- K0001->K0003
  - Short-term use

Sunrise Quickie Guardian 3000 (K3)

High-Strength Lightweight
(K0004)

- A little lighter (< 34 lbs)
- More sizes available
- Limited adjustability
- Appropriate when
  - Dimensions not available in K0001-3
  - Used less than 2 hours/day
  - Cannot "engage in frequent activities" in K0001-3
  - Users are less active and agile
- Certificate of medical necessity

Invacare Action Patriot

Ultra-Lightweight
(K0005/K0009)

- Very light (20-30 lbs)
- Fully customizable
- Quick release axles

Invacare Top End

Quicki GPV

Rigid Frame Ultralight

- Varied materials
- Many frame designs
- Adjustable/custom
- Active users
- Individual consideration
  - Describe routine activities
  - Describe features which are needed compared with K0004

Key Features of Ultralights

- Durable
  - *Cooper et al., 1999*
- Cost effective to operate
  - *Cooper et al., 1996; Cooper et al., 1997; Fitzgerald et al., 2001*
- Custom configured via adjustability or frame design for:
  - Comfort (DiGiovine, 2000)
  - Postural support (Hastings, 2003)
  - Skin protection (Cook, 2002)
  - Efficient propulsion & injury prevention

  (Brubaker, 1986; Beekman, 1999; Boninger, 2000; Richter, 2001)

Heavy Duty Wheelchairs

- Heavy duty (K0006)
  - > 250 lbs
  - Or severe spasticity
- Extra Heavy Duty (K0007)
  - > 350 lbs
  - Heavy (100 lbs)

Wheelchairs of Kansas Wizz-ard

Regency XLC

Other MWCs

- Adult Tilt-n-Space (E1161)
- E1231 – E1238
  - Pediatric tilt-n-space, folding or rigid, with and without seating system
- Other Base (K0009)
  - Include narrative description of item, make/model, and statements justifying medical necessity

Invacare Solara

Many MWC Options . . .

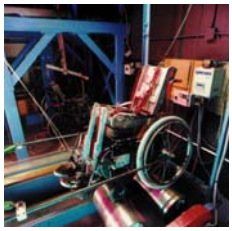
Life-Cycle Analyses

(Cooper et al., 1999; Fitzgerald et al., 2001)

- Performance of selected wheelchairs determined by ANSI/RESNA standardized tests
- Compare the durability, stability, and cost-effectiveness of depot (K0001), Lightweight (K0004), and Rehab Wheelchairs (K0005)

Test Cycles

- 200,000 drum cycles
- 6,666 curb drops



Mean Life Cycles

(Fitzgerald et al., 2001)

- Depot (K0001): 117,210
- Lightweight (K0004): 200,029
- Ultralight (K0005): 309,362

Cost Findings

(Cooper et al., 1999)

- Depot (K0001) = 78 Cycles/$
- Lightweight (K0004) = 112 Cycles/$
- Ultralight (K0005) = 263 Cycles/$

K0005 Conclusions

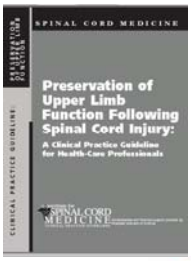
- Get more than three times value of a K0001
- Get more than two times value of a K0004
- Have more adjustability
- Are easier to propel
- Are more comfortable

Manual Wheelchair Configuration Recommendations

Ultralights are the ONLY option for active, full-time users

Clinical Practice Guideline (PVA, 2005)

#7. "Provide manual wheelchair users with SCI a highstrength, fully customizable manual wheelchair made of the lightest possible material." (p.1)



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Rear Axle Position

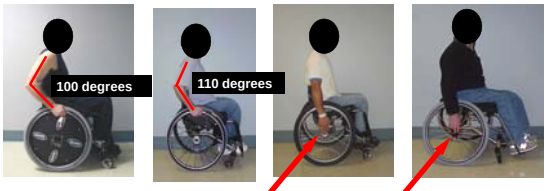
- Moving axle forward
  - Brings seat "back"
  - Wheels closer to the front of the body

Rear Wheel Forward

Supported by research . . .

- Decreased roll resistance (Brubaker et al., 1986)
- Handrim contact increased (Hughes et al., 1992)
- Propulsion with less muscle effort, smoother joint patterns & lower stroke frequency (Masse, 1992)
- Lower peak forces, less rapid loading of pushrim, fewer strokes, greater contact angles with handrim (Boninger et al., 2000)

Vertical Axle Position



- With hand at top dead center of handrim, recommended elbow angle is between 100 and 120 degrees (van der Woulde, 1989)
- Strong clinical correlation with center of finger at center of axle

Vertical Axle Position

Seat too low | Seat just right | Seat too high

Camber

- Improved access to the pushrim
- Advantageous or turns
- Increased roll resistance
- Increased lateral stability
- Increased width

Seat & Back Width

- Snug fit without skin or comfort compromise
- Must optimize frontal plane alignment *FIRST*

Seat Depth

- Determine from evaluation, identified needs, front frame angle and knee flexion
- Optimize sagital plane posture before determining seat depth
- Consider front frame angle, knee and foot position

Seat Angle (Slope)

- Facilitates stabilization of the pelvis and trunk in combination with back height and angle
- Sagital plane alignment
- May make transfers more difficult – teach skills

Seat-to-Floor Heights

Considerations:

- Front / Rear = Seat Slope
- Rear Wheel Access
- Clearance
- Transfers
- Postural Support

Seat-to-Floor Heights

- Foot propulsion

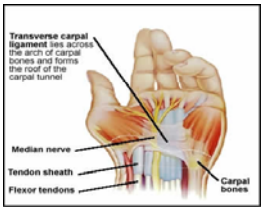
- Sling vs. Solid Seat

Backrest Height

- Configure back height in conjunction with back angle and seat slope
- Must be high enough that pelvis and trunk are well supported, low enough to allow available full upper body function and optimized postural alignment (i.e. thoracic flexion over lumbar extension).

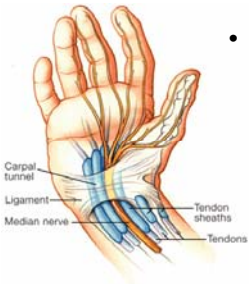
Back Height

Wheelchair Use & Pain Carpal Tunnel Syndrome (CTS)



- High prevalence in wheelchair users – ranges from 40%-70%
  (Gellman et al., 1992; Aljure et al., 1985; Gellman et al., 1988; Tun et al., 1988; Davidoff et al., 1991)
- Correlation of median nerve injury to wheelchair propulsion
  (Boninger et al., 1999; Boninger et al., 2003)

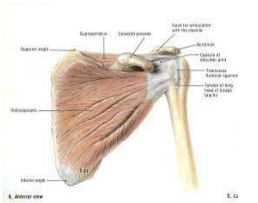
WC Use and CTS



- Key Factors:
  - Repetition
  - Force application
  - Extreme wrist range of motion
  - Presence and magnitude of wrist flexor activity
  - Vibration

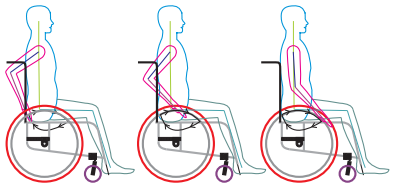
Shoulder Pathology

- Shoulder pain common in wheelchair users with prevalence 31%-73%
  (Gellman et al., 1988; Bayley et al., 1987; Wylie et al., 1988; Nichols et al., 1979; Sie et al., 1992; Subbarao et al., 1994)
- Wheelchair propulsion is just ONE of many factors to evaluate

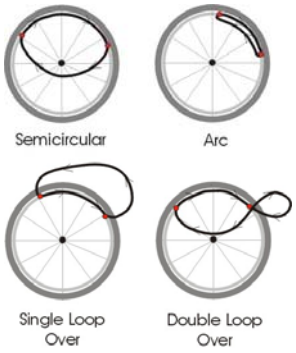


Wheelchair Propulsion

- Propulsion Phase
- Recovery Phase



Propulsion Patterns



Propulsion Patterns

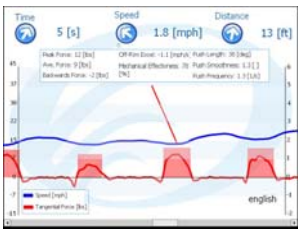
- Single-loop over most common pattern (45%)
  - DLOP, SC, then ARC
- Semi-circular corresponds with
  - Reduced stroke frequency
  - More time spent in push phase
  - More efficient
- Racing Technique

(Boninger et al., 2002)

Reach back and contact rim

Release rim in full elbow extension

Propulsion Training



SmartWheel Graphical Display

Propulsion Biomechanics in Multiple Sclerosis

(Fay et al., 2004)

- Compared biomechanical analysis of 13 people with MS to 15 with paraplegia
- Findings:
  - Propel at slower velocities
  - Produce higher propulsive forces
  - Produce braking moments at beginning and end of push phase

MWC Options & Accessories

- Arm supports
- Side guards
- Rear wheels
- Wheel locks
- Pushrims
- Casters
- Seating interface

MWC Maintenance

- Tires inflation
- Rear Wheel Alignment
- Front Caster Alignment
- Wheel & Caster Bearings
- Upholstery
- Wheel locks