
# Shoulder Evaluation and Intervention for Manual Wheelchair Users

Wendy M. Koesters, PT, ATP/SMS
Carmen P. DiGiovine, PhD ATP/SMS RET

The Ohio State University
Wexner Medical Center

# Outline

- Part I
  - Overview of injury risk and location for manual wheelchair users
  - Assessments to localize dysfunction
  - Intervention strategies via standard of practice with Physical Therapy.
- Part II
  - Evaluate current equipment use
    - Modifications, replacement, mechanical add-on, power add-on or power wheelchair
  - Assessment tools to aide in evaluation of manual wheelchair configuration and technique
- Part III
  - Future prevention strategies
  - Case studies

# Objectives

- State clinical prediction rules for the most common shoulder dysfunctions encountered by manual wheelchair users
- Demonstrate 3 home program interventions to increase scapular stability/posterior shoulder girdle strength for client's with impaired core stability such as SCI.
- State 3 therapist guided activities to improve shoulder flexion.
- State 2 outcome measures to assess impact of intervention both via therapy intervention and w/c set up

# Resources on Upper Extremity Preservation

- Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) Position on the Application of Ultralight Manual Wheelchairs

DiGiovine et al, 2012.

- Preservation of Upper Limb Function Following Spinal Cord Injury: A Clinical Practice Guideline for Healthcare Professionals, 2005

Boninger et al, 2005.

# Resources on Upper Extremity Preservation

- The need for updated clinical practice guidelines for preservation of upper extremities in manual wheelchair users: a position paper

  Sawatzky et al, 2015.

- Pushrim biomechanics and injury prevention in spinal cord injury: recommendations based on CULP-SCI investigations, 2005.

  Boninger et al, 2005.

# It's all about…functional independence and upper extremity preservation

- According to the Consortium for Spinal Cord Injuries Clinical Practice Guidelines 2005 (Surveys and Cross Sectional Studies) it is estimated to be up to **60%** incidence in SCI.
- Shoulder pain is a problem in up to **86%** of persons with spinal cord injury.

Eriks-Hoogland et al, 2014.

**Evaluation and Treatment of the Shoulder Complex in Individuals with Spinal Cord Injury:** Utilizing the Best Available Evidence
**Martin J. Kilbane, PT, OCS** *November 17, 2014*

- **63% vs. 15%** will have a rotator cuff tear comparing long-term manual wheelchair users vs. matched able-bodied group.

Morrow et al, 2014

# Upper Extremity Preservation

- Only 2% of this population undergoes shoulder surgery treatment for rotator cuff tear and shoulder disability (out of 60% who reported pain).

Pellegrini et al, 2012.

- Reduction in shoulder pain were related to significant increases and social participation and improvements in quality of life in people with long term paraplegia.

Kemp et al, 2011.

**Evaluation and Treatment of the Shoulder Complex in Individuals with Spinal Cord Injury:** Utilizing the Best Available Evidence **Martin J. Kilbane, PT, OCS** *November 17, 2014*

# Predisposing factors for injury for wheelchair users:

- Poor sitting posture
- Muscle imbalance
- Weight bearing upper extremity
- Improper wheelchair configuration
  - Rear wheel horizontal and vertical position
    - Access to wheel
    - Stability
    - Maneuverability
  - Frame size

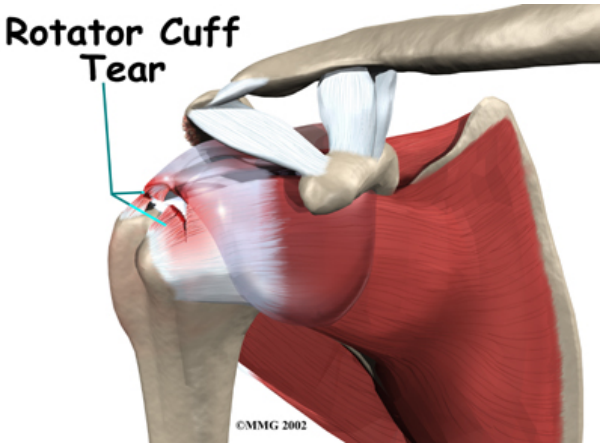
# Biomechanical factors linked to injuries

- High frequency tasks
- Forces required to complete tasks
- Extreme positions
  - Wrist
  - Hand above shoulder
  - Extreme shoulder internal rotation and abduction (=impingement)

Boninger et al, 2005

# Most common injuries from repetitive strain

- Carpal Tunnel Syndrome
- Rotator Cuff tear
- Impingement syndrome of shoulder
- Chronic pain syndromes cervical and thoracic spine
- Bicep tendonitis
- Tennis elbow




www.houstonmethodist.org

Boninger et al, 2005

# Warning signs

- Pain with palpation
- Active movement or stretching of involved tissue
- Pain with overhead activities
- Difficulty with repetitive arm motions
- Difficulty with upper body dressing
- Impaired sleep- particularly side lying

# Seating Therapist to Clinical Therapist

1. Optimize biomechanics, strength and flexibility
2. Equipment fitting and skill of use
3. Injury intervention and prevention

# Evaluation

1. Medical diagnosis
2. Systems review to rule out contributing factors
3. Clinical exam
4. Functional assessment

# Evaluation

1. **Medical diagnosis**
    a) Muscle innervation
    b) Sensation
    c) Postural control
    d) Spasticity
    e) Fatigue
2. Systems review to rule out contributing factors
3. Clinical exam
4. Functional assessment

# Evaluation

1. Medical diagnosis
2. **Systems review to rule out contributing factors**
3. Clinical exam
4. Functional assessment

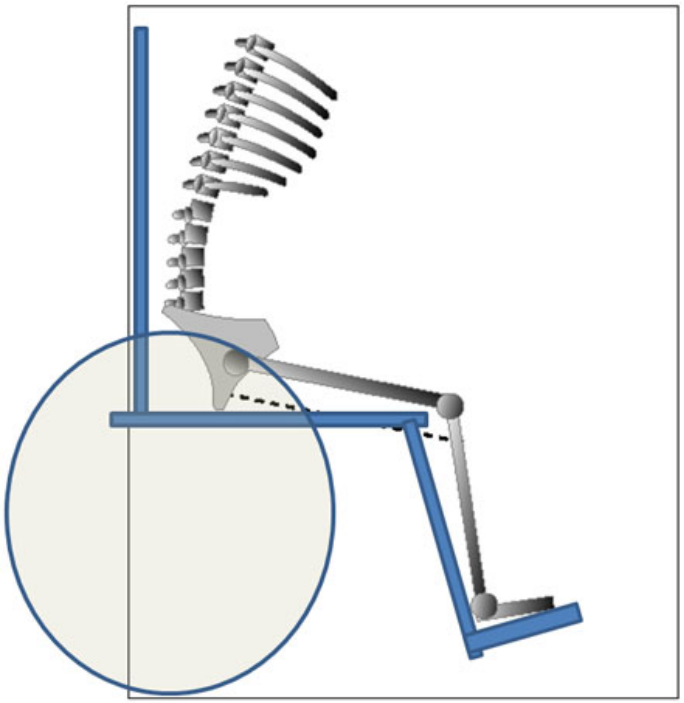
# Evaluation: Clinical Exam

1. Medical diagnosis
2. Systems review to rule out contributing factors
3. **Clinical exam**
   a) Posture
   b) Palpation
   c) Scapular position
   d) Flexibility
   e) Strength
   f) Special tests
   g) Outcome measures (WUSPI, DASH, SPADI)
4. Functional assessment

# Evaluation

1. Medical diagnosis
2. Systems review to rule out contributing factors
3. Clinical exam
4. **Functional assessment**
    a) Transfer, bed mobility, sleep position
    b) Self care
    c) Work, recreation, sport
    d) Wheelchair skill level
    e) Pressure relief

# Posture



http://www.mychhs.colostate.edu

- Forward head
- Kyphosis
- Scapular protraction
- Posterior pelvic tilt

"Repetitive wheelchair propulsion mechanics encourage repetitive protraction of the scapula, which has been suggested to lead to altered posture, weaker scapular stabilizers and tighter anterior muscles".

Aytar et al, 2014.

# Palpation

- Deltoid
- AC joint
- Cervical spine
- Upper trap
- Anterior joint
  - Long head of bicep
  - Supraspinatus insertion
- Posterior joint line
- Scapular border

# Scapular position

ID rest position

- Superior
- Medial / winged
- Abducted and downwardly rotated –monitor at inferior angle

Abnormal position a result of lack of innervation or abnormal force couples:

- Deltoid vs. rotator cuff
- Upper trap vs. serratus anterior and lower trapezius
- Anterior vs. posterior rotator cuff

Abnormal force couples impact glenohumeral rhythm with resulting *impingement*.

When rotator cuff is dysfunctional pressure from humeral head into subacromial arch is increased approximately 60%.

Ludewig and Cook, 2000

# SCI- force couples are out of balance

- Hypertrophied upper trapezius
- Overactive levator scapula
- Tight and over dominant pectorals
- Overactive and tight shoulder internal rotators
- Weak rhomboids
- Weak lower trapezius
- Weak serratus anterior
- Weak shoulder external rotators

# Shoulder screening

- ✓ AROM
  - ✓ r/o capsular tightness
  - ✓ Instability- be cautious
- ✓ Strength
- ✓ Special Tests
- ✓ Outcome Surveys
  - Establish baseline
  - Make objective goals
  - Track progress
- ✓ Education on results
- ✓ Appropriate referrals

## Clinical prediction rules for specific diagnosis

- Cervical radiculopathy
- Sub acromial impingement
- Acromioclavicular joint involvement
- Rotator cuff tear
- Carpal Tunnel Syndrome

## Rule in/ Rule out

- Labral pathology
- Elbow tendonitis

Sample documentation for EMR- see appendix

# Therapy intervention

- Activity modification
  - Transfers with excessive IR of shoulder
  - reaching into back pack behind chair
  - lifting use elbow flexors
  - height of frequently used items on lower shelves
  - Sleep position
  - ergonomic evaluation of work station: APTA
- Joint protection
  - decreasing frequency of prop forward onto elbows (kyphosis, axial extension end range)
  - bracing on tire
  - hooking on arm rest
- Energy conservation

# Therapy intervention

- Taping and/or modalities for pain management
- Individualized home program for flexibility and strength
- Return to sport

# Flexibility

- Joint mobilizations
  - Caution with cervical spinal cord injuries, hemiplegic shoulder
- Stretches
  - Anterior shoulder
    - Pectoralis
    - Shoulder internal rotators
    - Long head of bicep
  - Upper trapezius
  - Posterior capsule (sleeper stretch)
- Pain free movement
  - progressing from passive to active assistive to active
- Normalize biomechanics-scapula humeral rhythm

# Strength

- No weight for unstable scapula
- Target posterior muscles:
  - Supraspinatus (scaption thumb up-30° ER)
  - Infraspinatus/teres minor (external rotation with towel roll)
  - lower trapezius (scaption or pull down)
  - Rhomboids (prone or seated row, scap retraction)
  - serratus anterior (push up plus or punch at 120 degrees)

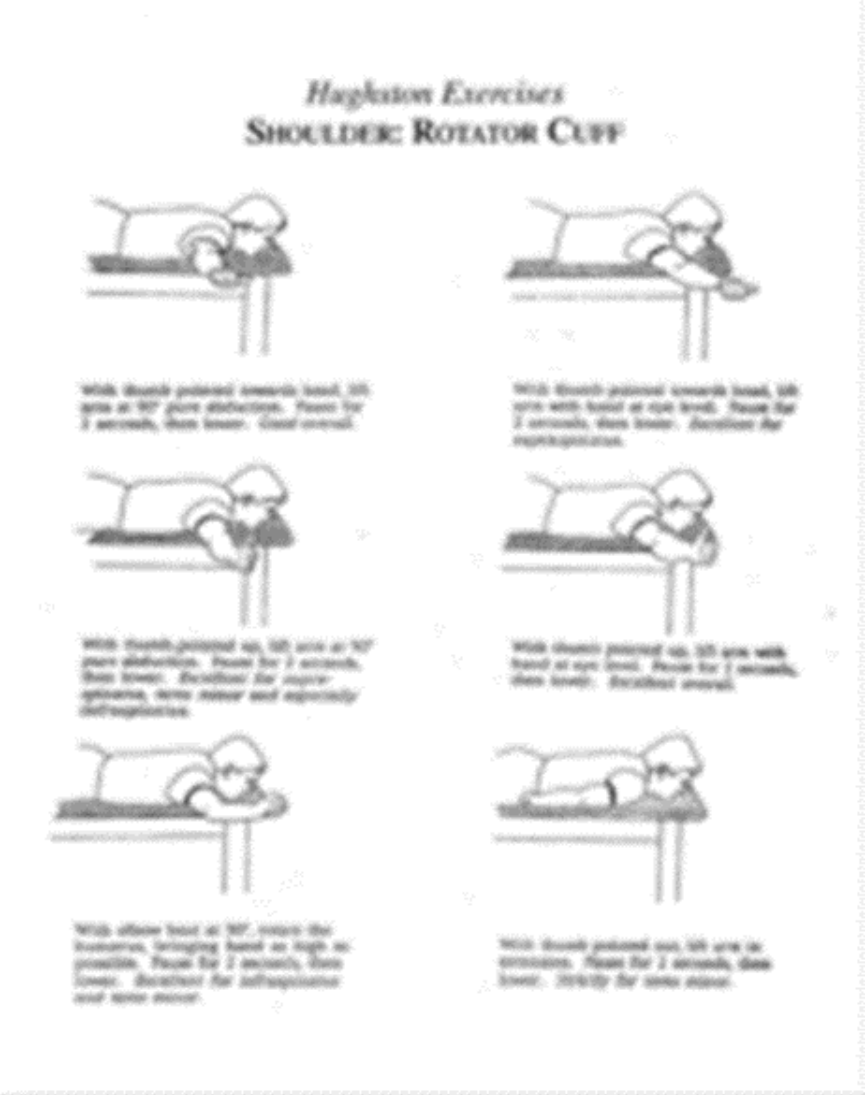
# Strength

- Additional recommended:
  - Shoulder IR, horizontal abduction
- Reps:
  - Untrained 1 set to fatigue 10-15
  - Trained 2-3 sets to fatigue
  - Super sets

# Typical Home Program

1. Posture
   - Cervical retraction, scapular retraction, reverse shoulder rolls
2. Posterior shoulder strength
   - Scaption, row, external rotation, serratus punch at 120°
3. Stretching
   - Anterior shoulder
4. Cardio

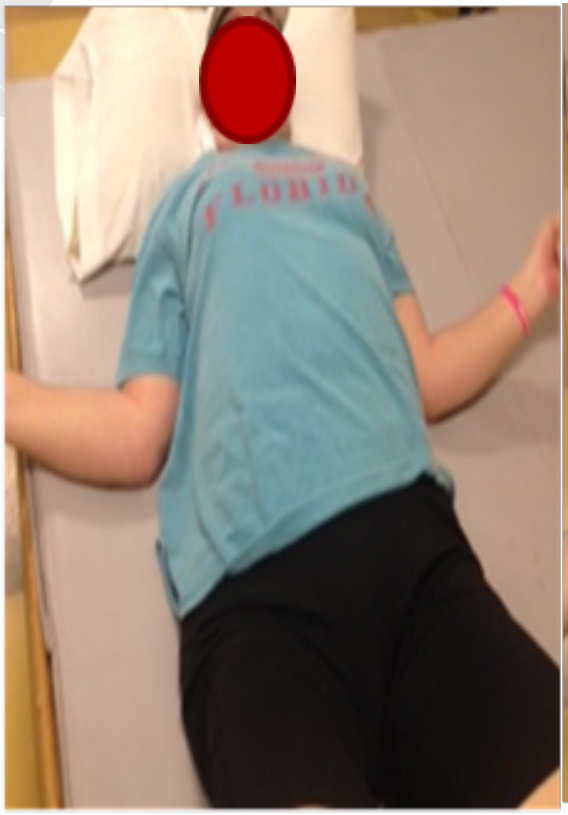
# Written plan- “a picture is worth a thousand words…..”



*Hughston Exercises*

**SHOULDER: ROTATOR CUFF**

Quizlet.com



# Research for specific rehabilitation programs

- PVA consortium for spinal cord medicine. Preservation of upper limb function following spinal cord injury: a clinical practice guideline for health-care professionals. J Spinal Cord Med. 2005; 28(5)" 434-70.
- Sasso E, Backus D. Home-based circuit Resistance Training to overcome barriers to exercise for people with spinal cord injury: a case study. JNPT 2013; 37: 65-71.
- Mulroy S et al. Strengthening and optimal movements for painful shoulders (STOMPS) in chronic spinal cord injury: a randomized controlled trial. Physical Therapy 2011; 91(3): 305-324.
- Kimberle A et al. Effectiveness of exercise programs for management of shoulder pain in manual wheelchair users with spinal cord injury. JNPT 2015, Oct; 39: 1-7.
- Meegan G et al. Effectiveness of home exercise on pain, function and strength of manual wheelchair users with spinal cord injury: a high-dose shoulder program with tele rehabilitation. Archive of Phys Med 2014;95:1810-7.
- Merolla G et al. Assessment of the ability of wheelchair subjects with spinal cord injury to perform a specific protocol of shoulder training: a pilot study. Muscles, Ligaments and Tendons Journal 2014; 4(2): 165-176.
- Aytar A et al. Scapular resting position, shoulder pain and function in disabled athletes. Prosthetics and Orthotics internation 2014: 1-7.
- Troy K et al. An exercise trial targeting posterior shoulder strength in manual wheelchair users: pilot results and lessons learned. Disabil Rehab Assist Technol 2014, April 3; 1-6.
  - "Regular exercise improves cardiorespiratory fitness and did not exacerbate shoulder pain in this group of manual wheelchair users".
  - "Exercises that target posterior shoulder muscle groups, such as rowing, may improve muscle balance and reduce the risk of shoulder impingement."

# Questions?

# Pathway

1. Screening (joint, function, pain, develop goals/ priorities)
2. Assessment of current seating vs. new
3. Implementation
    a) Equipment
    b) Wellness
4. Follow up

# Evaluation of current equipment daily use or sport

Take pictures!

# Evaluation of current equipment daily use or sport

## Prioritize Goals – Functional Mobility Assessment

Subject Code: _____

**Functional Mobility Assessment (FMA)**

**DIRECTIONS:**

**Step 1.** Please answer the following 10 questions by **placing an 'X' in the box under the response** (completely agree, mostly agree, slightly agree, etc.) that best matches your ability to function while in your current means of mobility (i.e., walking, cane, crutch, walker, manual wheelchair, power wheelchair or scooter). All examples may not apply to you, and there may be tasks you perform that are not listed. **Mark each question only one time.** If you answer, ***slightly, *mostly, or *completely disagree for any question,** please **write and specify the reason for your disagreement in the C*omments* section.**

**Step 2.** Please determine your priorities, by rating **the importance of the content in each of the 10 questions** in the shaded box to the right of each question. Rate your highest priority as 10, and your lowest priority as 1.

| **What is your current means of mobility device?** *(Check all that apply)* | Walking_____ Walker_____ Cane_____ Crutch_____ Manual Wheelchair_____ Power Wheelchair_____ Scooter_____ |
|---|---|

| | Completely Agree | Mostly Agree | Slightly Agree | *Slightly Disagree | *Mostly Disagree | *Completely Disagree | Does not apply | Rating priority (1-10) |
|---|---|---|---|---|---|---|---|---|
| **1. My current means of mobility allows me <u>to carry out</u> my daily routine as independently, safely and efficiently as possible:** *(e.g., tasks I want to do, need to do, am required to do- when and where needed)* | | | | | | | | |
| **Comments:** | | | | | | | | |
| **2. My current means of mobility meets my <u>comfort needs</u>:** *(e.g., heat/moisture, sitting tolerance, pain, stability)* | | | | | | | | |
| **Comments:** | | | | | | | | |
| **3. My current means of mobility meets my <u>health needs</u>:** *(e.g., pressure sores, breathing, edema control, medical equipment)* | | | | | | | | |
| **Comments:** | | | | | | | | |
| **4. My current means of mobility allows me <u>to be as independent, safe and efficient as possible</u>:** *(e.g., do what I want it to do when and where I want to do it)* | | | | | | | | |
| **Comments:** | | | | | | | | |

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER



Adapted from the FEW(2003) and FAW (2004)

# Gather Data

- Wheelchair user's shoulder pain index (WUSPI)
- Kirby's manual wheelchair skills test (MWST)- establishing a baseline
- Grip strength with dynamometer
- SmartWheel propulsion analysis

# Current equipment

- Key points-
  - Overall length and width
  - Seat to floor front and rear=dump
  - Center of gravity
  - Frame length
  - Cushion size
  - Back height

# Activity and Participation

- Transfer style- floor, uneven height, approach angle
- Lifestyle needs: work, children, access to tables/desks
- Driving and transfer style/goal
- Fears - stability
- Activity in community, sports and recreation

# Activity and Participation continued

- Where is chair used majority of time (i.e. terrain)?
- Impact of spasticity on hip and foot positioning?
- How do you reach for things at home and office?
- Skin integrity-current and history
- Pressure relief strategy and independence in monitoring

# Assessing balance when modifying or completing new configuration choices

- Hand to mouth (Chipolte burrito)
- Forward and lateral reach
- Chair spin
- Reach to floor
- Tippy Test
- Wheelie ability

# Targets with wheelchair configuration

- Dump for balance and skin protection (desk knee clearance)
- Transfer independence
- Elbow flex 100-120 degrees-at top of rim
- Proper width and height plus propulsion strategy for minimal to no shoulder IR =chicken winging

# Targets with Wheelchair Configuration

- No front loading of weight in the chair: castor weight / entire frame target 20%
- Reach goals achieved (floor, shelves)
- Stability on ramps
- Minimize weight: components of chair, no back pack hanging off the back

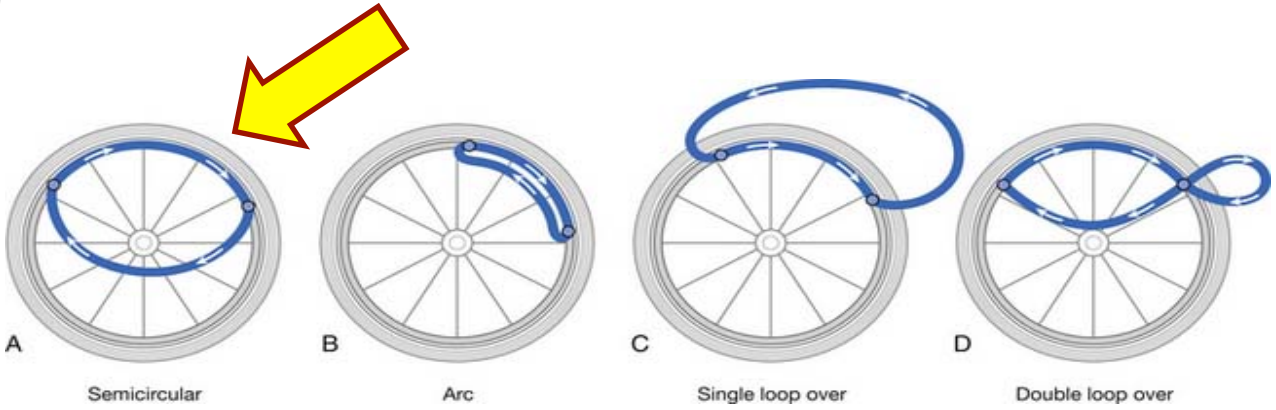
# *Skill training: "How do you push?"*

- CPG recommendations to pushing-
  - Use long, smooth strokes that limit high forces on the hand rim
  - Minimize frequency of repetitive upper limb tasks
  - Minimize forces required to complete upper limb

- *Preservation of Upper Limb Function Following Spinal Cord Injury: A Clinical Practice Guideline for Healthcare Professionals, 2005*

# Optimal stroke:

- “long stroke”




http://clinicalgate.com/wheelchairs-and-seating-systems/

- Semi circular technique

# Propulsion Analysis

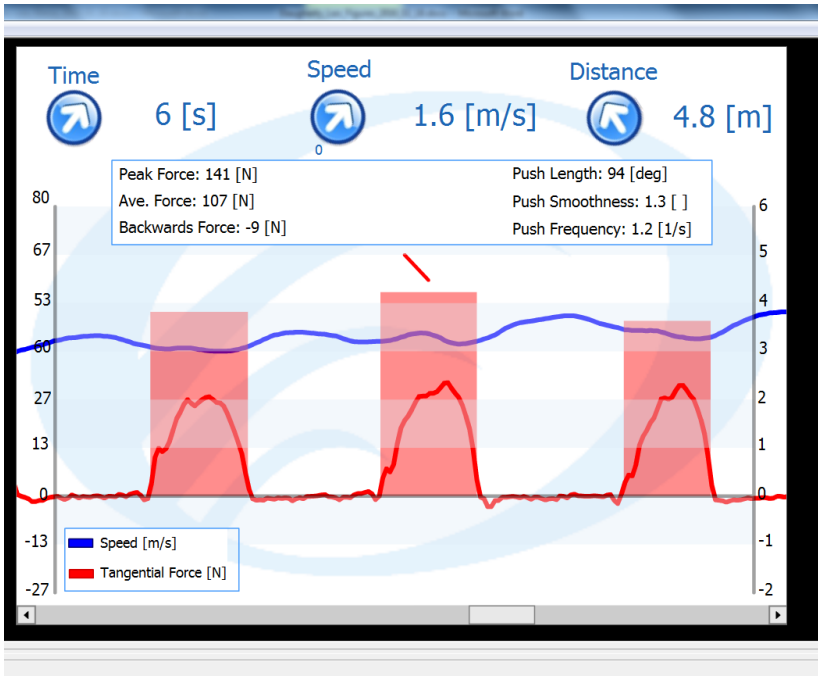
- Wheelchair skills test manual and power
  - Includes transfers (even to floor), ramps 2x of ADA requirement, wheelies, curbs

    http://www.wheelchairskillsprogram.ca/eng/testers.php
- Wheelchair propulsion test (speed, push frequency, and efficiency)

  http://www.wheelchairskillsprogram.ca/eng/propulsion_test.php
- SmartWheel: blue tooth computerized wheel sensor measuring 3D forces and moments at push rim
  - Speed
  - Push frequency
  - Force/braking
  - Push length

# SmartWheel

- Gives valuable visual and measured data to provide education on current ability and assess changes to target areas of deficit
- Establish baseline for comparison in future if skill level declines from overuse




# SmartWheel Intervention

- If short stroke and frequent braking then…
  - assess if balance can be improved via exercise or wheelchair configuration
- If too low of force then…
  - assess if access to wheel can be improved
  - utilize skill training for improved propulsion style
- Data to support power add on to manual wheelchair or transition to power

# Questions

# Future Prevention Strategies

- Assess, fit and train early and often on:
  - Configuration
  - Propulsion
  - transfers wheelchair use plus configuration
- Educate on risk factors
- Educate on conservation
- Identify warning signs
- What can therapy offer?  When?  How?
- Establish feasible home program
- Be their resource for future needs

# Daily use: “It’s a lifestyle….”

# Frank: 42 yo, T9 SCI (7 years post injury)

New wc eval with 6/10 back and 9/10 shoulder pain with self care, transfers-specifically car and chair breakdown.

- Home program: nerve glides, inferior joint mob, RC strength, joint protection, pressure relief strategies
- Educated choices for new ultra light wc
  - Narrower
  - Locking back rest when folded

New Rx: adhesive capsulitis L, carpal tunnel syndrome. Resting global L arm pain 7/10

- DASH, WUSPI
- decreased ROM
- *grip R 85# L 14#*
- Positive CPG for cervical radiculopathy

- Intervention: ultrasound, posterior girdle mob and stretching, ice, traction and deep neck flexor strength. Pain management prior to working into active movement and strength focus posterior shoulder.  OT custom splint.

Post treatment: 4/10 pain with activity

Full ROM and self care, *grip R 85# L65#,* WUSPI drop from 82 to 61, symmetric cervical rotation

- Home program:
  - Stretch pec, bicep, sleeper stretch, upper trap
  - Strength-seated or supine modified hughston's, band row and lat pull down, prone prop with plus.

**Implement new wheelchair:**

shoulder pain 4/10 with activity

- MWST, review of exercise, pressure relief and use of taller Roho

**1 month f/u**

shoulder pain 4/10, continues with ex 3x per week

- Propulsion analysis
- Trialed power add on's- LMN for smart drive completed
- Plan to implement and train on power add on at clinic.


# Manual wheelchair add ons:

- Free wheel
- Smart drive
- Emotion
- Dragonfly
- Widget

# Kelly-35 yo, 17 years post T12/L1 SCI

- Referred for new wc and AC joint pain
- Adapted rower, job that requires propelling long distances plus travel, pain with transfers
- Goal for wc “10# lighter”
- 5/10 R shoulder and back pain

- Explored alternate options to her rigid titanium frame
  - carbon fiber
  - different titanium frame styles

To shave off any extra weight with hybrid titanium frame she chose:

1. Different back rest style with streamlined hardware
2. Rigid side guards
3. Non-folding back rest
4. No foot plate overlay
5. Titanium or carbon fiber components when available

Joint protection=Rethink exacerbating end range motions

- Internal rotation
- Horizontal adduction

1. Pressure relief- limit to no push ups
2. Transfer set up
3. Reach into back pack
4. Wash her back
5. Don bra
6. Car transfer frequency

# Donny- 40 yo, 26 years post C7 SCI

Winter 2014-

Wheelchair assessment

Fall 2015-

PT referral shoulder pain post ITB pump placement. Pain 10/10 with activity in shoulders

Post intervention pain 5/10.

Independent transfers.

# Sources


- Morrow M, Van Straaten M, Murthy N, Braman J, Zanella E, Zhao K. Detailed shoulder MRI findings in manual wheelchair users with shoulder pain. Biomedical Research Internation. Volume 2014, Article ID 769649.
- Eriks-Hoogland IE, Hoekstra T, de Groot S, Stucki G, Post MW, van der Woude LH. Trajectories of musculoskeletal shoulder pain after spinal cord injury: Identification and predictors. J Spinal Cord Med. 2014 May;37(3):288-98.
- **Kilbane, M. Evaluation and Treatment of the Shoulder Complex in Individuals with Spinal Cord Injury:** Utilizing the Best Available Evidence. Inservice, *November 17, 2014*
- Pellegrini A, Pegreffi F, Paladini P, Verdano MA, Ceccarelli F, Porcellini G. Prevalence of shoulder discomfort in paraplegic subjects. Acta Biomed. 2012 Dec;83(3):177-82.
- Kemp BJ, Bateham AL, Mulroy SJ, Thompson L, Adkins RH, Kahan JS. Effects of reduction in shoulder pain on quality of life and community activities among people living long-term with SCI paraplegia: a randomized control trial. J Spinal Cord Med. 2011;34(3):278-84.
- DiGiovine, C., Rosen, L., Berner, T., Betz, K., Roesler, T., & Schmeler, M. (2012). *RESNA Position on the Application of Ultralight Manual Wheelchairs*. Arlington, VA: Rehabilitation Engineering and Assistive Technology Society of North America (RESNA). Retrieved from http://web.resna.org/resources/position-papers/UltraLightweightManualWheelchairs.pdf
- Boninger, M. L., Waters, R. L., Chase, T., Dijkers, M. P. J. M., Gellman, H., Gironda, R. J., … McDowell, S. (2005). *Preservation of Upper Limb Function Following Spinal Cord Injury: A Clinical Practice Guideline for Health-Care Professionals*. Consortium for Spinal Cord Medicine. Retrieved from http://www.pva.org/publications/pdf/upperlimb.pdf
- Sawatzky, B., DiGiovine, C., Berner, T., Roesler, T., & Katte, L. (2015). The need for updated clinical practice guidelines for preservation of upper extremities in manual wheelchair users: a position paper. *American Journal of Physical Medicine & Rehabilitation / Association of Academic Physiatrists*, *94*(4), 313–324.
- Boninger, M. L., Koontz, A. M., Sisto, S. A., Dyson-Hudson, T. A., Chang, M., Price, R., & Cooper, R. A. (2005). Pushrim biomechanics and injury prevention in spinal cord injury: Recommendations based on CULP-SCI investigations. *J Rehabil Res Dev*, *42*(3 Suppl 1), 9–20.
- Aytar A, Zeybek A, Pekyavas N, Tigli A, Ergun N. Scapular resting position, shoulder pain and function in disabled athletes. Prosthetics and Orthotics International. 2014, 1-7.

# Thank You

wendy.koesters@osumc.edu

carmen.digiovine@osumc.edu

1. Ludewig P, Cook T. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Physical Therapy. 2000 March: 80(3): 276-91.

2. http://www.moveforwardpt.com/resources/detail/workplace-wellness

3. Sasso E, Backus D. Home-based circuit Resistance Training to overcome barriers to exercise for people with spinal cord injury: a case study. JNPT 2013; 37: 65-71.

4. Mulroy S et al. Strengthening and optimal movements for painful shoulders (STOMPS) in chronic spinal cord injury: a randomized controlled trial. Physical Therapy 2011; 91(3): 305-324.

5. Kimberle A et al. Effectiveness of exercise programs for management of shoulder pain in manual wheelchair users with spinal cord injury. JNPT 2015, Oct; 39: 1-7.

6. Meegan G et al. Effectiveness of home exercise on pain, function and strength of manual wheelchair users with spinal cord injury: a high-dose shoulder program with tele rehabilitation. Archive of Phys Med 2014;95:1810-7.

7. Merolla G et al. Assessment of the ability of wheelchair subjects with spinal cord injury to perform a specific protocol of shoulder training: a pilot study. Muscles, Ligaments and Tendons Journal 2014; 4(2): 165-176.

8. Aytar A et al. Scapular resting position, shoulder pain and function in disabled athletes. Prosthetics and Orthotics internation 2014: 1-7.

9. Troy K et al. An exercise trial targeting posterior shoulder strength in manual wheelchair users: pilot results and lessons learned. Disabil Rehab Assist Technol 2014, April 3; 1-6.

10. Betz K. Pushing a simple task accomplished. PN; 2007, Mar: 30-35.

11. Boninger M et al. Manual wheelchair pushrim biomechanics and axle position. Arch Phys Med Rehab 2000, May; 81; 608-13.

# Appendix A – EMR Tools

# Shoulder screen for electronic medical record

Postural screen:

- Cervical alignment
- Spinal curvature (Kyphosis and Scoliosis-name apex and posterior rotation)
- Scapular position (inferior, medial, superior)
- Pelvic tilt
- Pelvic obliquity/rotation
- Leg position

Palpation:

- transdeltoid
- AC joint
- cervical spine
- upper trap
- superior lateral shoulder joint line
- anterior shoulder joint line
- posterior shoulder girdle
- medial scapular border

Joint Assessment:

Compare to norms for PROM and AROM- Cervical spine, shoulder, elbow, wrist

Shoulder norms

- Flexion (0-180°)
- Abduction (0-180°)
- ER at 0° of abduction: (0-90°)
- ER at 90° of abduction (0-90°)
- IR at 90° of abduction: (0-90°)
- Functional reach along spine IR (T7)
- Functional reach along spine ER (C7)
- Horizontal adduction (135)
- Horizontal abduction (45)

Strength:

Myotomes

- C1/2 Upper Cervical Flexion/Extension
- C3 Cervical Lateral flexion
- C4 Scapular elevation
- C5 Shoulder Abduction (supraspinatus), elbow flexion
- C6 Elbow flexion/wrist extension
- C7 Elbow extension/Wrist flexion
- C8 thumb extension
- T1 hand instrinsics

Rotator Cuff

- Infraspinatus (ER at 0 degrees of abduction)
- Teres minor and infraspinatus (ER at 90 degrees of abduction)
- Subscapularis (IR), with lift off of lumbar spine
- Scapular retraction

Clinical prediction rule for cervical radiculopathy: (if 3/4 tests are positive= 94% specificity for this diagnosis)

- spurling's
- distraction
- upper limb neural tension test
- <60 degree cervical rotation to involved side

Clinical prediction rule for sub-acromial impingement syndrome: (if 3/5 tests are positive SAIS can be confirmed and <3/5 positive it can be ruled out):

- Hawkin's Kennedy
- painful arc
- external rotation resistance (infraspinatus test)
- Neer
- Empty can

Clinical prediction rule for AC join involvement: (If 2/3 tests positive: 89% specificity, and 3/3 97% specificity for this dx)

- Cross body adduction
- O'Brien's
- AC Resisted Extension

Clinical prediction rule for Rotator cuff tear (all 3 present and age >60 yo probability 98% of tear)

- Drop arm
- Supraspinatus weakness=external lag sign
- Hawkin's Kennedy

Clinical prediction rule for Carpel Tunnel Syndrome: (If 4/5 positive tests, positive likelihood ration 4.6; and 5/5 positive likelihood 18.3)

- shaking hands for symptom relief
- wrist-ration index>0.67
- symptom severity scale >1.9
- decreased sensation of thumb
- Age >45 yr.

Labral Pathology rule in diagnosis:

- decreased pain with distraction and ER

Labral Pathology rule out:

- Yergason's
- Bicep's Load II test
- Speed's
- Compression Rotation
- O'Brien's

Elbow tendonitis Rule in

- Lateral: resisted wrist extension
- Medial: Restisted wrist flexion Medial: resisted forearm pronation

Outcome tools:

- Manual Wheelchair skills test
- Wheelchair Propulsion Test
- WUSPI
- DASH
- SmartWheel comparison to norms

Intervention:

“Pt was educated on results of shoulder screen and daily tasks/activities that likely exacerbate these deficits.

Pt was educated on the benefits of reduced average forces, decreased stroke frequency, and increased push length and reduction of risk of shoulder injury with appropriate manual wheelchair propulsion mechanics.”

# Appendix B – Tools

# Measurement Tools

- **Low Tech**: Analog in nature, low cost, portable and relatively low precision. (goniometer, tape measure, bathroom scale)
- **Medium Tech**: Digital in nature, do not require external power, low to medium cost, portable, and medium to high precision. (camera, laser distance meter)
- **High Tech**: digital and application specific, medium to high cost, transportable or stationary, medium to high precision; requires more training to utilize (SmartWheel, pressure imaging, Balance Master)

# Low Tech Tools

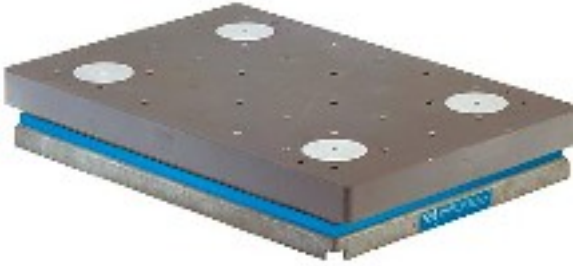
- Analog angle finder
- Goniometer
- Stopwatch
- Bathroom scale
- Fish scale
- Hand tools

# Medium Tech Tools

- Digital caliper
- Digital inclinometer
- Digital force gauge
- COMPASS software
- Language Activity Monitor (LAM)
- Camera
- Power tools


# High Tech Tools

- Wheelchair scale
- Motion analysis
- Force plate
- Pressure imaging
- SmartWheel
  (WC propulsion)
- Data Logger
- Accelerometers



# Low Tech Tools

| Manufacturer | Item | Retailer | Retail Price |
|---|---|---|---|
| Stanley | 16’ Tape Measure | Home Depot | $10 |
| Johnson | Pitch & Angle Locator | Home Depot | $5 - $10 |
| Baseline | Plastic Goniometer | Amazon | $10 - $20 |
| SportLine | Stopwatch | Target | $10 |
| Health-o-meter | Scale | Amazon | $25 - $150 |
| Berkely | Digital Fish Scale | BassPro | $20 - $50 |

# Medium Tech Tools

| Manufacturer | Item | Retailer | Retail Price |
|---|---|---|---|
| Mitutoyo | Digital Caliper | Grainger | $150 - $200 |
| Irwin | Sonic Distance Meter | Home Depot | $30 - $50 |
| Leica | Laser Distance Meter | Berland's House of Tools | $200 - $1000 ($300 A3) |
| Mitutoyo | Digital inclinometer | Grainger | $225 - $250 |
| Imada | Digital Force Gauge | Imada | $500 - $1000 |
| HP, Kodak, Canon | Digital Camera | Amazon | $200 - $500 |

# High Tech Tools

| Manufacturer | Item | Retailer | Retail Price |
|---|---|---|---|
| Health-o-meter | Wheelchair Scale | Health Check Systems | $1000 - $2000 |
| Vicon, Optotrak, Peak | Motion Analysis | Direct from Manufacturer | >$5000 |
| Kistler | Force Plate | Direct from Manufacturer | >$5000 |
| Three Rivers | SmartWheel | Direct from Manufacturer | >$5000 |
| Dataloggers | Not commercially available | -- | -- |
| Vista, Xsensor | Pressure Mapping | CRTS, Manufacturer | >$5000 |

# Appendix C - EBP

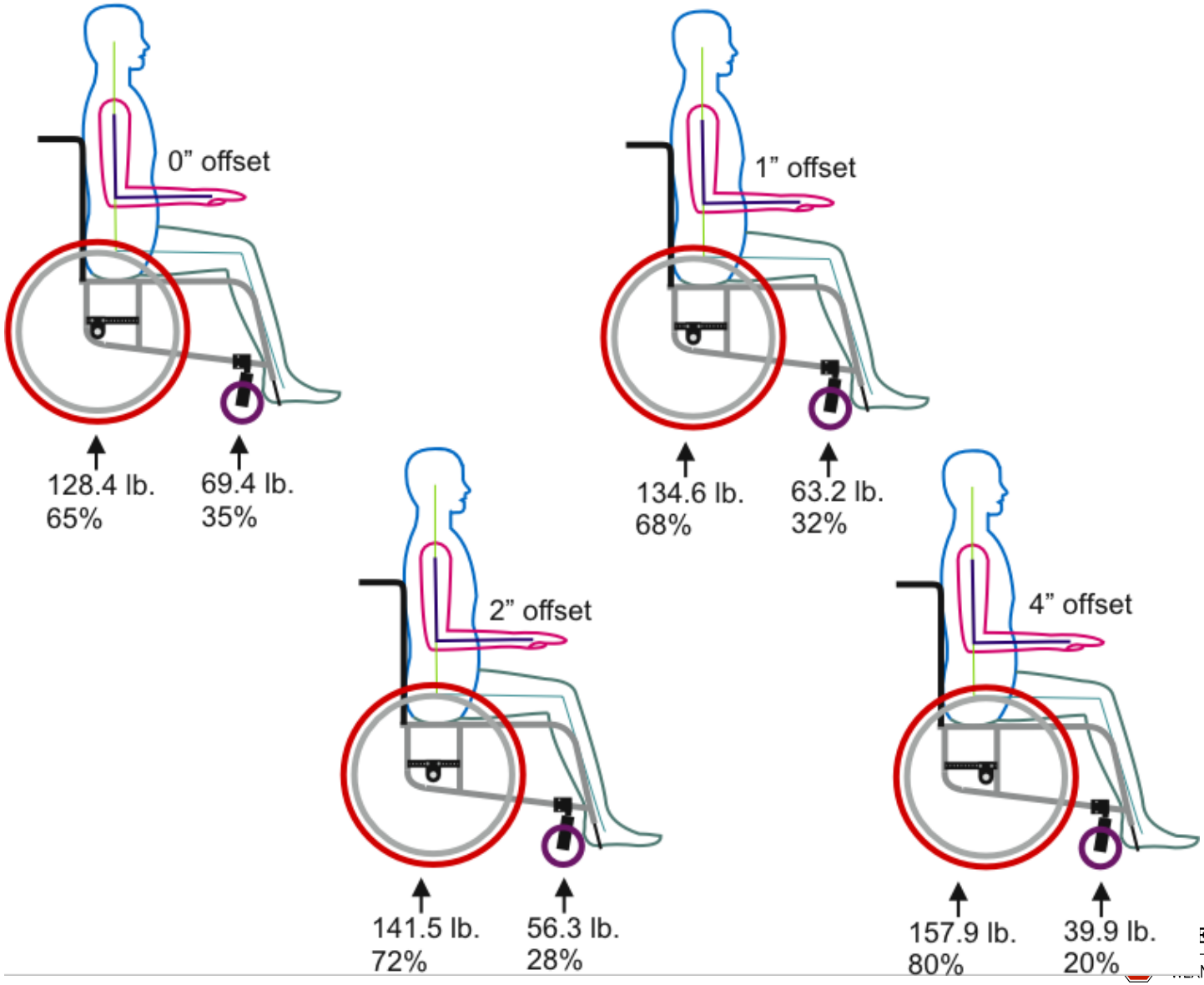
# Evidence Based Practice

(Rappolt, 2003)

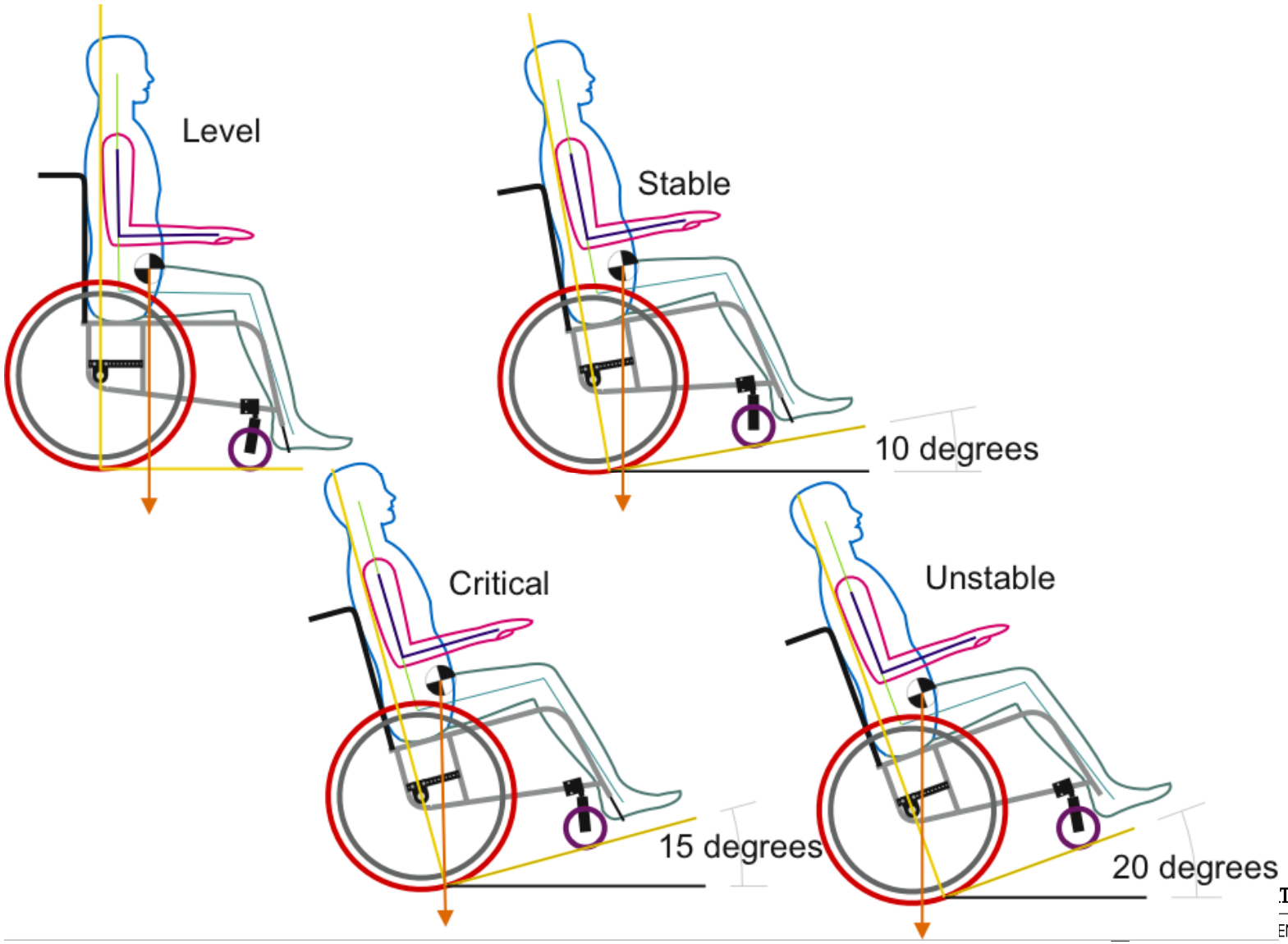
- Client Evidence
- Research Evidence
- Professional Expertise
- Integration
- Clinical Decision Making

# Appendix D – Axle Placement

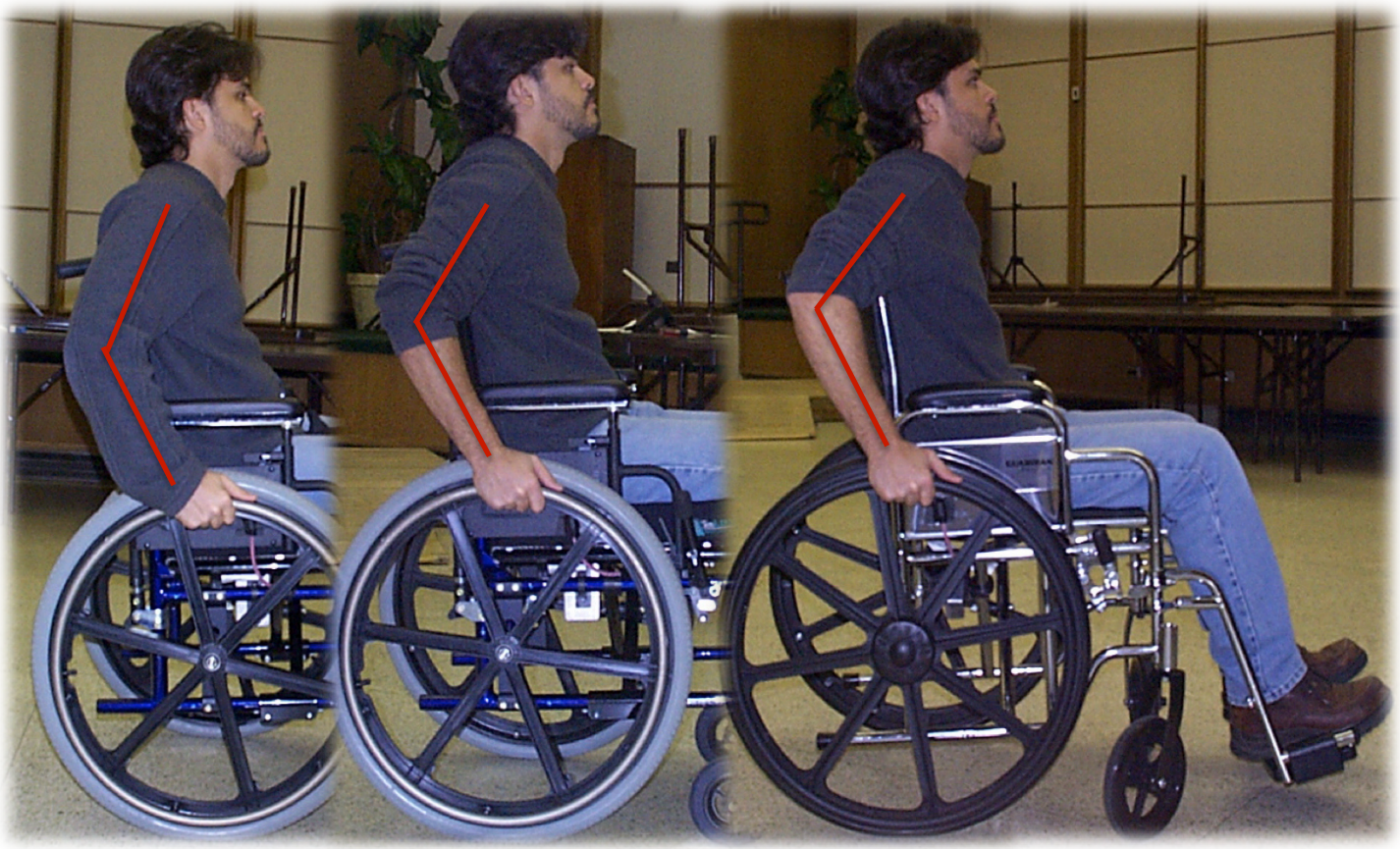
# Rear Wheel & Axle Plate



# Rear Wheel & Axle Plate - Stability

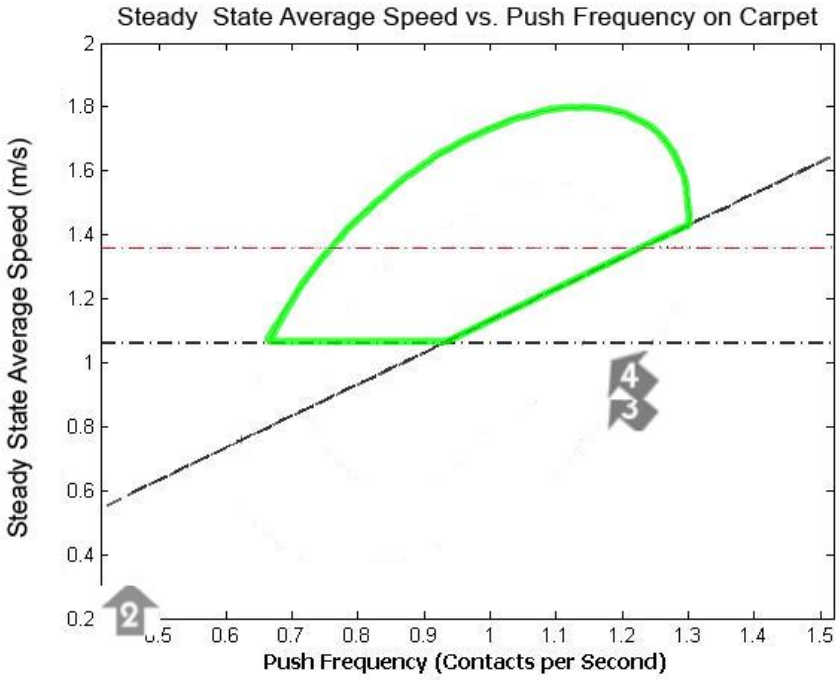


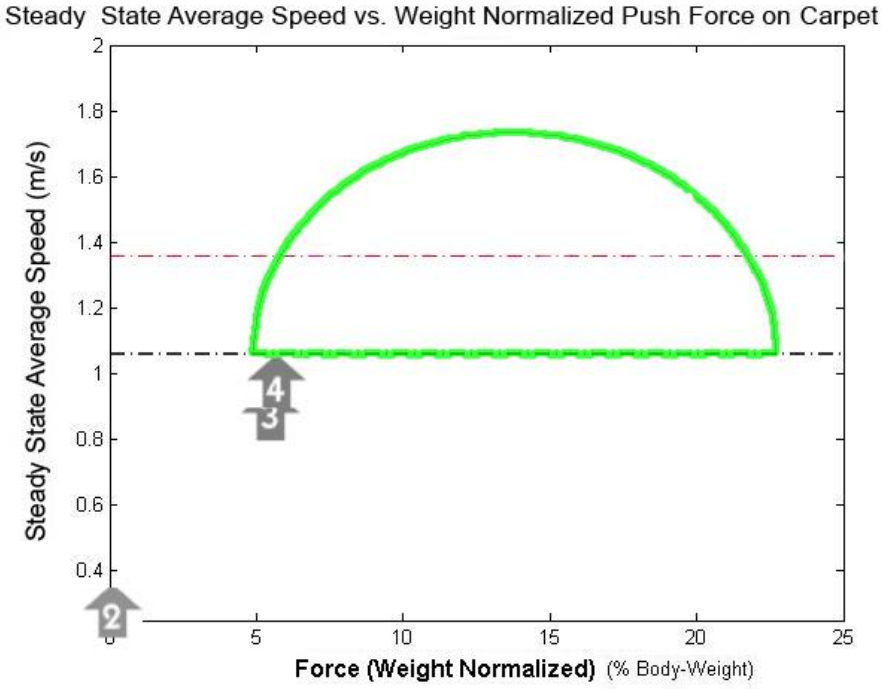
# Small Changes are Important



# Appendix E – Propulsion Analysis Case Studies

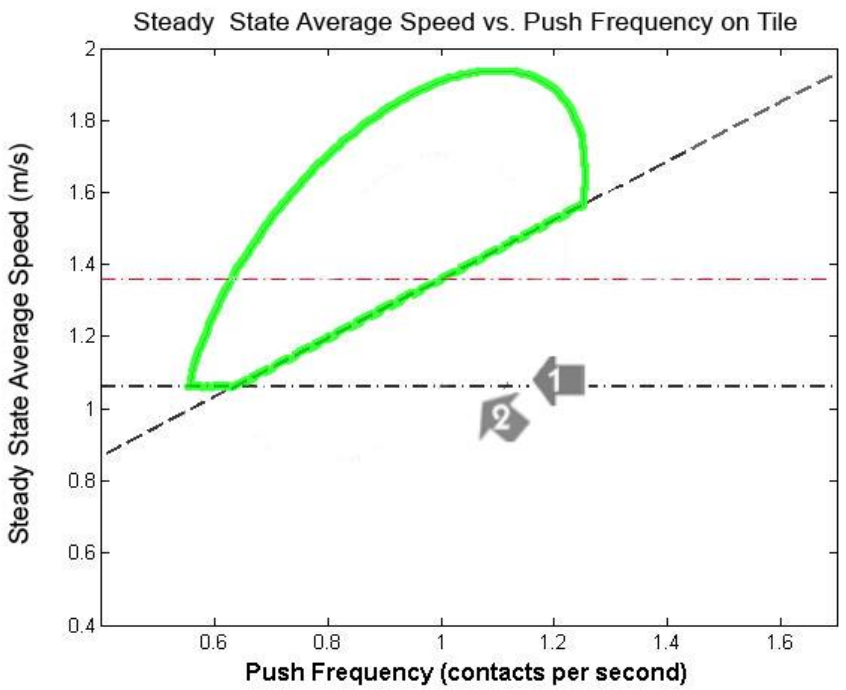
# Case Study – Carpet – PAPAW vs Non-Papaw

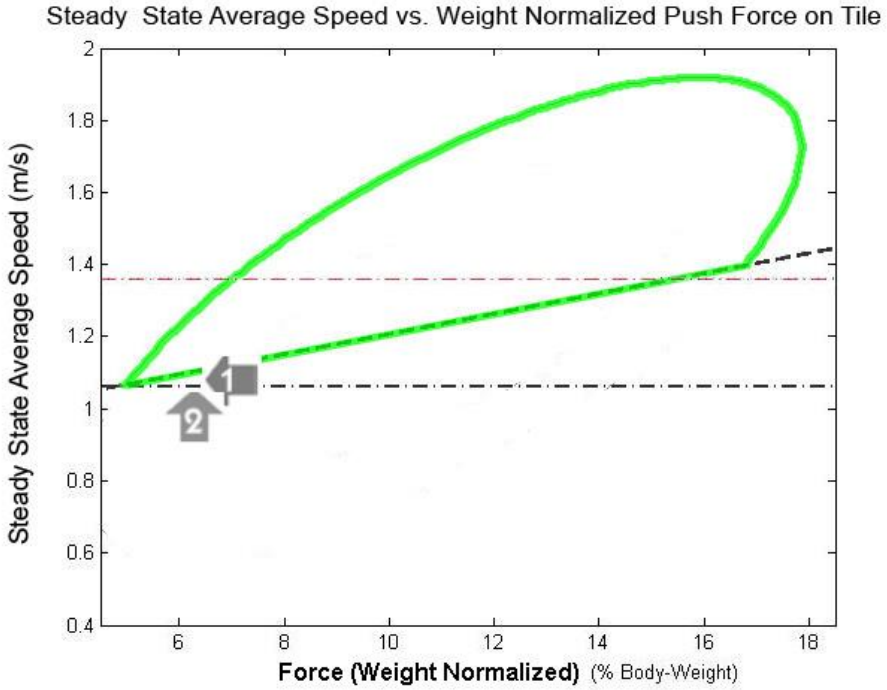



| | Ti Aero T with SmartDrive | Ti Aero T with SmartDrive | Ti Aero T - Trial 1 | Ti Aero T - Trial 2 | **Database Average † ǂ** | **Database Top 25% ‡** |
|---|---|---|---|---|---|---|
| **Speed [m/s]** | 1.7 | 2.0 | 0.9 | 1.0 | 1.10 | 1.62 |
| **Push Frequency [1/s]** | 0.0 | 0.0 | 1.2 | 1.2 | 0.97 | 1.11 |
| **Push Length [degree]** | 10.0 | 10.0 | 59.8 | 60.5 | 80.85 | 88.87 |
| **Force (Weight Normalized) %** | 0.0 | 0.0 | 5.7 | 5.9 | 14.67 | 15.39 |

# Case Study – Tile – Shoulder Pain

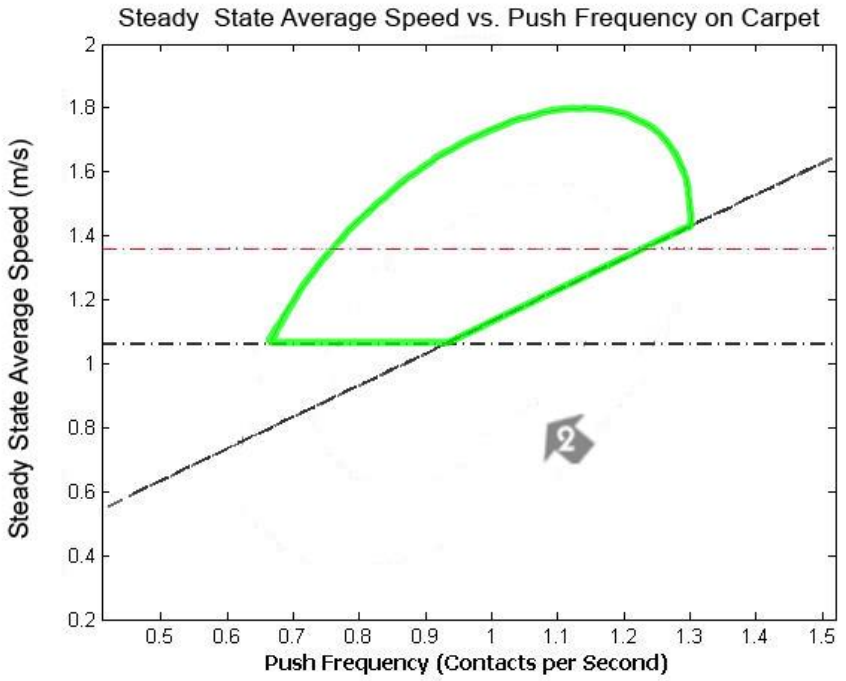


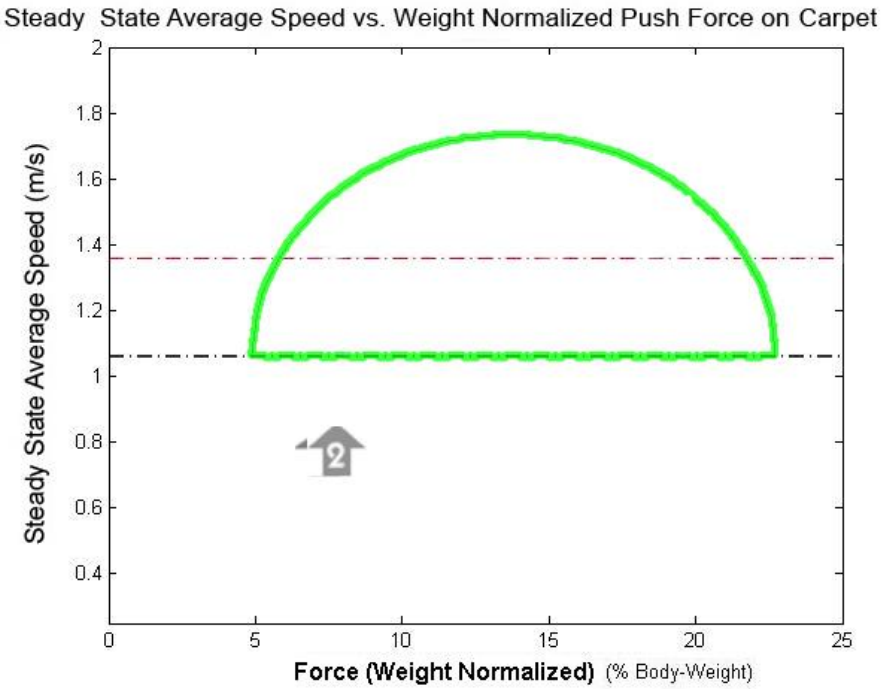




| | Quickie 2 - Tile | Quickie 2 - Tile | Database Average †╪ | Database Top 25% ‡ |
|---|---|---|---|---|
| **Speed [m/s]** | 1.1 | 1.0 | 1.29 | 1.73 |
| **Push Frequency [1/s]** | 1.2 | 1.1 | 0.91 | 1.05 |
| **Push Length [degree]** | 58.2 | 58.8 | 74.48 | 82.90 |
| **Force (Weight Normalized) %** | 6.7 | 6.0 | 11.32 | 12.95 |

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

# Case Study – Carpet – Shoulder Pain

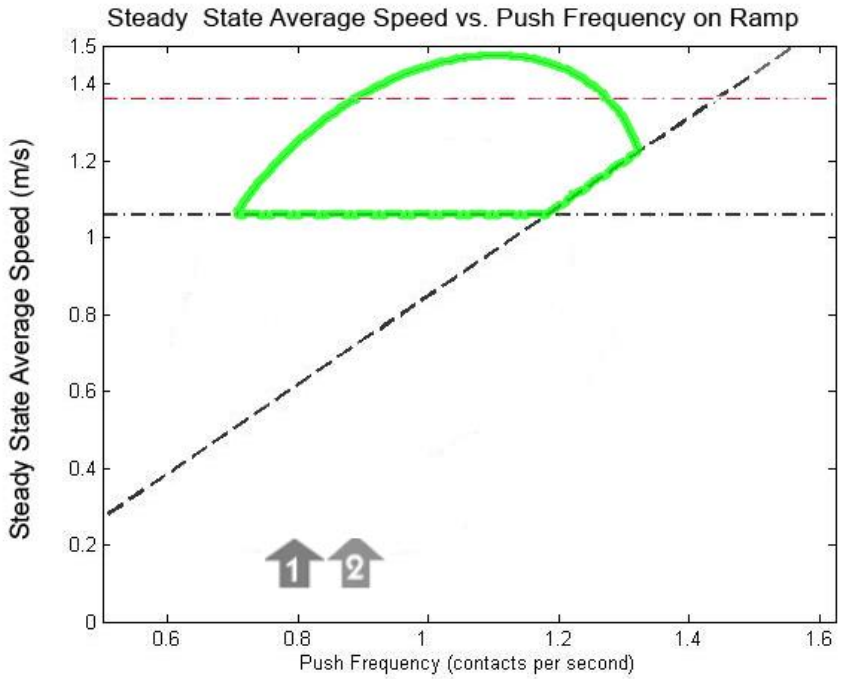


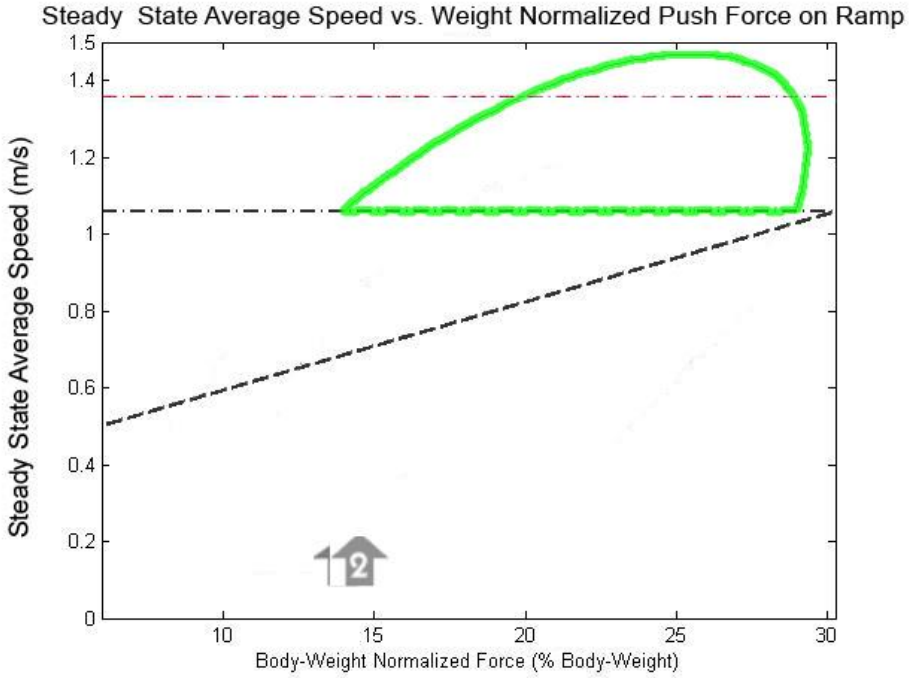




| | Quickie 2 - Carpet | Quickie 2 - Carpet | Database Average † ╪ | Database Top 25% ‡ |
|---|---|---|---|---|
| **Speed [m/s]** | 0.8 | 0.8 | 1.10 | 1.62 |
| **Push Frequency [1/s]** | 1.1 | 1.1 | 0.97 | 1.11 |
| **Push Length [degree]** | 58.8 | 58.5 | 80.85 | 88.87 |
| **Force (Weight Normalized) %** | 7.6 | 8.0 | 14.67 | 15.39 |

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

# Case Study – 3m 1:12 Ramp– Shoulder Pain




| | Quickie 2 – Ramp | Quickie 2 - Ramp | Database Average †╪ | Database Top 25% ‡ |
|---|---|---|---|---|
| **Speed [m/s]** | 0.2 | 0.2 | 0.84 | 1.30 |
| **Push Frequency [1/s]** | 0.7 | 0.8 | 0.99 | 1.13 |
| **Push Length [degree]** | 40.5 | 36.2 | 80.85 | 92.96 |
| **Force (Weight Normalized) %** | 13.9 | 14.4 | 19.52 | 23.33 |

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

# Tile, Capet, Ramp – Force and Speed