
motion
COMPOSITES

# MEASUREMENTS FOR MANUAL WHEELCHAIRS:

## SMALL DETAILS MAKE A BIG DIFFERENCE

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MotionU

# FACULTY DISCLOSURE


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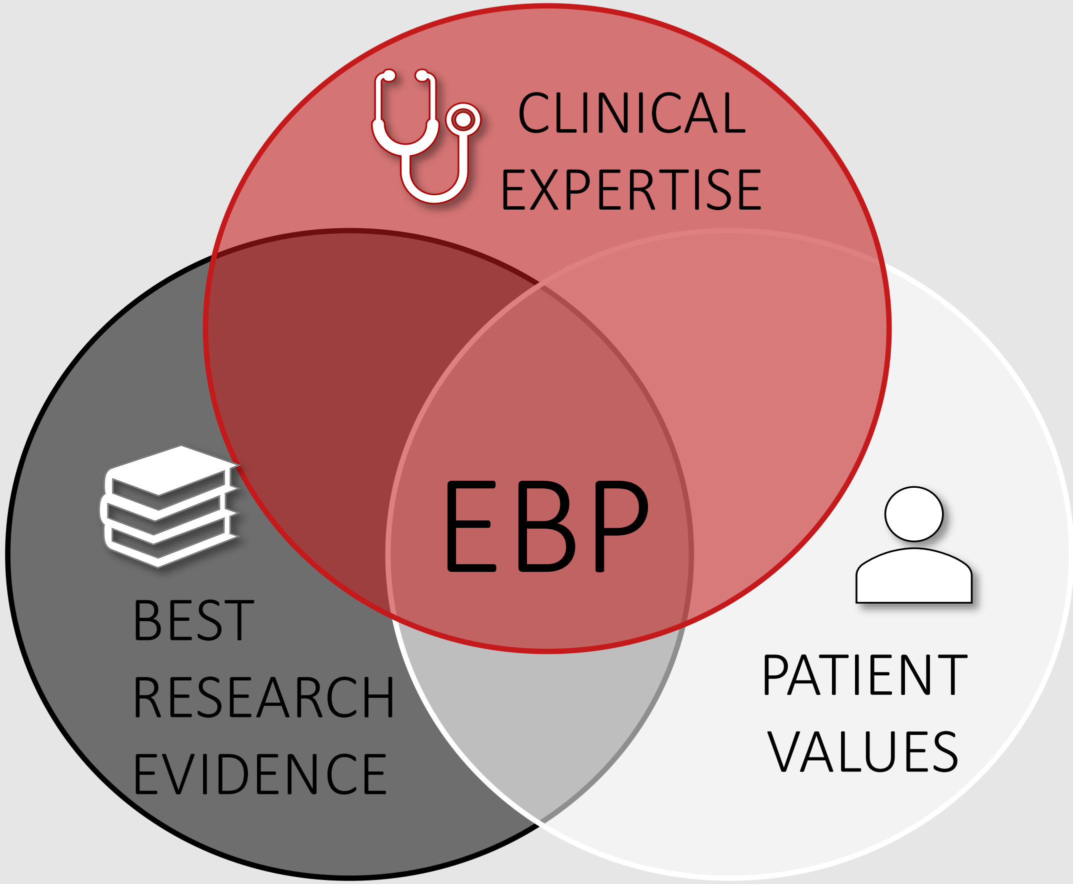
# MOTION COMPOSITES


"LEAD THE EVOLUTION OF MOBILITY FOR BETTER LIVING"

Wishes for Wheels

# EVIDENCE BASED PRACTICE

OUR FOUNDATION




Integrating individual clinical expertise with the best available external clinical evidence from systematic research.
-David Sacket, 1996

# LEARNING OBJECTIVES

BY THE END OF THE PRESENTATION,
PARTICIPANTS WILL BE ABLE TO:

1. Identify and apply three key measurements for manual wheelchair set-up, correlating them with order form specifications.
2. Analyze the effects of implementing the three key measurements on client outcomes.
3. List three techniques for client measurements, prioritizing methods that enhance performance and functionality.

# HOW DO DETAILS MAKE A DIFFERENCE?

APPROPRIATENESS (Petrie et al., 2018)

- The degree to which the wheelchair meets the patients’ functional and health needs
  - Wheelchair quality
  - Durability
  - Customizations
- Inappropriate wheelchairs can cause adverse consequences to physical functioning, safety, quality of life, and vocational and economic standing (Requejo et al., 2015)

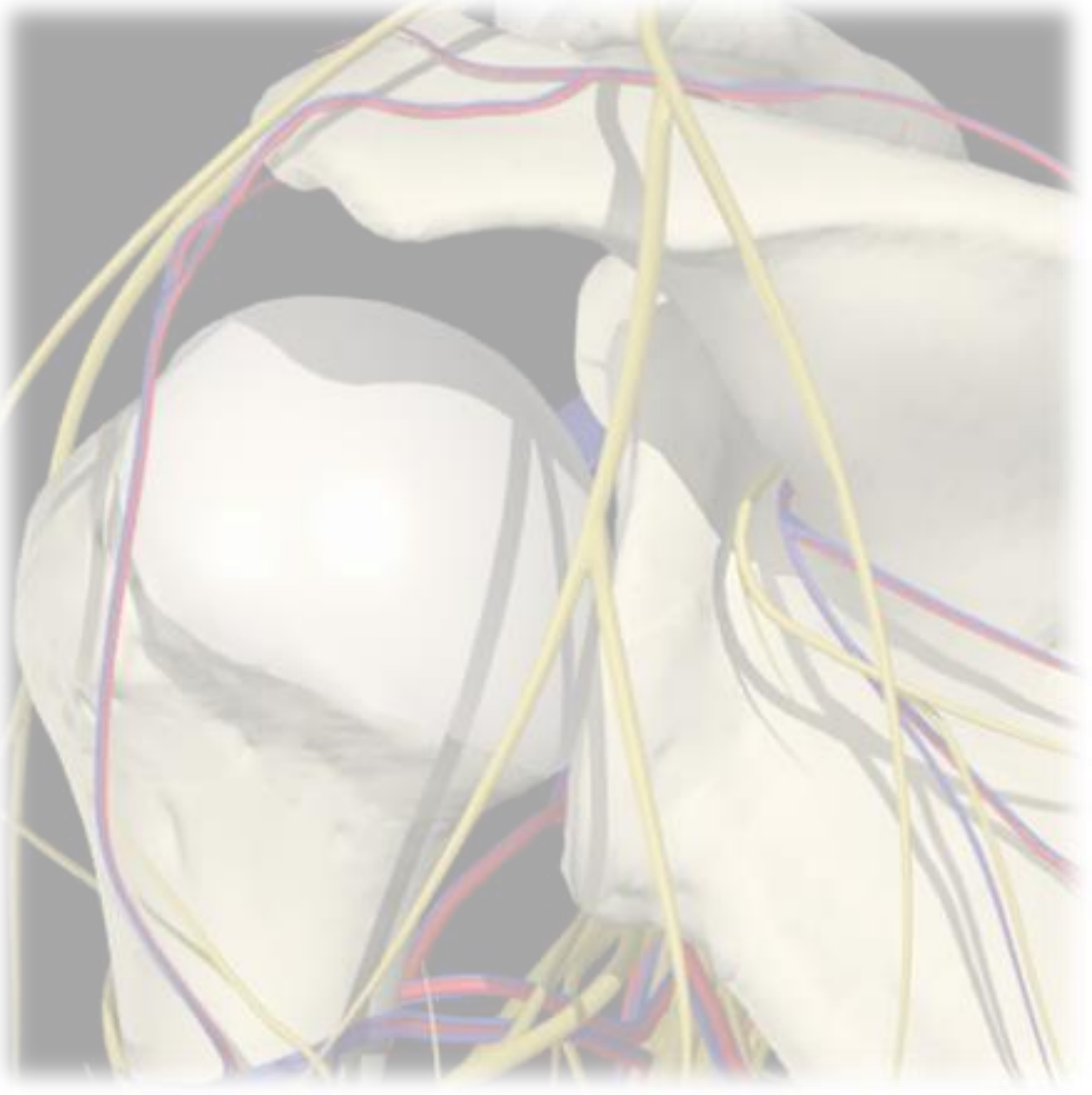
# HOW DO DETAILS MAKE A DIFFERENCE?

ABANDONMENT (Petrie et al., 2018)

- 31% of users who have had a stroke and 38% - 50% of those with other disabilities will abandon their equipment prior to the intended length of time for use
- Sizing
- Weight
- Change in the user's needs
- Lack of involvement in the prescription process.

# UNDERSTANDING USER HEALTH

- The decisions made during the wheelchair prescription process influence the user's health, propulsion technique, level of independence and therefore overall quality of life (Kamaraj et al., 2017)
    - 68% of the evaluated wheelchairs were not suitable for their users
    - Shoulder pain prevalence in wheelchair users ranges from 70-100%
    - Degree of pain/derangement/disability is directly proportional to age/time since injury
- Therefore, it is important that during all stages of assessment, client goals and current and future factors are considered.



# WEIGHT VS. CONFIGURATION

- Propelling a lighter-weight wheelchair was shown to be more efficient than propelling a standard wheelchair. The greater efficiency of the lightweight wheelchair is attributed to differences in individualizing the wheelchair prescription and configuration in addition to the total mass of the device
- A user seated in an ill-fitted wheelchair—regardless of its mass—exerts more effort than if seated in a well-fitted wheelchair
- Equal attention must be paid to configuration and weight

*(Requejo et al., 2015; Sprigle & Huang, 2015)*

# GUIDELINES & RECOMMENDATIONS

- RESNA Position Paper (2022): “Position on the Application of Ultralight Manual Wheelchairs.”
- The Consortium of Spinal Cord Medicine (2005): “Preservation of Upper Limb Function Following Spinal Cord Injury: A Clinical Practice Guideline for Healthcare Professionals.”
- Sawatzky et al. (2015): “The Need for Updated Clinical Practice Guidelines for Preservation of Upper Extremities in Manual Wheelchair Users: A Position Paper.”
- Cowan et al. (2009): “Impact of surface type, wheelchair weight and Axle Position on Wheelchair Propulsion by Novice Older Adults.”

RESNA MWC

# WHEELCHAIR SERVICE PROVISION GUIDE

- Wheelchair assessment can be broken down into three broad categories (RESNA, 2011):
  - Body Structure and Functions
  - Activities and Participation
  - Environment and Current Technology
- Formal assessment can assist in determining both physical abilities and limitations of the wheelchair user
- Informal assessment can determine client goals, hopes and past experiences

RESNA WC GUIDE

# THE CLINICAL GOAL

- Maximize mobility/function
- Maximize/improve quality of life (QOL)
- Minimize fatigue during normal daily activities
- Delayed onset or prevention of UE injury/dysfunction
- Minimize risk of abandonment & poor outcomes


# HOW DO WE DO THIS?

# PHYSICAL EXAMINATION

- Determines client's capabilities and limitations
- Supine (mat) evaluation
  - Formal training recommended
  - Not covered today
- Sitting evaluation
  - In and out of the chair
  - Sometimes current seating is causing issues
- Use a team approach
  - Therapist & ATP

# SUPINE MAT EVALUATION

- Pelvis and Lumbar Spine
  - Anterior/posterior pelvic tilt
  - Pelvic obliquity
  - Pelvic rotation
- Hips
  - Flexion
  - Abduction & adduction
  - External & internal rotation
- Knees
  - Hamstring length
- Feet
  - Dorsi & plantar flexion
  - Inversion & eversion
- Trunk, shoulder, neck, & head position
- ROM
- Tone
  - Spasticity, flaccidity, dystonia, other

** Correctable or non-correctable? **

# SITTING EVALUATION

- On a firm surface
- Posture and balance
- Trunk support
- Pelvis
  - Tilt
  - Obliquity
  - Rotation
  - Palpation of ITs
- Lower extremities
  - Hip flexion
  - Knee extension
  - Ankle dorsiflexion

# WHEELCHAIR ASSESSMENT

- Guidelines on measurement technique are available
- Technique is known to vary between professionals
  - Personal expertise come into effect
- General practice involves measuring client body segments and then translating them into equipment dimensions
  - Involves clinical judgement

WC EVAL

# MEASUREMENTS

A Clinical Application Guide to Standardized Wheelchair Seating Measures of the Body and Seating Support Surfaces, Revised Edition

- By Kelly Waugh & Barbara Crane
- Document striving to regulate practices across the wheelchair industry to allow for more standardization and therefore better outcomes
- Actual vs effective dimensions

STANDARD MEASURES

# ANATOMICAL VS. WHEELCHAIR DIMENSIONS

| ANATOMICAL | WHEELCHAIR |
| --- | --- |
| Hip width | Seat width |
| Buttock to popliteal fossa | Seat depth |
| Lower leg length (knee to heel) | Seat to footrest height |
| Thigh to trunk angle | Seat to back angle |

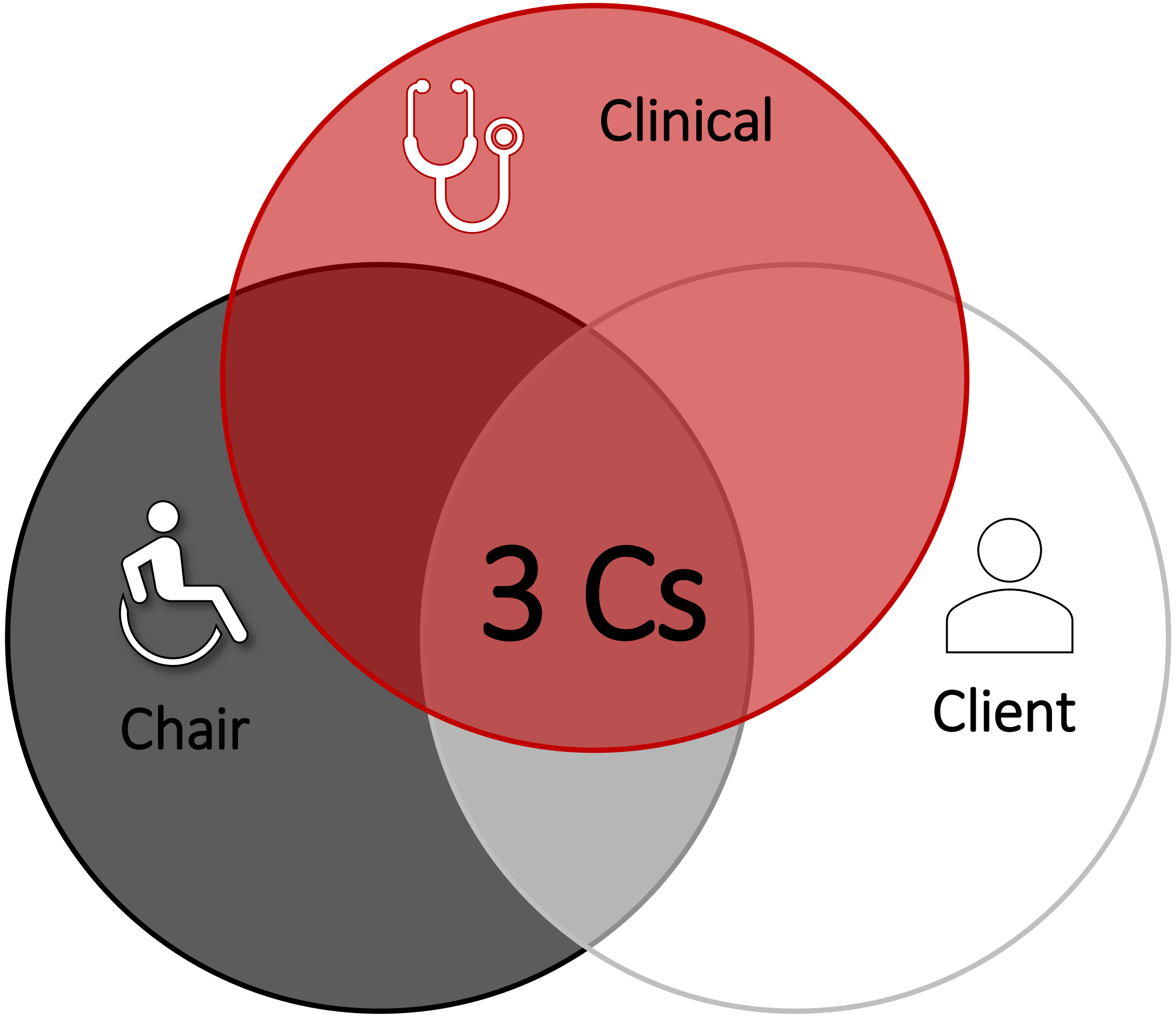

# THE THREE Cs

CLIENT

CHAIR

CLINICAL

# CLINICAL DECISION MAKING




# THE FIT

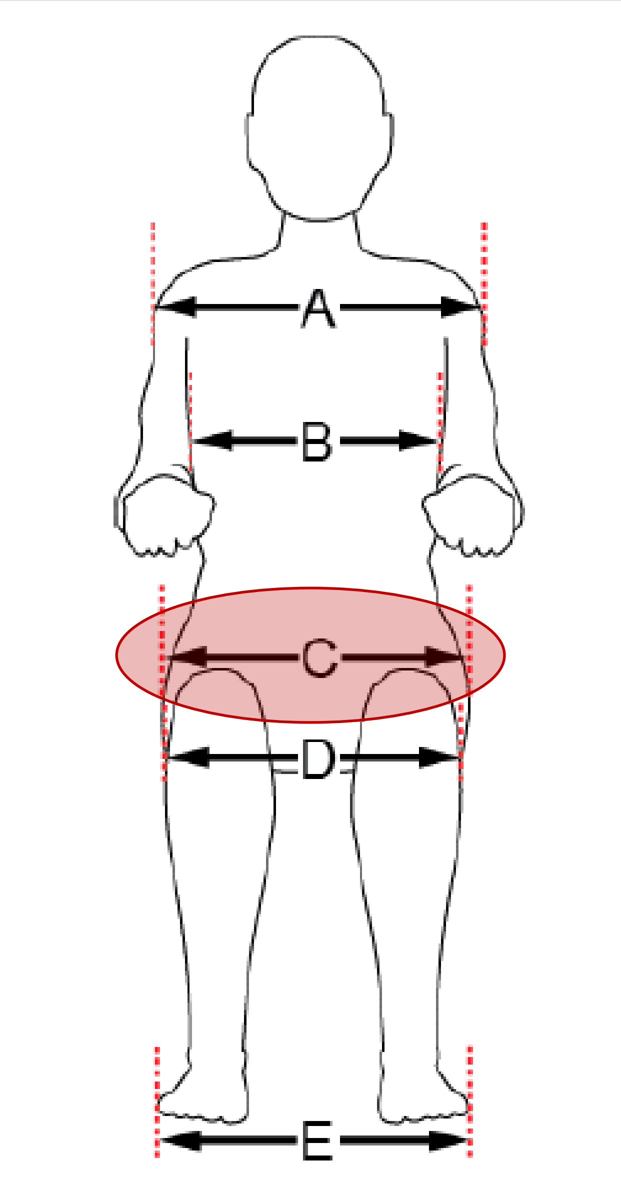
# HIP WIDTH:
## *CLIENT*

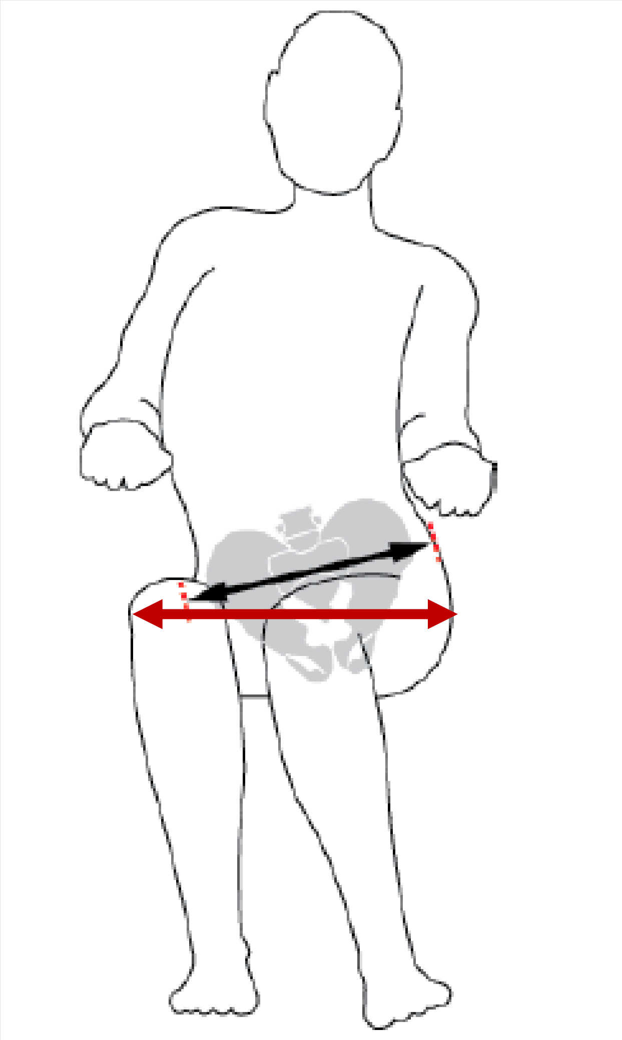
Anatomical Measurement:

- Trochanter width
- Tissue can be slightly compressed
- Look at risk factors
- Assess growth options/likelihood

What if?

- Windswept
- Edema
- Wider area



*Images from: Waugh & Crane, 2013*

# SEAT WIDTH:
## *CHAIR*

- Equipment measurement:
  - Outside seat rail to outside seat rail
- Not always the upholstery width
  - Dependent on wheelchair

# SEAT WIDTH:
## *CLINICAL IMPACT*

- Function
    - Posture
    - Propulsion
    - Accessibility
- Efficiency
- Camber

*Think about the fit of a prosthetic limb*


# BUTTOCKS TO POPLITEAL FOSSA: *CLIENT*

- Anatomical measurement:
  - Back of sacrum to popliteal fossa
- Is it the same bilaterally?
- Considerations
  - Knee flexion
  - Foot propulsion
- What if?
  - Kyphotic posture
  - Contractures
  - Leg length discrepancy

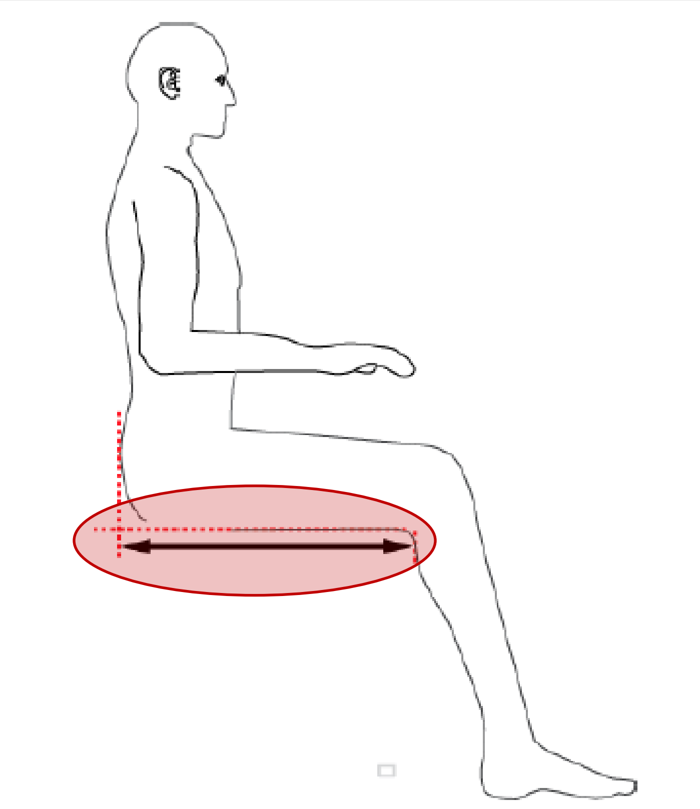


*Image credit: Waugh & Crane, 2013*

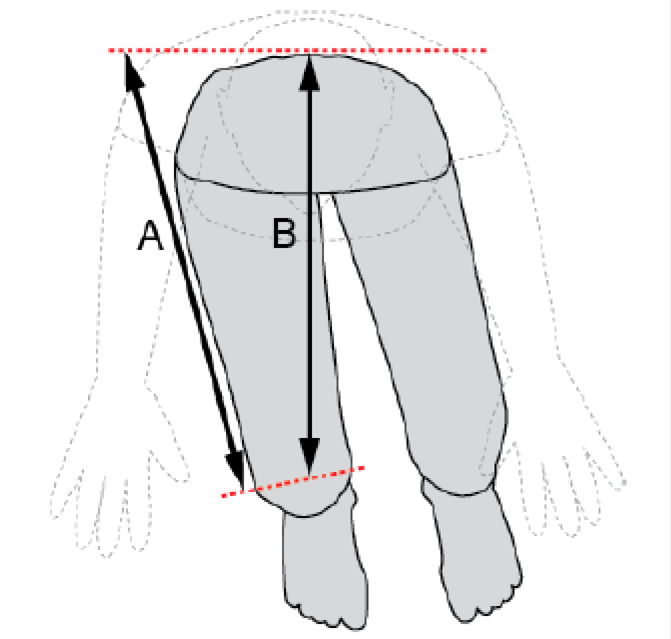



*Image credit: Waugh & Crane, 2013*

# SEAT DEPTH:
## *CHAIR*

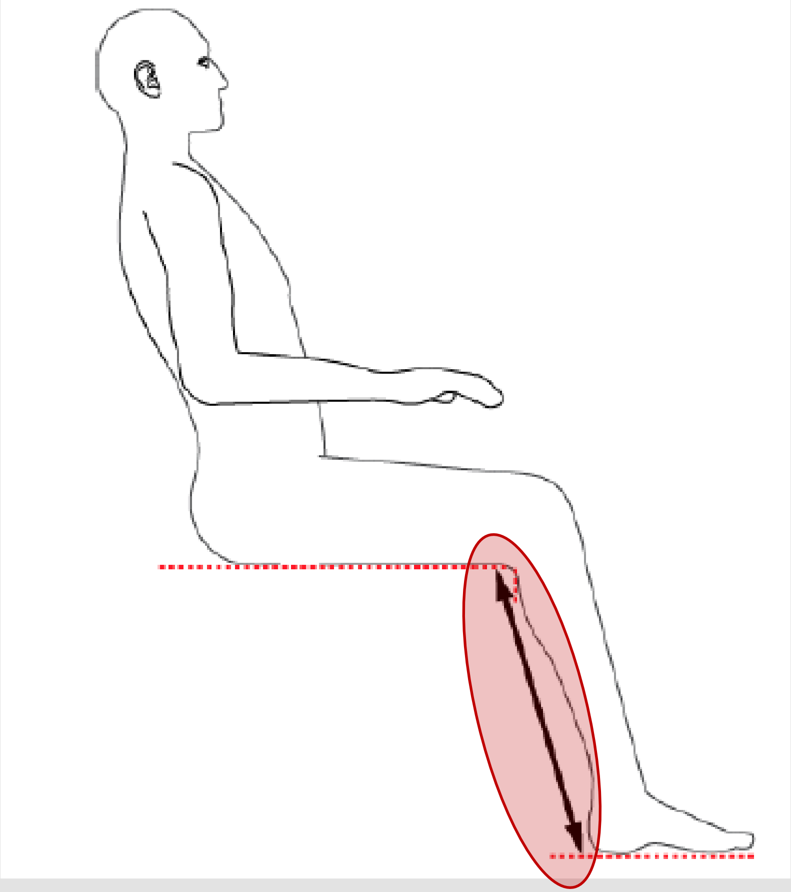
- Equipment Measurement:
  - Front of back post to front of seat sling
- Functional Considerations
  - Accessibility
  - Leg management
  - Back selection
- Seat depth ≠ frame length

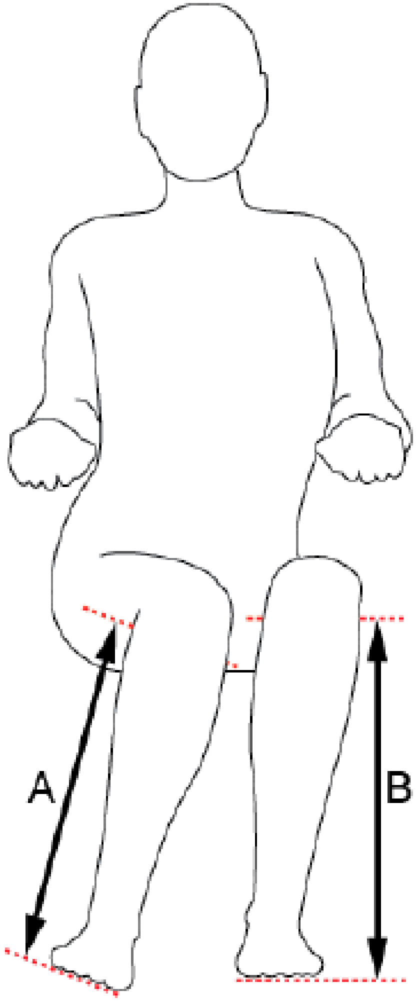
# SEAT DEPTH:
## *CLINICAL IMPACT*

- Functional:
  - Posture
  - Pelvic stability
  - Pressure distribution
  - Access to the wheels
  - Accessibility
- Leave room for the distal thigh/popliteal space
- Recognize the impact of seat slope

# SEAT TO FOOTREST HEIGHT: *CLIENT*

- Anatomical measurement:
  - Popliteal fossa to heel
  - With most commonly worn shoes
- Is it the same bilaterally?
- What if?
  - Lower leg length discrepancy
  - Ankle ROM limitations






*Images from: Waugh & Crane, 2013*

# SEAT TO FOOTREST:
*CHAIR*

- Chair measurement:
    - Measure from front edge of seat upholstery to attachment point of footrest
- Considerations:
    - Seat cushion
    - Floor clearance
    - Footwear

# LOWER LEG LENGTH:
## *CLINICAL IMPACT*

- Functional Impact:
  - Stability and positioning
    - Sliding
  - Pressure distribution
  - Foot propulsion
  - Optimal support

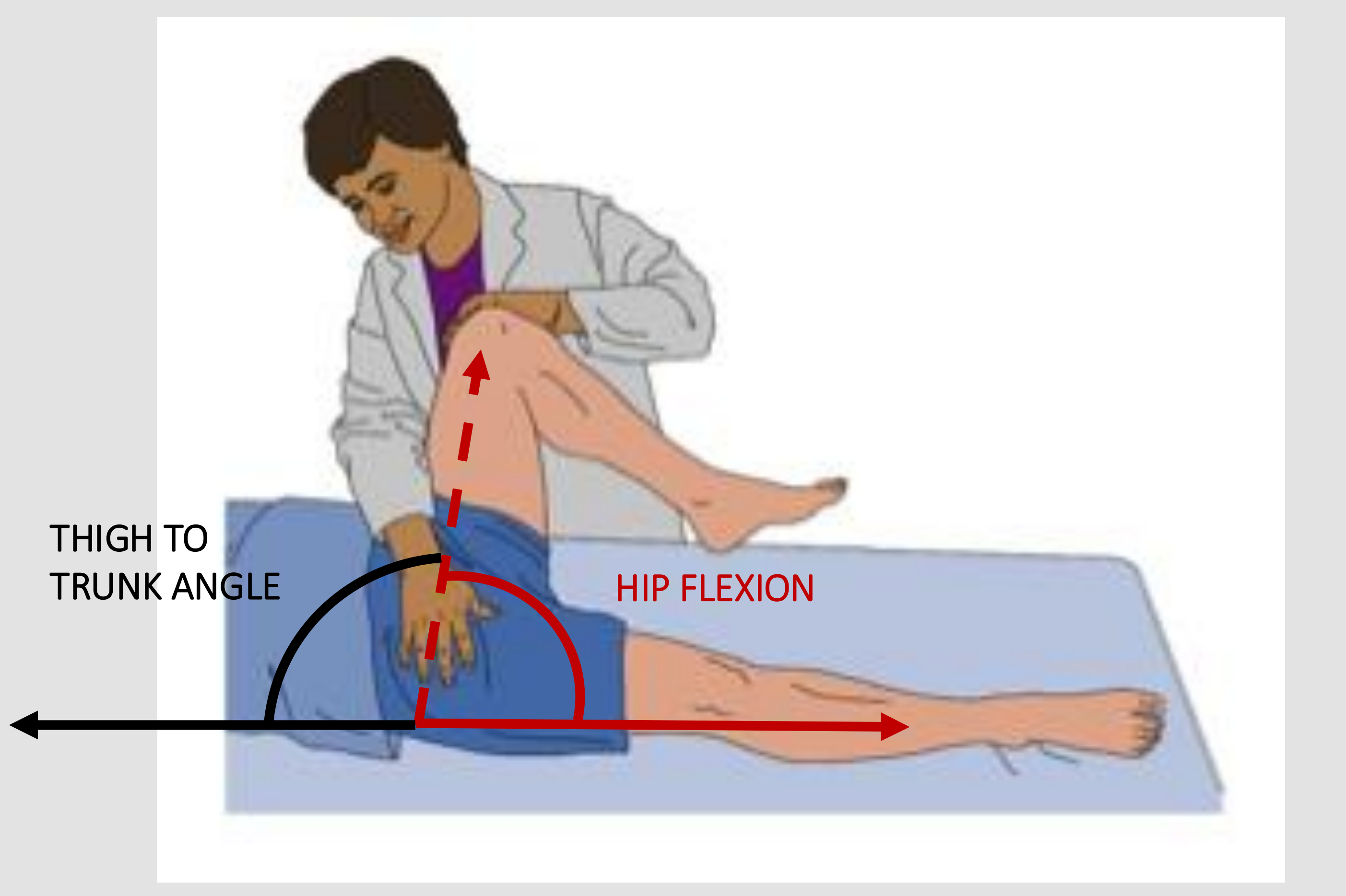


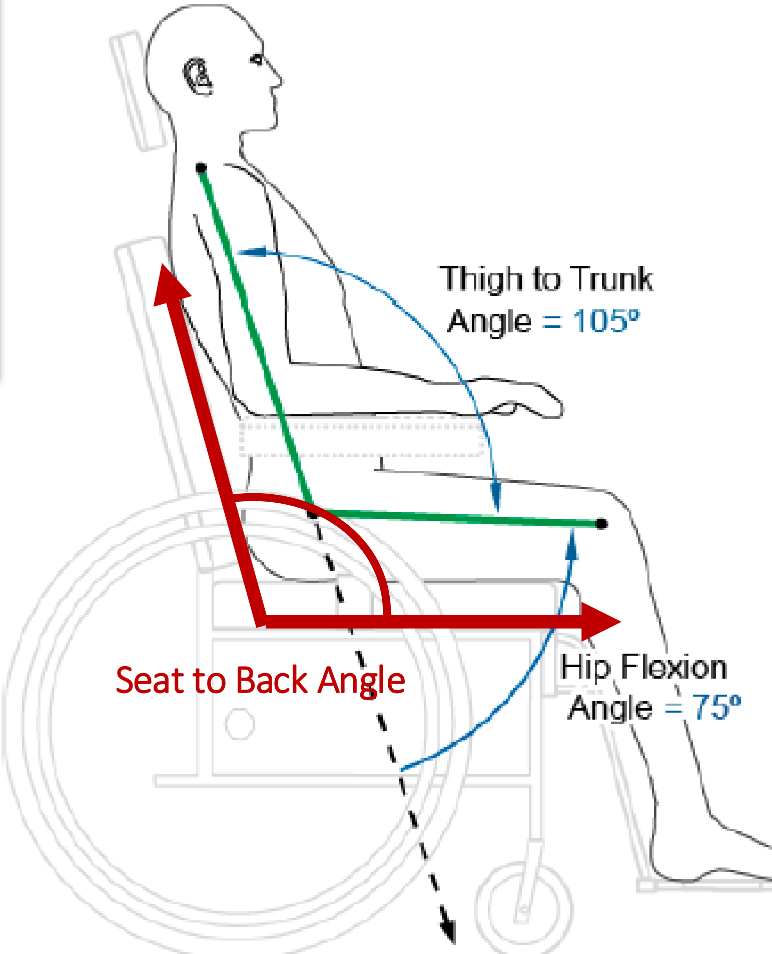

Photo credit: https://asia-spinalinjury.org/wp-content/uploads/2016/02/Motor_Exam_Guide.pdf

# THIGH TO TRUNK ANGLE: *CLIENT*

- Anatomical Measurement:
  - Place a goniometer over the greater trochanter and align one arm along the femur and one pointing towards the acromion
- Typical angles
  - 90°-120° but can fall between 60°- 80°
- Thigh to trunk angle ≠ hip flexion angle
  - E.g., 80° hip flexion = 100° thigh to trunk angle

# SEAT TO BACK ANGLE:
## *CHAIR*

- Chair Measurement:
  - Angle between the seat rail and the back cane
- Can achieve this angle through the back angle/back support, the seat slope/seat cushion or a combination of features
- Thigh/trunk angle ≠ seat/back angle



# SEAT TO BACK ANGLE:
## *CLINICAL IMPACT*

- Client specific
- Will be dependent on back height and seat slope
- More open vs more closed


# THE SET-UP

# IMPORTANCE OF REAR WHEEL POSITION

## THE EVIDENCE

Research shows that vertical and horizontal wheel position is one of the most important adjustments to minimize impact on the UE during propulsion

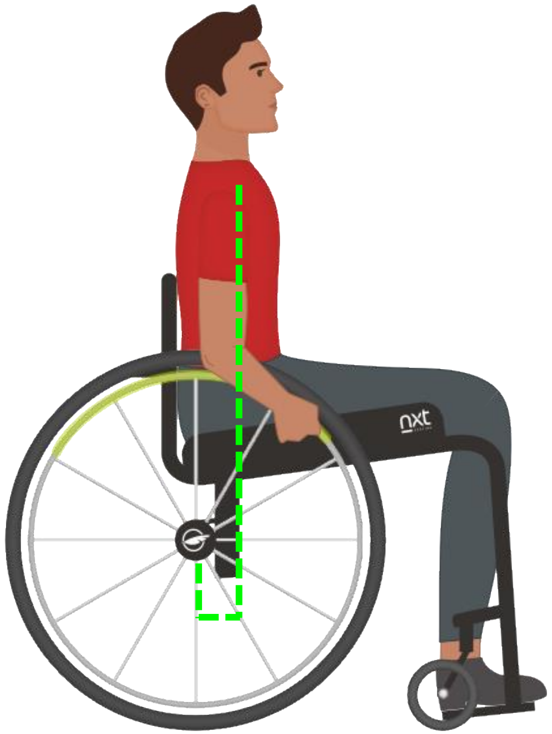
- Rehabilitation Engineering & Assistive Technology Society of North America [RESNA] (2022). "Position on the Application of Ultralight Manual Wheelchairs."
- Medola et al. (2014): "Aspects of Manual Wheelchair Configuration Affecting Mobility: A Review."
- Freixes et al. (2010): "Wheelchair axle position effect on start-up propulsion performance of persons with tetraplegia."

# IMPORTANCE OF WHEEL POSITION

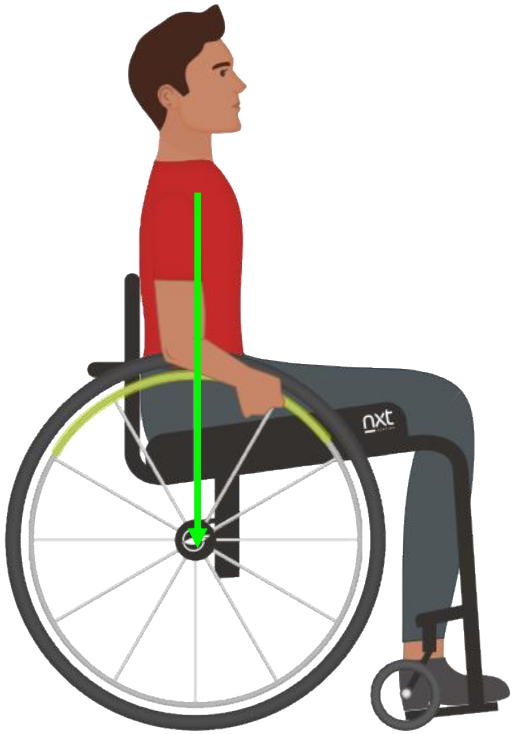
- Research shows that vertical and horizontal wheel position is one of the most important adjustments to minimize impact on the UE during propulsion
- Decreases rolling resistance
- Decreases stroke frequency
- Increases maneuverability
- Higher mechanical efficiency

# HORIZONTAL REAR AXLE POSITION

- Move the rear wheel as far forward as possible without compromising the stability of the user
- Axle at or in front of the shoulder



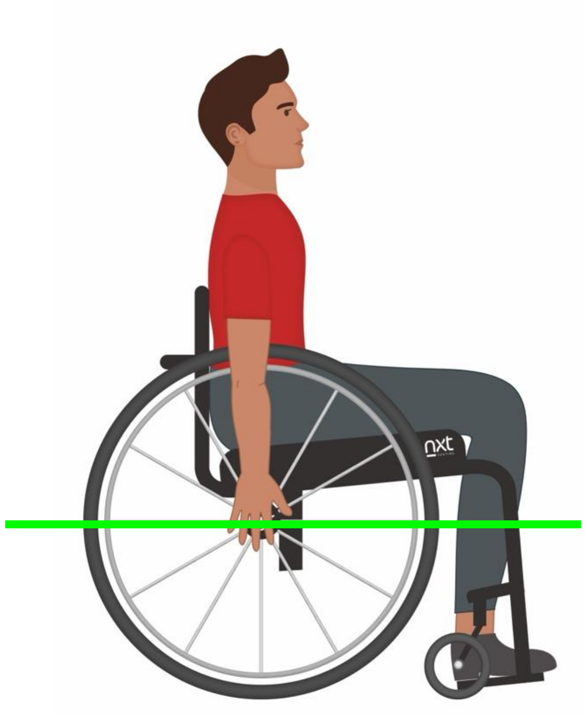
REARWARD HORIZONTAL AXLE POSITION



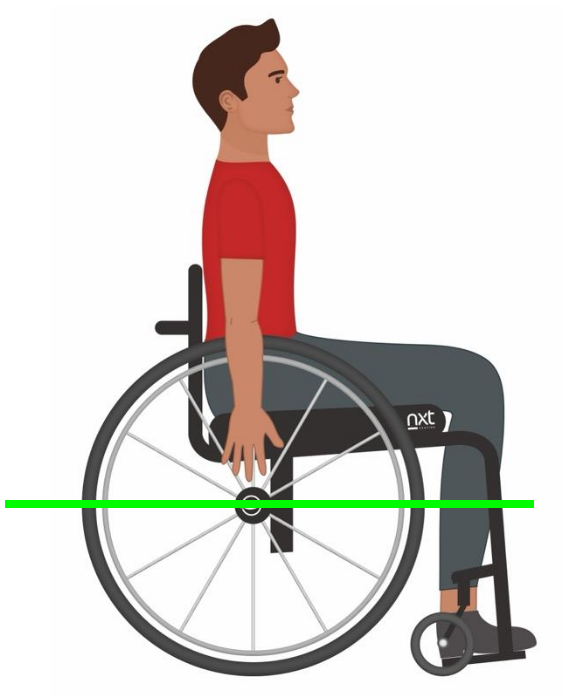
OPTIMAL HORIZONTAL AXLE POSITION

# VERTICAL REAR AXLE POSITION

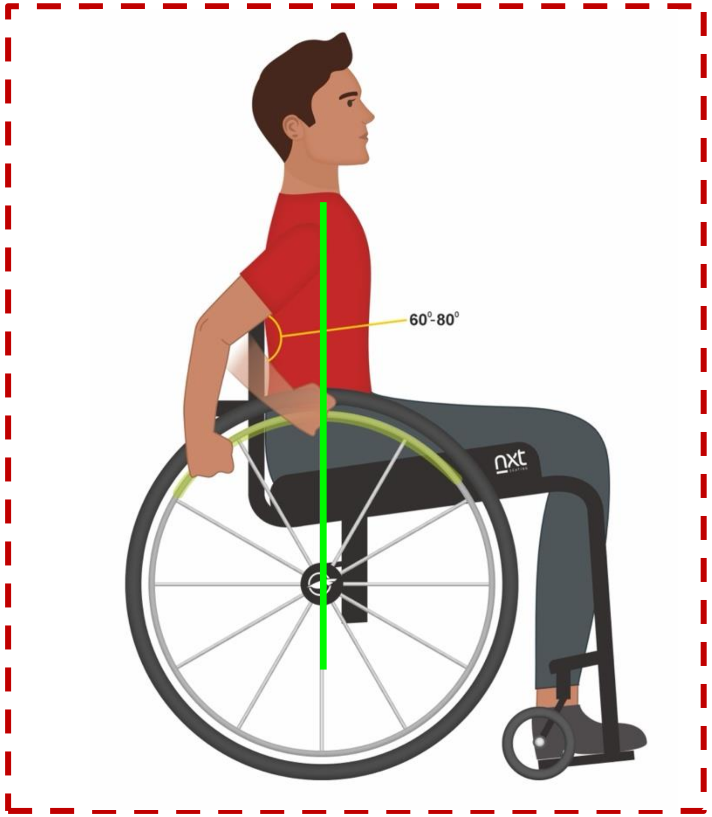
- Angle between the arm and forearm between 100-120°
- 60-80° of elbow flexion when the hand is on the top of the pushrim
- Can be difficult to optimize with some clients



EXCESSIVELY LOW AXLE POSITION



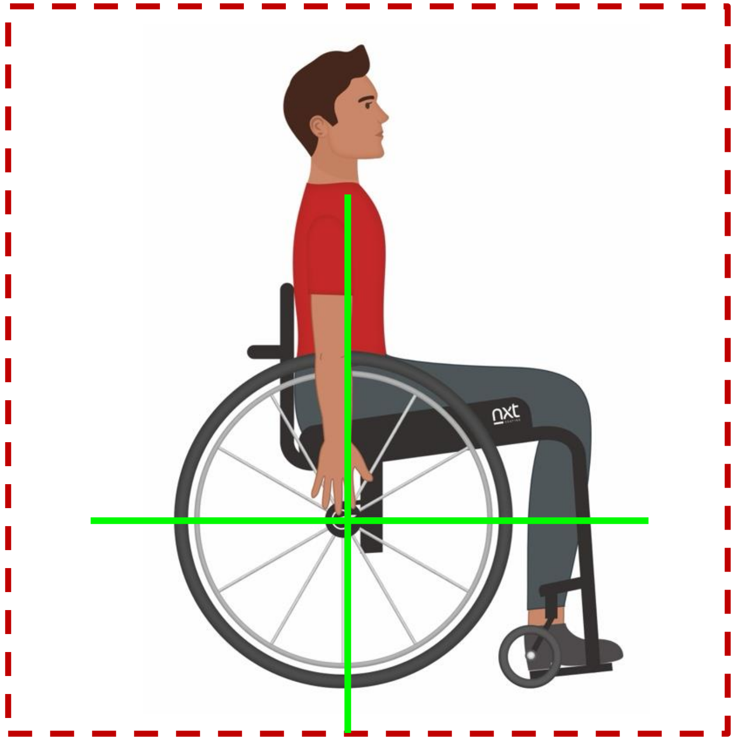
EXCESSIVELY HIGH AXLE POSITION




POSITION 2

# VISUALIZATION OF REAR WHEEL POSITIONING

- Great way to look at horizontal & vertical at the same time
- Middle finger in line with center of axle; shoulder in line or slight behind the axle




POSITION 1


# OPTIMAL FIT & WHEEL POSITION RESULTS IN

More efficient propulsion →

The chair appears to roll easier & “feels lighter”

# CASE STUDY

## JEREMY

# JEREMY

- Age: 24
- Injury: T10 Complete SCI
- Date: Sept 8, 2011
- Cause: workplace injury
- Personal:
    - lives with his girlfriend
    - hopes to return to work (steel estimation for construction)
- Leisure:
    - enjoys skiing, surfing, hand cycling
    - hoping to try mountain biking

# CURRENT EQUIPMENT

# TILITE TR & ROHO SEAT CUSHION

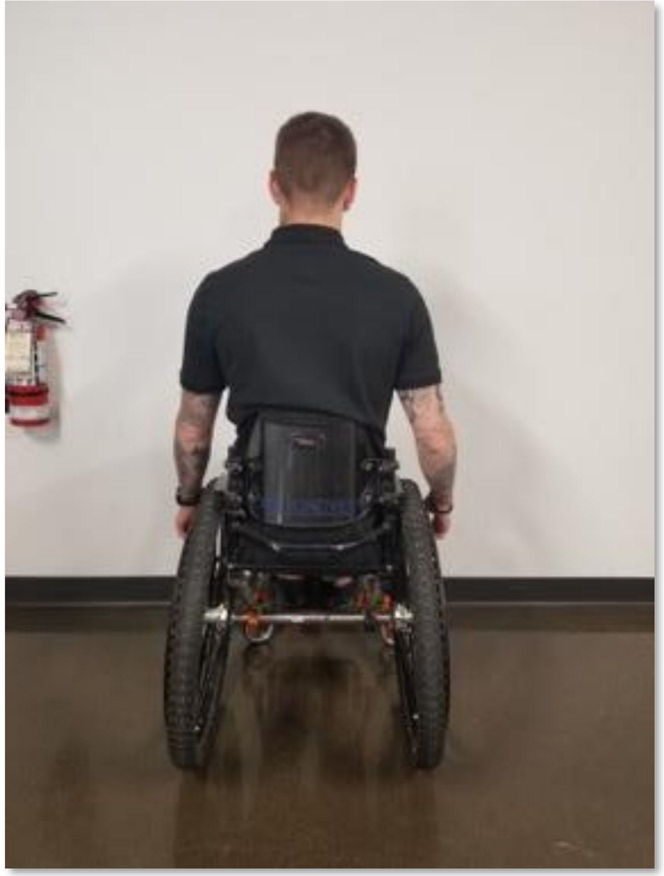
## *CONCERNS*

- Seat to floor (STF) is too high
  - poor access
- Footrest position inadequate
  - feet falling off footrest
- Minimal slope in chair
  - contributes to poor seated posture
  - visible spinal curve/rotation
  - abducted L LE
  - posterior pelvic tilt
- Fatigued by the end of the day
- Difficulty with transfers into truck

** TiLite TR: fixed rear STF height, COG only adjustable approx. 1”

# JEREMY'S ORIGINAL POSITIONING

L LE abducted
Excess seat width



Scoliosis of spine

Regular chair:

- Better posture
- More neutral LEs

# JEREMY'S NEW APEX CARBON


## SOLUTIONS

- Lowered overall height
- Increased seat slope by 1" (to 2" total)
- Reduced seat width from 15" to 13"
- Closed back angle to 93°
- Increased seat to footrest length for better LE positioning and foot placement

## OUTCOMES

- Improved seated posture
  - Visible reduction of scoliosis
  - Reduced posterior tilt
- Appropriate foot and LE position
- Better functional access
- Significantly lighter, can lift with one hand into vehicle
- Report increased energy at the end of the day

*"felt like I was in his 'sit-ski', I could make small turns without even touching the wheels"*

# JEREMY'S IMPROVED POSITIONING

More snug fit
Neutral LEs

Well supported feet/LEs

More neutral posture

# JEREMY BEFORE & AFTER

# TAKE AWAY MESSAGE


- Assessment: The Client
- Equipment: The Chair
- Translation: The Clinical
- Product trials

# Thank You!

For more information contact:

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