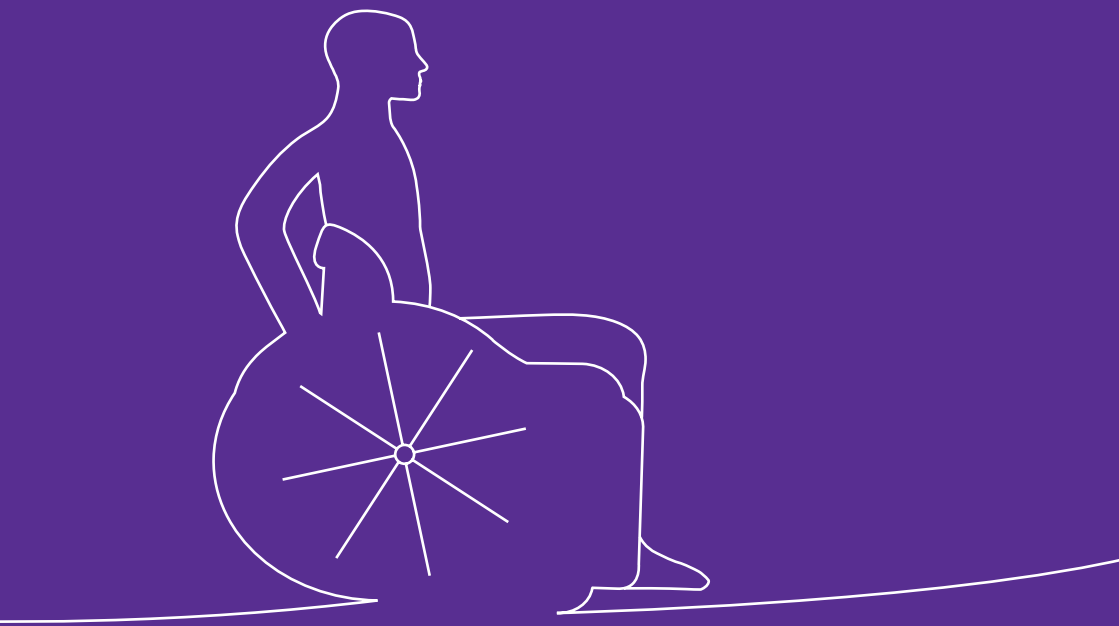
Manual Wheelchair Guide

A comprehensive introduction to optimising manual mobility for client function



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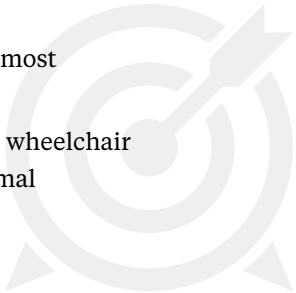
Purpose of this Guide

One of the greatest barriers to the provision of seating and wheeled mobility is first identifying the need and then documenting and justifying that need for equipment. This guide is meant to be a helpful resource to healthcare professionals to:

- Identify the need for manual mobility
- Translate the need for a mobility device to the most appropriate wheelchair model and options
- Understand what the components of a manual wheelchair are and how to appropriately measure for optimal configuration



✱ Look for these info boxes throughout the guide. They include quick tips or takeaways for that section.

This guide is meant to be a introduction to manual mobility. For advanced learning opportunities, contact local training coordinators for in deep workshops agenda or visit permobil.com

Note

This guide is not intended to replace the advice of a medical professional.

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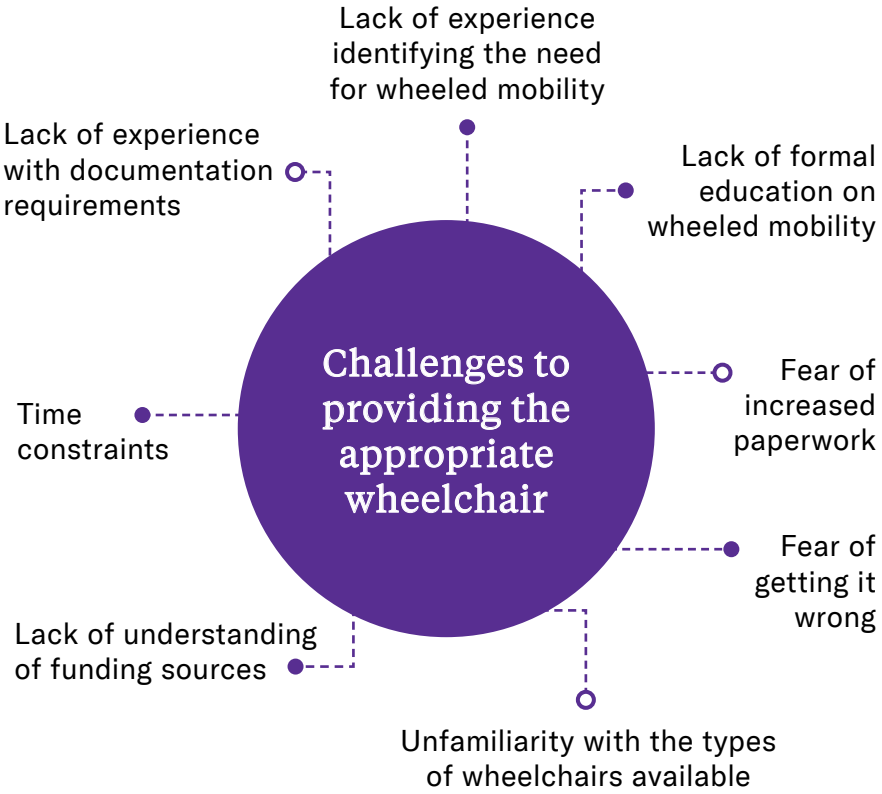
Manual Wheelchair Universal Terms

Common Challenges



* Despite wanting what is best for our clients, the above factors may prevent us from doing it.

Identifying the Need

HOW DO I KNOW IF MY PATIENT NEEDS A WHEELCHAIR?

Consider your patient's quality of life. Document any of the indicators below to justify the need.

1. Patient is non-ambulatory
2. Demonstrates decreased safety with ambulation or is at risk for falls within the home. Ask about history of falls; perform an objective balance assessment, e.g. BERG Balance Scale (BBS), Dynamic Gait Index (DGI), Timed Up and Go (TUG)
3. Requires assistance for ambulation within the home and wheeled mobility would allow independence
4. Requires increased time for ambulation within the home. Perform a gait speed test; think about performing ADLs in a reasonable amount of time
5. Unable to consistently ambulate throughout the day in the home, which affects their ADLs. Look at a 24-hour period
6. Their current wheelchair is in disrepair or not meeting their needs for mobility or postural support

* Here are scenarios where wheeled mobility could significantly increase a person's quality of life:
  - They can ambulate but are at high risk of falls
  - They have frequent urge incontinence because they are unable to get to the restroom on time
  - Their O_2 saturations drop below or heart rate increases above a safe range with ambulation
  - Their day consists of sitting in a recliner and transferring to a bedside commode as needed
  - Nature of their diagnosis, over-fatigue is contraindicated, and a WC is required in order to avoid exacerbation of symptoms

Manual Wheelchair Justification

HOW DO I JUSTIFY MY CLIENT'S NEED FOR A WHEELCHAIR?

Prior to choosing the type of wheelchair, the PT/OT needs to justify the need for a manual wheelchair.

Ask yourself the following questions, and the answers will begin to guide you towards the right wheelchair:

1. Does your client have a mobility limitation that significantly impairs his/her ability to participate in one or more MRADLs in the home?
2. Does it prevent them from doing MRADLs?
3. Are they unsafe to perform MRADLs?
4. Can they perform MRADLs in a reasonable time frame?
5. Can the mobility limitation be resolved by a cane or walker?
6. Do they have the desire or capability to propel a wheelchair?
7. If they can't propel, do they have a willing caregiver?
8. Does the client's home have the space/layout for functional wheelchair use?
9. Measure doorways and ask your sales representative for required measurements to get through doorways based on the wheelchair model selected
10. Measure the time it takes to propel the WC to the bathroom from someplace else in the home

* Always document how the right equipment allows them to perform routine tasks more independently.

WHAT IF YOUR CLIENT ALREADY USES A WHEELCHAIR?

If your client uses a wheelchair already, ask the following:

1. How is their posture in their wheelchair?
2. Do they have pain when using their wheelchair?
3. Can they effectively propel their wheelchair?
4. Are they independent in their ADLs?
5. How old is their wheelchair?
6. Was it originally ordered for them, or did they get it from someone else?

* Just because a person already has a wheelchair, it doesn't mean it's the most appropriate one for them.

Long Term Use Manual Wheelchairs

The description below will help define the difference in products that qualify as Long term use:

- Medically necessary, individually-configured manual and power wheelchairs, adaptive seating systems, alternative positioning systems, and other mobility devices
- Require evaluation, fitting, configuration, adjustment, or programming
- Designed to meet specific and unique medical, physical, and functional needs of individuals to optimise independence and function.

A primary diagnosis resulting from hemiplegia, hemiparesis, a congenital disorder, progressive or degenerative neuromuscular disease, or from certain types of injury or trauma may be a place to start thinking Long term use, but do not limit yourself to those diagnoses.

WHO MIGHT BE AN APPROPRIATE USER FOR LONG TERM USE MOBILITY EQUIPMENT?

A seating evaluation will define if there is need for long term use equipment, but the list below can help you identify the type of user appropriate for long term use equipment.

- Uses a wheelchair as primary mobility every day
- Sits in the wheelchair for long periods of time
- Has limitations in sitting balance
- Needs specific dimensions to maintain posture and optimise function
- At risk for/has current postural deformities
- Has pain in sitting
- Needs specific support, configuration, repositioning, and/or adjustments to maintain posture, protect skin, and maximise function
- Propels on varied surfaces/terrain indoors and outdoors
- Has tonal abnormalities that interfere with positioning/mobility
- Has a progressive condition

Best practice for assessment and provision of MWC's:

- OT/PT performs clinical evaluation
- Supplier performs technology assessment and equipment trials with PT/OT
- PT/OT writes clinical documentation
- Supplier submits paperwork to insurance
- Supplier and OT/PT deliver, fit, and provide training for equipment

**Depends on Market/Country*

✱ Providing equipment:

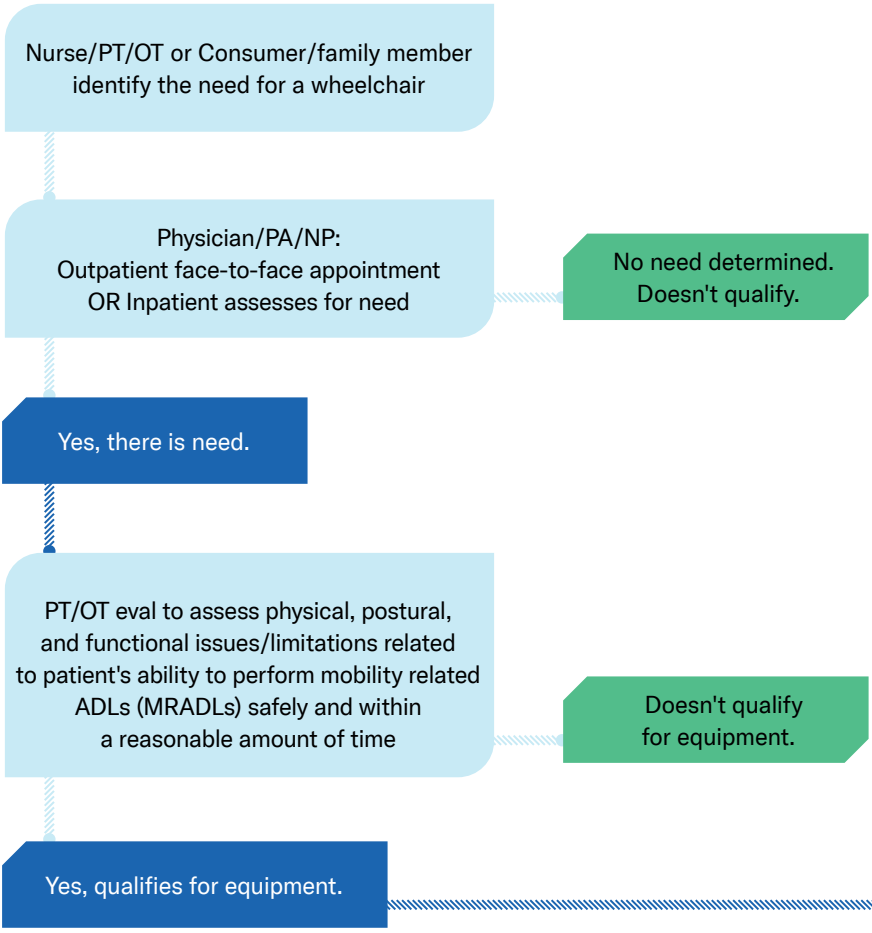
- Requires more knowledgeable, skilled, and experienced professionals
- Requires specialised evaluations, measurements, trials, fittings, training, education, and ongoing modifications
- Companies must comply with more rigorous quality standards

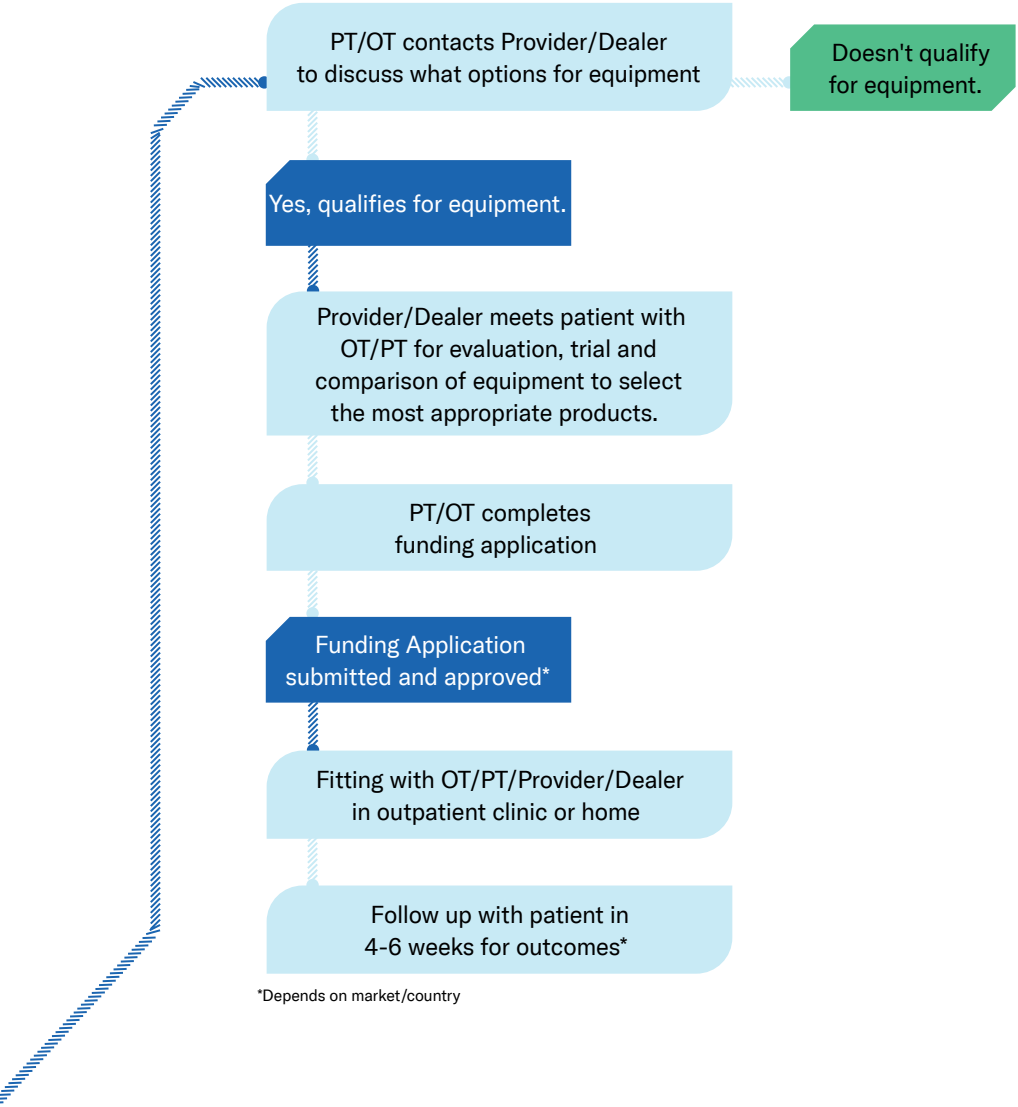
✱ A long term use wheelchair is going to be best practice for a full-time wheelchair user every time.

The Process of Getting a Manual Wheelchair

WHERE DO WE START?

Let's look at the big picture of how to get equipment:





*Depends on market/country

Long-term Use Wheelchairs

Long-term (and/or full-time) means that the client will need a wheelchair indefinitely as their primary means of mobility whether independent or dependent.

Manual Tilt-in-Space when positioning is the priority

When is a Tilt-in-Space wheelchair appropriate?

- Client is dependent in mobility
- Client is unable to perform independent pressure relief
- Client requires tilt pressure reliefs during the day and is able to perform tilt-in-space pressure relief via self-activated lever
- Client requires postural support, head and trunk control, and accommodation of postural asymmetries
- The goal is to increase sitting tolerance/ endurance through changing positions or pressure management
- Client needs improved line of sight due to forward head posture
- Client will benefit from trunk support and open thoracic posture for increased respiratory function
- Client requires safe positioning for feeding/gravity-assisted swallowing
- Client is requires gravity assisted positioning and can utilize UEs and/or LEs for self-propulsion

* A manual tilt-in-space wheelchair requires a PT/OT evaluation, justification that other manual wheelchairs are not appropriate.

Ultra-lightweight MWC when independent propulsion is the priority

This is **THE** manual wheelchair for a full-time wheelchair user with goals to be active at home and in the community. These wheelchairs can be individually configured to meet the needs of the wheelchair user and optimise function and propulsion. They are designed to be used on indoor and outdoor surfaces in the community and can be folding or rigid.

Progeo Noir

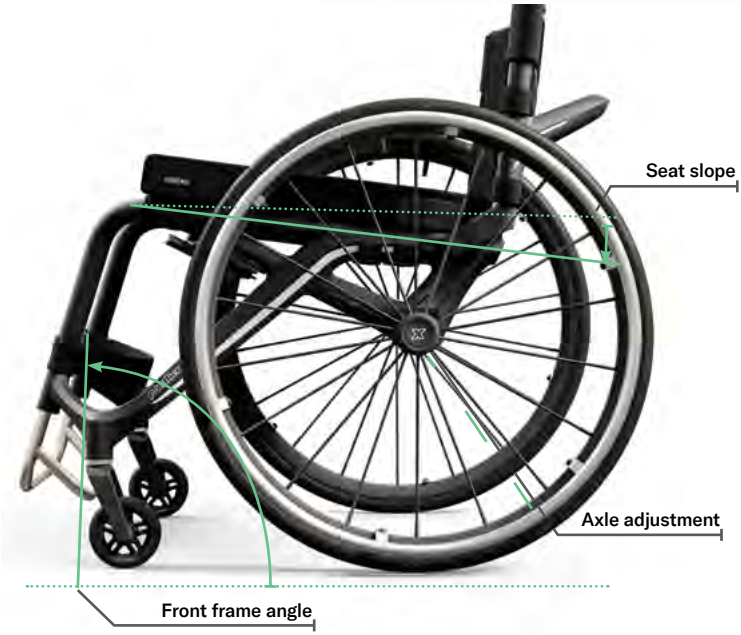
Panthera X3

TiLite ZRA

Ultra Lightweight Manual Wheelchairs

Requirements:

- Client is a full-time/long-term wheelchair user
- Client requires customisation such as axle configuration, wheel camber angle, front and/or rear seat-to-floor height (seat slope), or WC frame size that can't be accommodated by a a standard manual wheelchair
- This requires an evaluation by a PT/OT, and the involvement of a Dealer in the equipment selection process



Rigid vs folding frame

Rigid

- One-piece frame is comprised of bent and/or welded tubes
- Leg rest hangers are integrated

Folding

- Two-piece frame connected with cross and horizontal bars
- Removable/swing-away leg rests

Why use a rigid frame?	Why use a folding frame?
Generally lighter weight due to less parts. This is significant for push efficiency and loading into vehicles. Fewer parts can increase durability.	User choice! If someone has been using a folding WC for a long time or just likes folding frame wheelchairs, then that is reason enough.
More rigid equals more efficient. Folding frames will flex more which takes energy away from the push.	Standing, or partial standing, transfers are easier with swing-away leg rests. There are options on rigid frame wheelchairs, but generally a folding WC is easier for these clients.
Rigid frame wheelchairs fit in small areas as well! Consider a fold-down back & quick release wheels.	People who propel the wheelchair with their feet. There are options for rigid frame wheelchairs, but they tend to require custom builds.
	If there is need for elevating leg rests
	Transport efficiency for bariatric clients

Tips for Justifying an Ultra lightweight or Manual Tilt-in-Space Chair

HOW CAN I MAKE SURE THAT MY CLIENT GETS THE MWC THEY NEED?

Qualification for a long term use MWC is functionally based, not diagnosis based. Include a description of the client's routine activities and whether they are fully independent in the use of the wheelchair.

1. Use **objective tests** and measures such as a Wheelchair Propulsion Test

   Compare an optimally configured ultra lightweight wheelchair vs. lower-end wheelchair; time propulsion over a fixed distance; count push strokes; differentiate quality of propulsion; document pain; pulse oximetery
2. Compare **safety, efficiency, and ability** to **independently** complete all mobility related activities of daily living (MRADLs) **all day, every day**, with a lesser MWC
3. Consider the need to configure an ultra lightweight wheelchair for **better posture and mobility**
4. Document the **unique features of a ultra-lightweight manual wheelchair and *why* they are needed**:
   - Adjustable front and rear seat-to-floor heights
   - Individualised seat and frame width and depth
   - Axle adjustability
   - Seat slope
   - Rear wheel camber
   - Seat back angle

   OR,
5. Document the unique features of a Manual Tilt-in-Space chair and why they are needed. The ability to tilt the wheelchair seat posteriorly to:
   - maintain position in the chair due to spasticity, decreased trunk control, or endurance
   - to provide gravity assisted positioning required for optimal posture due to postural asymmetries
   - to assist with pressure management during the day
   - to change positions for activities of daily living

Examples **why** the features may be needed:

Adjustable axle plate is required for center of gravity adjustment to allow for efficient propulsion and decreased shoulder pain from 6/10 to 0/10.

Adjustable axle needed to allow for efficient propulsion compared to a lesser WC: Person took 35 push strokes & 5 min to propel 40' to bathroom, compared to ultra lightweight WC, where it took 15 push strokes & 2 minutes.

A manual tilt-in-space chair is required to provide regular weight shifts in the chair throughout the day; my client is unable to perform an effective pressure relief and is at risk for skin breakdown.

Manual Tilt-in-Space Configuration

WHAT ARE THE FUNCTIONAL CHARACTERISTICS OF A HIGHLY-CUSTOMISABLE WHEELCHAIR?

Configuration options	Why it matters
Front seat-to-floor height (FSTFH) (*Pages 21-22)*	Important for safe functional use and transfers
Adjustable Rear seat-to-floor height (RSTFH) (*Pages 21-22)*	Assists with pressure relief and wheel access
Seat slope: difference between the FSTFH & RSTFH (*Pages 23-24)*	Important for postural stability and optimal wheel access for self-propulsion
Foot support-to-seat length (*Page 27)*	Affects LE positioning w/ femoral contact for pressure redistribution or propulsion
Seat width (*Page 29)*	Affects posture, wheel access for propulsion, and environmental access
Seat depth (*Page 32)*	Optimises posture and pressure redistribution
Horizontal rear wheel axle position (*Pages 37-38)*	Improved push stroke for client
Weight capacity	Accommodating pediatric to bariatric enduser

Ultra Lightweight MWC Configuration

WHAT ARE THE FUNCTIONAL CHARACTERISTICS OF A HIGHLY-CUSTOMIZABLE WHEELCHAIR?

Configuration options	Why it matters
Front seat-to-floor height (FSTFH) (*Pages 21-22*)	Important for safe functional use during propulsion and transfers
Rear seat-to-floor height (RSTFH) (*Pages 21-22*)	Determines rear wheel accessibility and efficiency of propulsion
Seat slope: difference between the FSTFH & RSTFH (*Pages 23-24*)	Important for postural stability and optimal wheel access for self-propulsion
Foot support-to-seat length (*Page 27*)	This affects LE positioning, femoral contact for pressure redistribution, and foot plate clearance
Front frame angle (*Page 28*)	Legs and feet brought closer to the body make the overall WC footprint smaller, making it easier to get close to things for reaching
Seat width (*Page 29*)	Affects posture, wheel access for propulsion, and environmental access
Seat depth (*Page 32*)	Optimizes posture and pressure redistribution
Seat back height (*Page 34*)	An optimal back support height will balance postural stability and functional reach for ADLs
Seat-to-back angle (*Page 35*)	This angle provides optimal pelvic and trunk support for stability and daily function
Horizontal & vertical rear wheel axle position (*Pages 37-39*)	This can be configured for optimal center of gravity and wheel access for the most efficient push stroke
Rear wheels (*Page 43*)	Affects propulsion, rolling resistance, and weight
Rear wheel camber (*Page 44*)	Used to increase lateral stability and turning efficiency
Casters (*Pages 45-46*)	Stability, rolling resistance, and maneuverability

* An ultra lightweight MWC is an individually configured, tailor-fit wheelchair. It is not merely small, medium, or large.

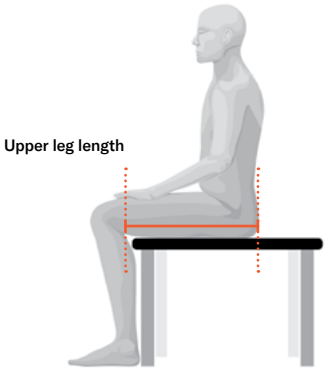
Measuring for an Ultra Lightweight Manual Wheelchair

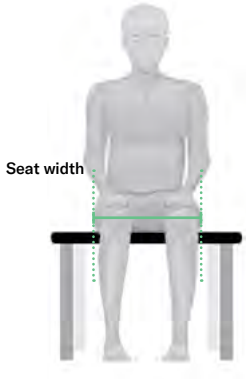
The features of a manual wheelchair will significantly affect the client and performance of the wheelchair in terms of postural support and wheelchair stability, maneuverability, and ease of propulsion.

This is why the ability to configure an ultra lightweight MWC is best practice for a person who uses a wheelchair long-term.

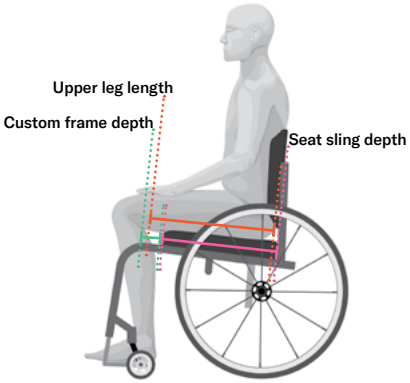
✱ Relating the client's measurements to the wheelchair specifications is key

Anatomical measurements
from mat evaluation





Wheelchair measurements
to be performed with the person in a WC seated in their desired position of propulsion



Seat-to-floor height (STFH)

The front and rear seat-to-floor height is usually not the same in an optimally configured ultra lightweight manual wheelchair. (visual on next page)

Front STFH measurement

WC measurement is from where the leading edge of the seat upholstery meets the frame of the wheelchair to the floor.

Anatomical measurement is meant to match the dimensions of the lower leg along with the foot plate to ensure lower extremity support and accessibility.

- An appropriate height will provide proper support of the thighs and lower legs to optimise stability and pressure redistribution

Rear STFH measurement

WC measurement is from the wheelchair frame seat tube to floor, right in front of the back post. You must have the client in a WC to determine their RSTFH

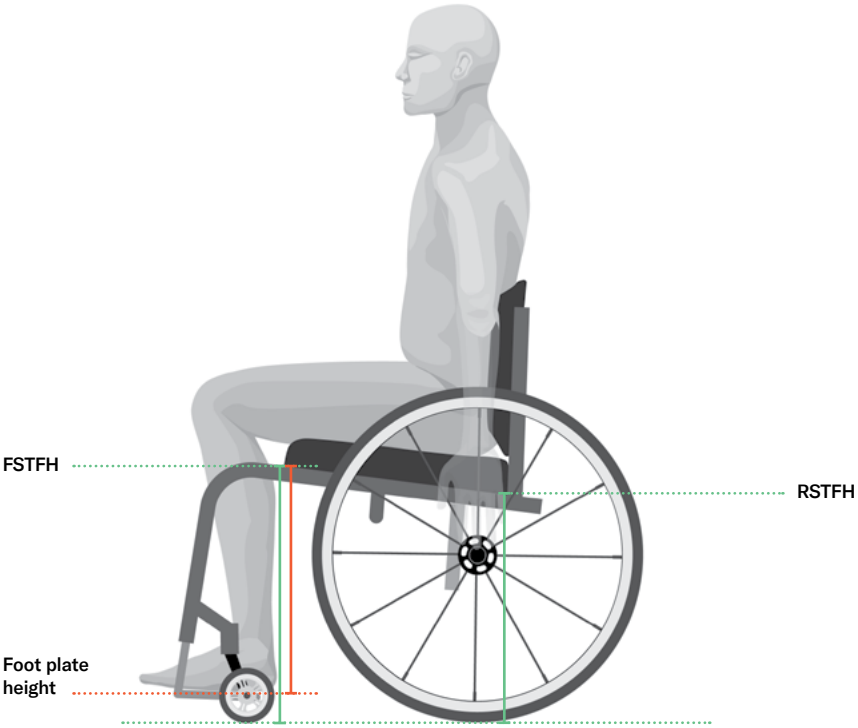
- This height is meant to ensure appropriate access to wheel handrims for optimal propulsion. Optimal RSTFH is when the finger tips of the client touch the axle of the wheel. *See "Vertical axle positioning" (page 45) for more*
- A lower rear STFH relative to the front STFH can provide increased postural stability for those with impaired trunk control

Foot plate height measurement

WC measurement is the distance from the top of the footplate to the seat upholstery. It should be equal to the lower leg length minus the height of the cushion. See page 33 for more.

Always consider the wheelchair seat cushion thickness and clearance of tables and desks when measuring STFH.

For determining both the front and rear STFH, keep in mind that some seat cushions may have a different thickness in the front and the rear of the cushion. The difference will affect seat slope if not accounted for.

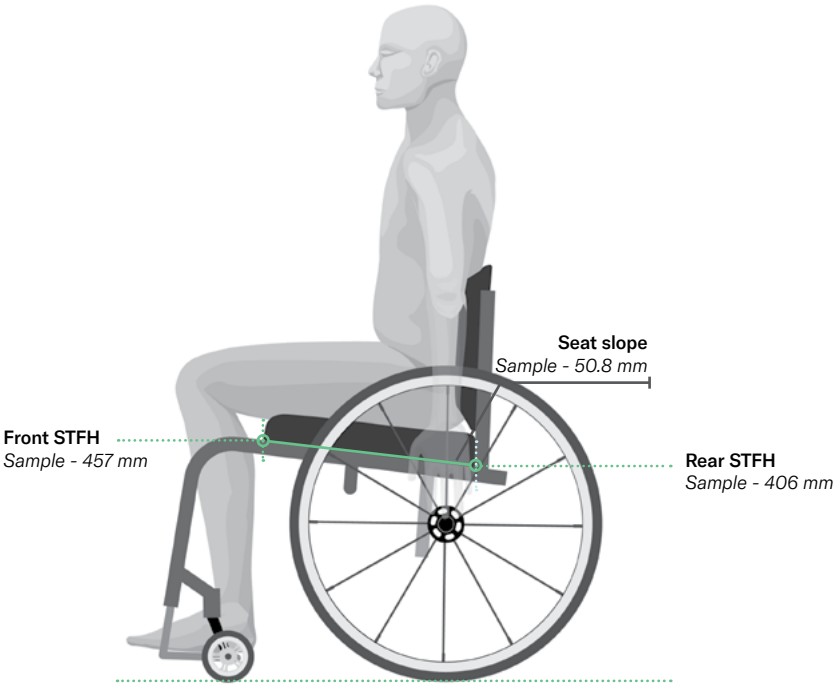


* USE A DEMO! All WC measurements should be completed with the client in a demo wheelchair! The demo does not have to be perfect for your client, but it will give the best starting point for fitting them.

Seat slope

The seat slope is the difference between the front and rear STFH and is important for postural stability and optimal wheel access for propulsion.

- The greater the seat slope from front to back, the more passive stability is provided for those with decreased trunk control
- Consider available hip and knee range of motion when determining seat slope
- Insufficient seat slope may make sitting up difficult while too much seat slope may make transfers more difficult



* Most adults need about 50.8 mm seat slope if they propel with their UEs. Foot propellers need 0 - 25.4 mm of seat slope.

Utilising an ergonomic (ergo) seat on an ultra lightweight MWC

Sometimes a conventional seat slope won't work for these reasons:

- There is an insufficient range of motion (ROM) at the hip and/or knee required for the slope
- The individual requires 76.2 mm or more seat slope for stability and rear wheel access
  With 76.2 mm or more of seat slope an acute hip-to-back angle is created so even a WC user with normal ROM cannot access the rear portion of the seat
- Individual may feel unstable
- Individual complains of pain
- Individual complains of sliding forward

Example of limited ROM at the hip: Individual slides into an abnormal posture by shifting their legs and pelvis forward to open the angle back up for comfort. Then, they slouch forward to maintain their center of gravity/stability.

Ergo seat for ultra lightweight manual wheelchairs

An ergonomic seat is intended to match an individual's shape while providing a lower RSTFH relative to the front. The RSTFH is maintained for a length of the frame before the seat tubing ascends up to the FSTFH specified.

- This promotes an upright posture by maintaining a more open STBA compared to a conventional seat slope
- It allows for better stability, positioning, and pressure distribution by creating a stable, neutral place to seat the pelvis and load the femurs
- Allows improved rear wheel access for more efficient propulsion
- It optimises total surface contact area, increasing pressure redistribution for the bony prominences and encouraging pelvic stability
- The shape allows the thighs to be more level, making it easier to carry items during daily tasks

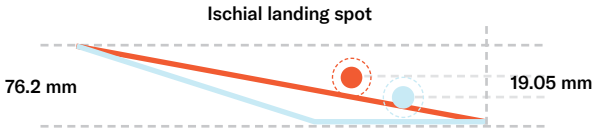
Ergo seat measurement

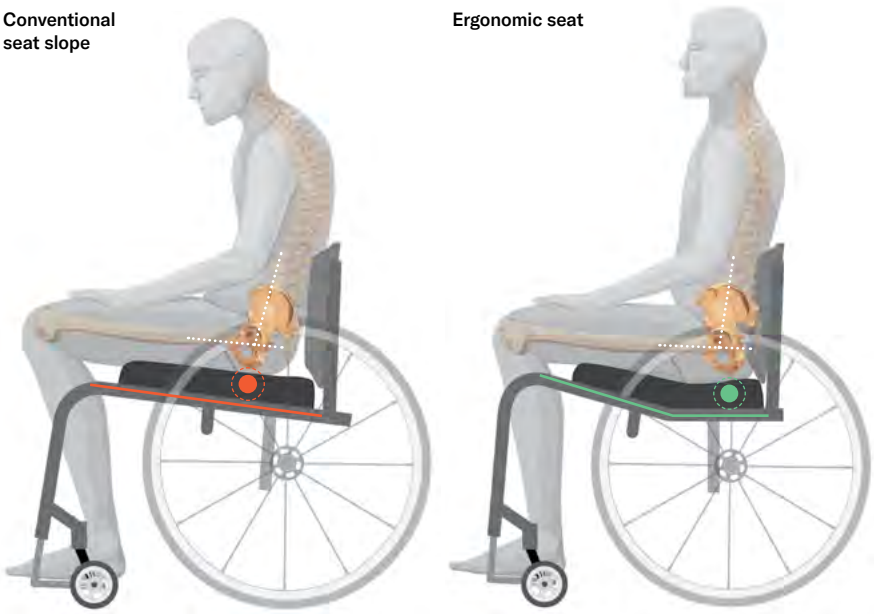
WC measurement is from the back post of the WC to the point in the tubing where you want it to start to bend upwardly.

Anatomical measurement is from behind the hip to the greater trochanter, plus 25.4 - 50.8 mm.

* Instability from an increased seat slope can be offset by using an ergo seat when clinically appropriate for the user.

The idea is to contain the ITs within the flat ergo well. Since the frame is providing the positioning, the goals of the cushion need to be consistent with the goals of the wheelchair. The cushion needs to follow the contour of the frame and provide a flexible pressure relieving interface between the frame and the wheelchair user.





Foot support-to-seat length

The foot support-to-seat length is also known as leg rest length. It is important to provide lower extremity support, ensuring optimal femoral contact at the seat surface and clearance of obstacles at the footplates.

It is important to use a demo wheelchair with the person in the desired position of propulsion, to get the most accurate measurement.

Foot support-to-seat - too short

- This can raise the knees which reduces clearance for under tables and increase slope of the upper legs which can make it harder to carry items
- Can reduce femoral contact and increase peak pressure at the ITs

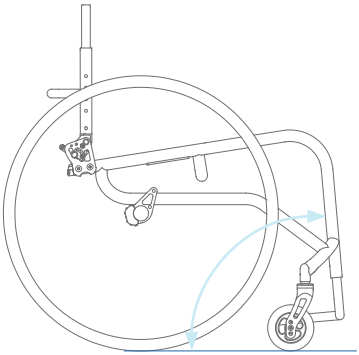
Foot support-to-seat - too long

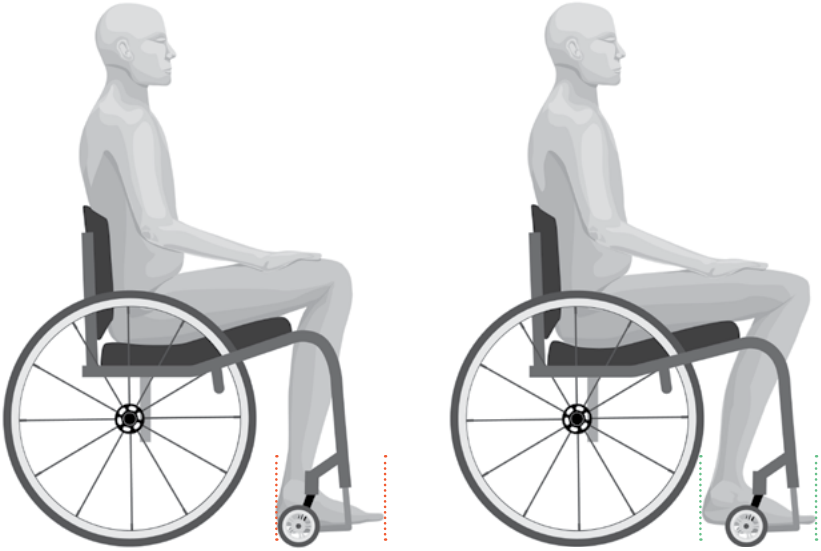
- Lower legs are unsupported and pressure increases distal femur. The client may slide forward to reach the foot support, and by doing so, shift into a posterior pelvic tilt
- This can increase risk of a postural abnormality and peak pressures at the seat and back support surfaces

Front frame angle

Front frame angle is critical to provide appropriate support to the lower extremities.

This should be set by asking the client where they want their feet (further in or out) and have the client place their feet where they want them. The front frame angle selected should be the one where the ball of the client's foot can rest on the foot rest tube. Measuring for the overall frame length is a more accurate way of determining the appropriate front frame angle for a client. *See page 60 for more.*





Example visual: A tall individual may need to tuck their legs in tight under the WC due to their longer lower leg length. This allows them to still clear the edges of tables, desks, counters and keep their overall wheelchair footprint smaller. They must have an available ROM at the knee for this.

Seat width

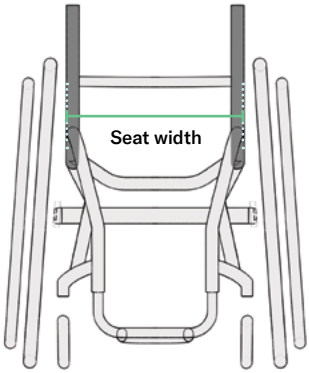
Measuring the appropriate seat width is critical for postural stability and propulsion efficiency.

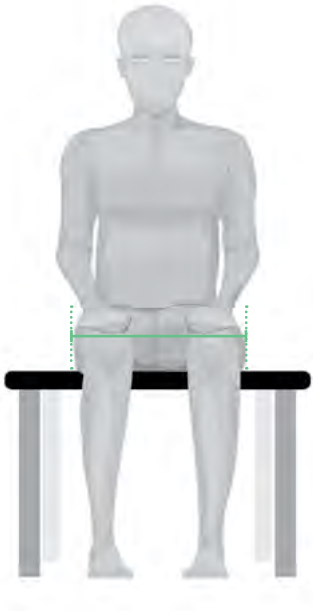
Seat width measurement

WC measurement is outside to outside of seat tubes at the back post. This should match the client's anatomical measurement.

Anatomical measurement is the widest point of the body at the hips including all residual tissue.

- The seat width affects the overall width of the wheelchair along with wheels and handrims





Seat width - too narrow

- This can lead to unwanted pressure and postural abnormalities due to compensation

Seat width - too wide

- This can make it difficult to access the handrims and result in inefficient propulsion which can cause upper extremity injuries over time
- Negatively affects environmental accessibility and positioning/posture in the WC

Front seat width

This measurement allows you to taper the front of the seat to match the client's posture. Front seat width can also be referred to as the seat taper.

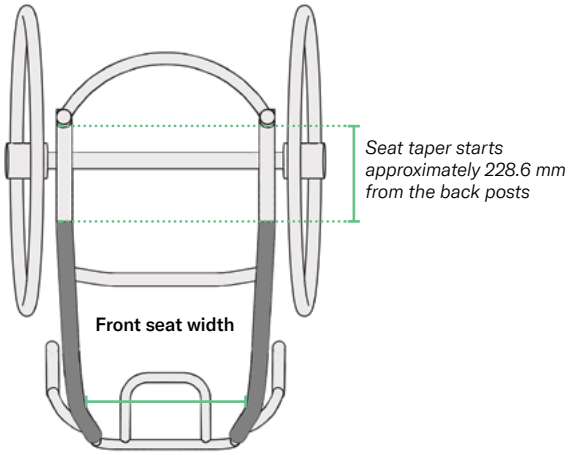
Not all client's need to have a tapered seat. However, client's whose LEs are much narrower than their hips may benefit from front seat taper to:

- Provide better LE positioning with better overall WC fit
- Allow the ability to get closer to things for transfers and reaching
- Provide a smaller overall footprint for accessibility
- "See me, not the wheelchair"

Front seat width measurement

WC measurement is inside of front frame tube to inside of opposite front frame tube.

Anatomical measurement is the width across the client's legs across the distal end of the femurs, proximal to the knees. This width should match the front seat width measurement.

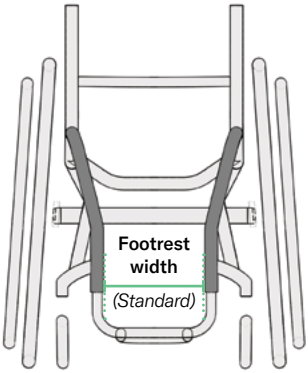


Footrest width

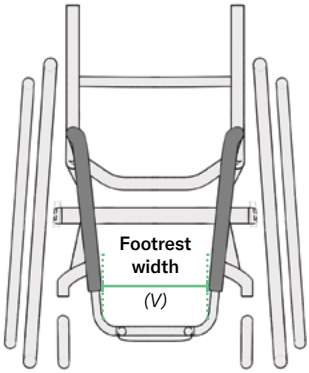
This measurement allows you to match the footplate with a LE positioning that is comfortable for the client. Someone who has large legs or LE edema may not need any front seat taper. Someone whose lower legs are smaller than their hip width may need some leg rest taper.

Footrest width measurement

Select a width that allows for adequate space for the client's feet and tapers to the client's desired position. Measure across both the client's feet with shoes.



Standard - Inside of front frame tube to inside of opposite front frame tube



V - Inside of front frame tube to inside of opposite front frame tube 63.5 mm above footrest

Footrest width - too tight

- The tubes press on the client's legs or feet
- The footplate may not be wide enough to allow the feet to pivot for transfers if the client leaves their feet on the footplate for transfers

Footrest width - too loose

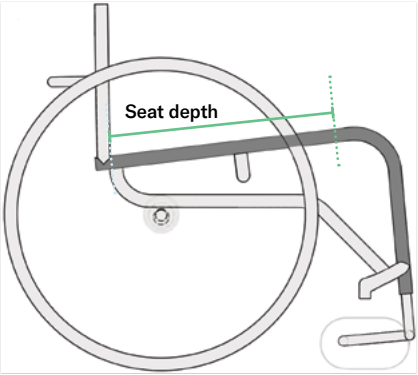
- The client does not have adequate foot/LE positioning coming from the WC. Legs and feet may lose position, especially with spasticity or going over bumps
- This can decrease environmental access by increasing the WC footprint

Seat sling depth

The goal of seat sling depth is to maximise support and pressure distribution without interfering with LE positioning. An appropriate depth will provide optimal stability in the wheelchair.

Seat depth measurement

WC measurement is from the back posts to the leading edge of the seat upholstery.



Anatomical measurement is from behind the user's hip including residual tissue to their popliteal fossa AND should account for where they want to position their legs, more or less tucked.

Seat depth - too short

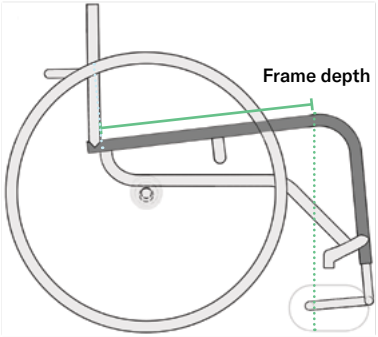
- Decreases femoral contact for pressure distribution which can lead to pressure injury

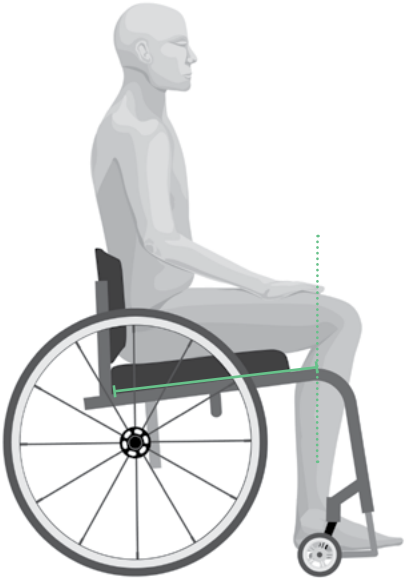
Seat depth - too long

- This may result in sliding forward to decrease pressure behind the knees, resulting in poor posture and decreased propulsion efficiency

Frame depth

The frame depth is measured from the front of the back cane to the front frame bend. The center point of the trailing front caster is usually lined up with the front frame bend, resulting in a balanced wheelchair for optimal stability and propulsion.





Frame depth on a rigid wheelchair should be set so that the bend in the frame lines up with the bend in the user's leg. This results in a balanced wheelchair because the front casters will move forward proportionally to the end user's body when frame length is added to fit their shape.

* If you notice anterior instability, caster loading, or impaired maneuverability, check the frame depth.

Seat back height

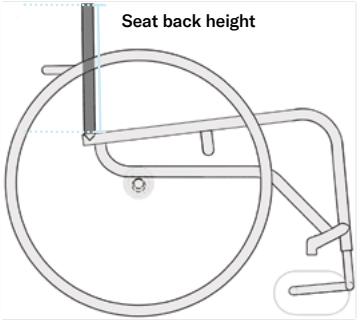
Proper back height in a ULMWC is important for providing appropriate postural support and upper extremity function for propulsion.

Seat back height measurement

The WC measurement is from the top of the back post to the top of the seat tube at the back post.

Select a seat back height that allows the prescribed back support to reach desired height to for adequate postural support.

An optimal back support height is determined by the lowest point of the trunk needing support for stability and function.

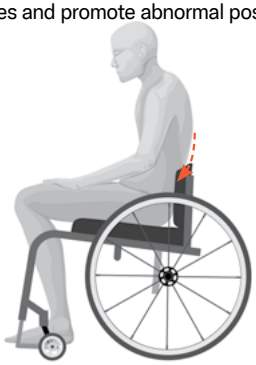


Back support - too high

- May limit scapular movement during propulsion which impacts upper extremity range of motion

Back support - too low

- May result in a feeling of instability
- Individual may slide into a posterior pelvic tilt seeking stability. This can increase peak pressures and promote abnormal posture



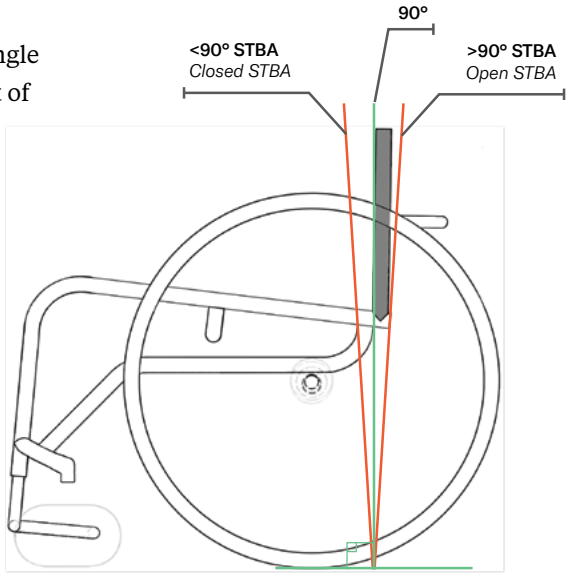
* When measuring for a manual tilt-in-space chair the back height should support the full length of the trunk, especially when in the tilted position. Measure from the seat to the top of the shoulder and consider the height of the cushion being recommended.

Seat-to-back angle

The seat-to-back angle (STBA) is critical for postural support and assuring the best position for efficient propulsion. Most adults need the STBA open a few degrees to allow room for their normal spinal curves. This angle can be further adjusted to the client's needs using adjustment on the back support mounting hardware and on the wheelchair itself if available.

STBA measurement

On the WC, seat-to-back angle is measured from the front of the back post to the floor.



- Greater than 90° may improve postural stability for individuals with impaired trunk control and/or limitations in hip range of motion. 92° - 93° may provide the lumbar area support for promoting normal spinal curves.

* Manual tilt-in-space wheelchair users often require a more open STBA to assist with balance and/or accommodate for the seating system recommended. In addition, some manual tilt-in-space chairs are also available with manual recline to further assist with positioning, balance, and activities of daily living in the wheelchair.

Position of the rear wheel axle

The horizontal and vertical positions of the rear wheel axle, have a significant impact on all of the functional characteristics of the wheelchair such as:

- stability
- weight distribution
- turning radius
- wheel access

Keep in mind that a forward axle position reduces the forces needed to propel and the rear axle should be set for the center of mass of the client.

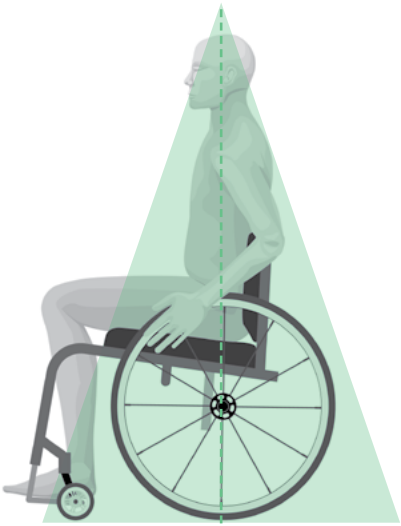
✱ Weight distribution and configuration have a greater impact on ease of wheelchair propulsion than overall mass of the chair. This applies to upper extremity, lower extremity and hemi-propulsion styles, as well as to a caregiver who is pushing the wheelchair.

Every full-time, long-term wheelchair user should have the rear wheel positioned uniquely for them to prevent injury and ensure full access to their environment.

Horizontal axle positioning

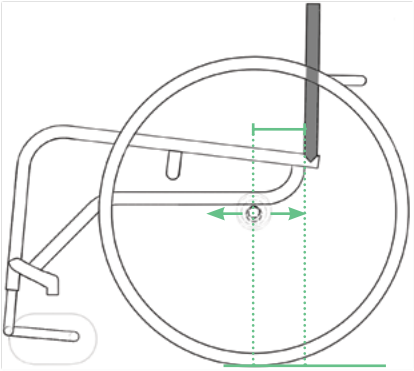
The horizontal axle position will determine the wheelchair center of gravity (COG).

When the axle is under the center of mass of the client, the majority of their weight is on the large rear wheel. Ideally, this is about 80% of their body weight. If weight is not on the rear wheels, it will load the front casters, requiring more force to roll the WC.



Horizontal axle measurement

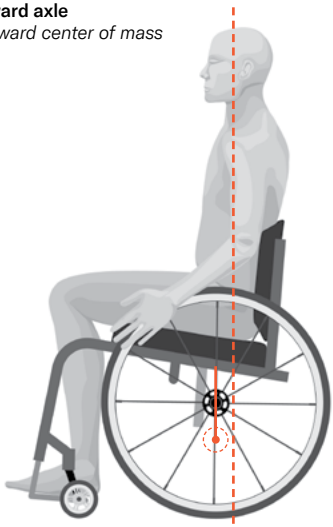
WC measurement is the horizontal distance from the front of the back post to the center of the rear axle of the wheelchair.



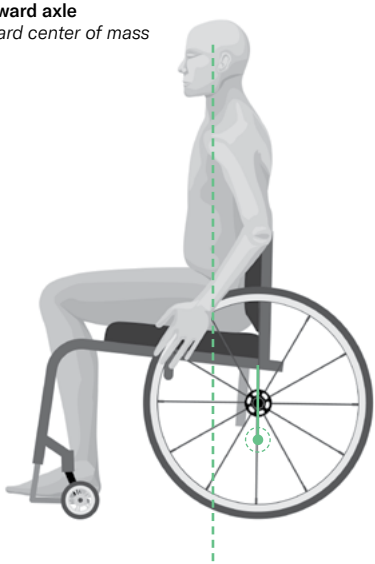
* Best practice is to position the rear wheel as far forward as possible without unsafe rear instability or caster interference.

  Some manual tilt-in-space wheelchairs offer the ability to adjust the center of gravity horizontally to assist with weight distribution for propulsion and stability in the chair. Other manual tilt-in-space chairs offer the option of a reverse configuration (large drive wheel in the front) to facilitate access to the drive wheel for propulsion.

Forward axle
Rearward center of mass



Rearward axle
Forward center of mass



Benefits

Allows for more efficient upper extremity position for propulsion

Increases frontward stability of the WC. WC is less likely to tip forwards when rolling down, reaching forward, or scooting forward for transfers

Decreases turning radius and overall footprint of the wheelchair, making it easier to navigate small spaces

Increases ease of performing a wheelie to maneuver obstacles

Considerations

If too far forward, it increases the risk of wheelchair tipping backwards

Benefits

The WC will be more stable in the rear*

Considerations

Less efficient upper extremity position to reach rims, could lead to injury over time

Increases the forces necessary to turn the wheelchair

Increased rolling resistance makes it harder to propel

Increases difficulty of performing a wheelie to maneuver obstacles

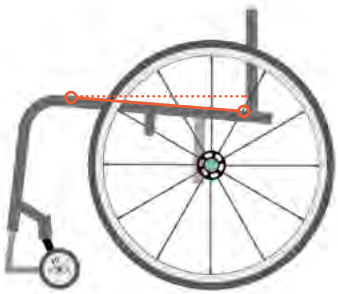
Increases the turning radius and length of the wheelchair footprint, making it difficult to navigate small spaces

*Increases risk of WC tipping forward

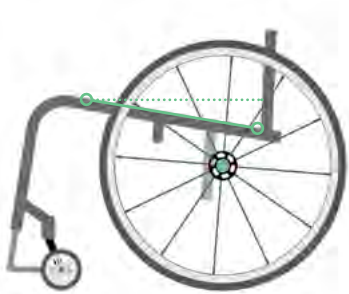
Vertical axle positioning

Proper vertical axle position allows for optimal upper extremity position for propulsion. Vertical axle position determines RSTFH measurement and therefore affects seat slope.

Lower axle (on axle post)
Higher RSTFH, less seat slope



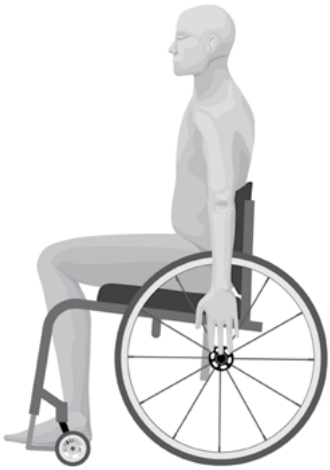
Higher axle (on axle post)
Lower RSTFH, more seat slope



Vertical axle measurement

The vertical position of the axle is determined by how high or low the RSTFH of the wheelchair needs to be. Remember to account for cushion thickness here.

For client's with hand function, finger tips should touch the center of the rear axle when sitting upright with arms to the side. For those with tetraplegia, use the thenar eminence instead as your reference point.



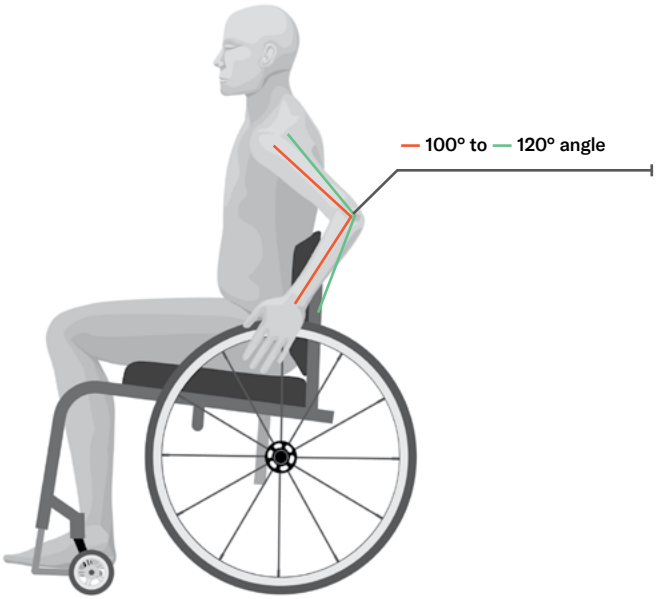
* Effective / efficient propulsion is affected if the vertical position is too high or low, and it may place the upper extremities in a position that could cause injury over time.

MWC propulsion

The wheelchair configuration is critical for optimal push efficiency. The goal is long, smooth strokes to decrease the frequency of pushing.

When propulsion forces and repetitions are minimised, the preservation of upper limb function is maximised. This reduces the risk of discomfort, pain, poor function, and injury.

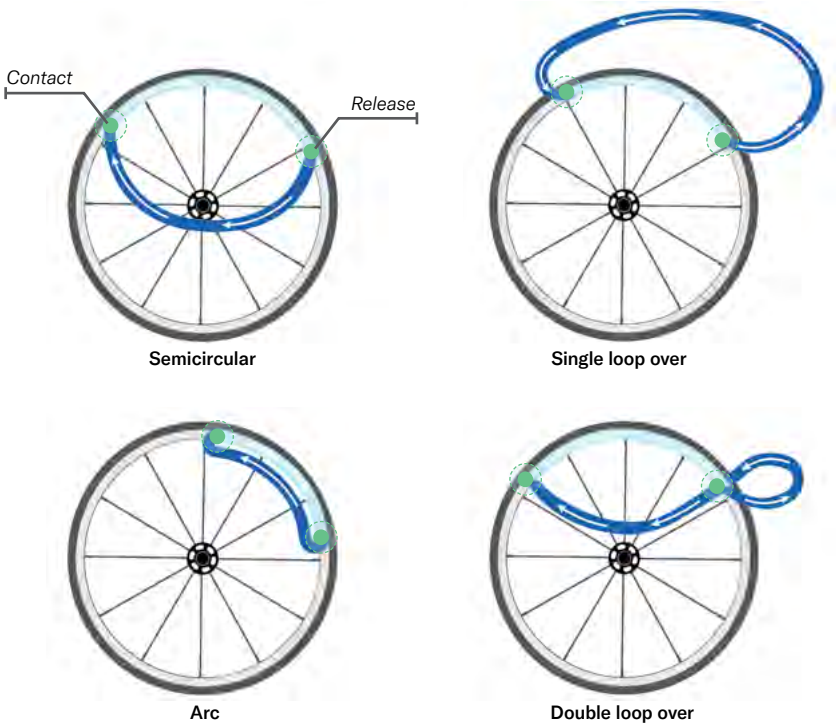
The ideal seat height and axle position is when the angle between the upper arm and forearm is between 100° - 120° when the hand is resting on the top center of the pushrim.



* For lower extremity or hemi-propulsion, optimal position also includes a FSTF that is up to 50.8 mm lower than the lower leg length to allow good foot contact with the ground, as well as 0 - 25.4 mm seat slope and a 95 degree open back angle.

Upper extremity propulsion patterns

There are four upper extremity stroke techniques consisting of a push phase and a recovery phase. The pattern of recovery (release to contact) is the largest difference between techniques.



The semicircular pattern is encouraged because:

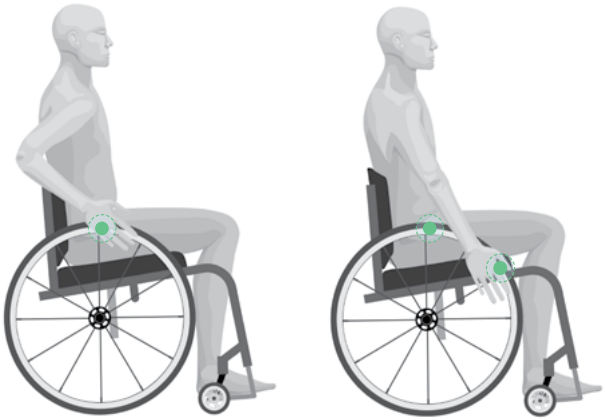
- It promotes better biomechanics
- It is associated with lower stroke frequency
- It promotes more time in push phase than recovery phase
- The hand follows an elliptical pattern with no quick changes in direction and no extra hand movements

Single loop over is the most common pattern for individuals with paraplegia.

Propulsion efficiency

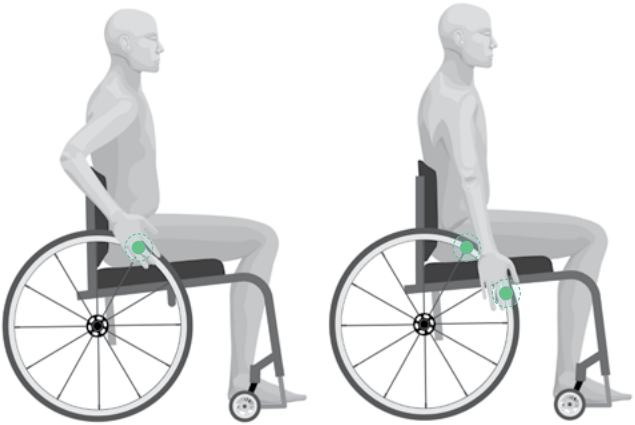
A forward axle position allows for longer, smooth push strokes which will also decrease frequency of pushes.

Forward axle -
Distance between contact & release



A rearward axle position reduces the user's ability to get a long stroke since they are starting the push phase near the front of the rear wheel.

Rearward axle -
Distance between contact & release



* A forward axle position distributes the user's weight over the rear wheel, making propulsion easier. A rearward axle position puts more weight on the front casters, adding more rolling resistance making propulsion more difficult.

Rear wheel options

Wheel type and size are important to minimise rolling resistance, decrease weight, and increase reliability of the system.

Rear wheel size

Diameter of the wheel is determined by the optimal RSTFH for a client. For example, a taller person may need a larger diameter wheel.

Rear wheels - too large

- The seat-to-floor height and access to the hand rims may be compromised
- A larger diameter wheel may interfere with transfers since they create a little bit bigger hurdle to transfer over
- A larger wheel will increase the length of the wheelchair footprint. This could negatively affect client reach, ADLs, and wheelchair maneuverability

Pneumatic vs Non-pneumatic tires

Pneumatic tires: (filled with compressed air)

- Weigh less with better shock absorption
- Must be inflated properly for optimal propulsion, under inflated tires are less efficient and harder to propel. Under inflation is a common occurrence
- High pressure pneumatic tires have lower rolling resistance (RR)

Non-pneumatic tire:

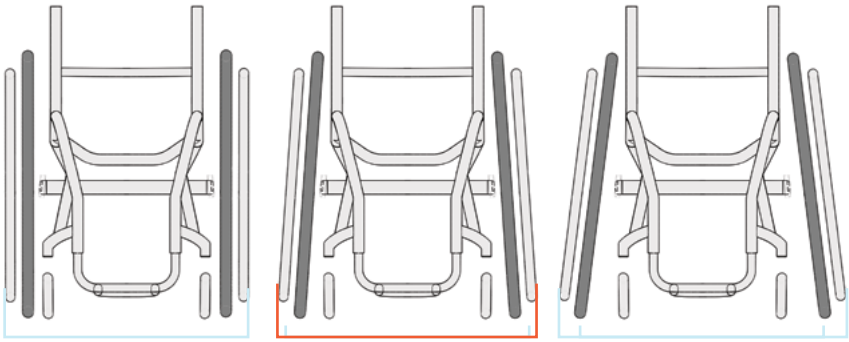
- May be solid or pneumatic with flat-free inserts
- Airless insert and solid tires have highest RR and low efficiency
- Often used when a flat-tire could be a safety risk because the ability to properly maintain pneumatic tires is in question
- Solid tires may have reduced maintenance

* Evidence shows that the perceived weight equivalent of airless insert tires is the same as adding 43.5 kg of weight that the user must carry.

  Choose a tire that is lightweight to decrease the initial force required to turn the wheels. Low tread and the least amount of surface contact to the ground decreases rolling resistance.

Rear wheel camber

Camber is the inward tilt of the rear wheel. The camber angle affects lateral stability and the efficiency of propulsion as well as rear wheel access. When performing tasks that require leaning outside the footprint of the wheelchair, increased camber will increase stability and promote maintaining an upright position in the wheelchair.



Sample 0° *Sample 4°* *Sample 7°*

Most adult wheelchairs used for daily use have 0° - 3° of camber while paediatric sizes may have more to improve wheel access. Wheel camber decreases proximal distance to the user at the top for wheel while increasing distance between wheels at ground level.

Sports WCs have greater than 3° degrees camber for stability. The extra wide camber also increases the ease of propulsion (longer lever arm).

Rear wheel spacing is the distance between the top of the wheel and the back post. The goal is the narrowest possible configuration to allow the most accessibility.

- Different amounts of rear wheel spacing is required for different camber angles and wheel/tire configurations

✱ Remember that adding camber will affect the overall footprint of the wheelchair.

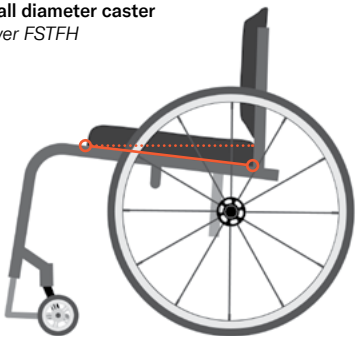
Caster options

Casters affect rolling resistance, stability, and manoeuvrability. The key is to have proper axle adjustment to get most weight through the rear wheel and decrease rolling resistance.

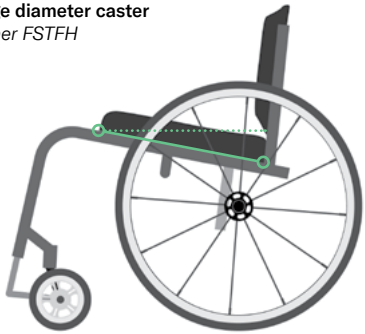
Caster size

Caster size affects FSTFH and seat angle of the wheelchair.

Small diameter caster
Lower FSTFH



Large diameter caster
Higher FSTFH



Most WC manufacturers will tell you which available caster sizes will work when you are selecting the front frame angle and STFH.

The old way of thinking is that large casters roll easier. However, the correct way of thinking is that less weight on the casters allow them to roll easier. The key is to decrease as much contact with the ground without compromising stability, while also having proper rear axle adjustments (rear COG) to get the most weight on the rear wheel.

The goal is always to minimise rolling resistance.
To achieve this, choose a caster shape and size with the least contact surface to the ground.

Casters - too large

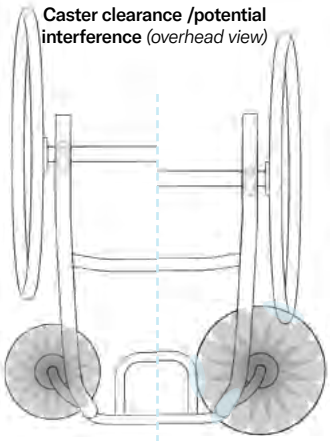
- May hit the user's feet
- May interfere with the footplate and the rear wheels

Casters - too small

- May make it difficult to go over obstacles

* Casters <6" are less susceptible to flutter and provide clearance for foot rests.

https://www.wheelchairstandards.pitt.edu/sites/default/files/fact-sheets/casterperformanceoverview.pdf



Caster - rear wheel & foot plate clearance

Larger caster with forward axle

Caster shape

Caster shape is also significant to their ability to roll. The less the caster touches the ground the less rotational inertia it takes to make the wheel turn. Most of the time, the wider the caster is, the more contact it has with the ground. Some styles have a tapered shape so that when on a flat surface the caster contact point is optimal. Then if the user rolls over a crack or into a softer surface (e.g. dirt, gravel) they have more surface area to help them when they need it.

Caster - too narrow

- May be difficult to manage rough terrain
- May have increased risk of getting caught. *Example: cracks in sidewalks*

Caster forks

Caster forks provide alignment and adjustment features of the casters for stability, and manoeuvrability based on client's needs and preferences. Suspension caster forks provide shock absorption.

Additional ultra lightweight MWC options

There are a variety of additional options for CRT manual wheelchairs because they are truly the most customisable MWC option. Some are for function, but may not be necessary for every client while others are more client preference.

Configuration options	Considerations
Handrim and wheel lock style	Affect use and propulsion (especially for those with limited dexterity), otherwise may be heavily dependent on client preference
Foot plate style	Affects safe foot placement/positioning Options may include rigid, adjustable, swing-away, flip-up, and flip-back
Arm rest (optional) style, height, attachment	May be needed to promote postural stability May provide a resting place to reduce fatigue Height can affect optimal wheel access Style can affect reaching and transfers Options may include: adjustable, swing-away, flip-up, and removable. Full and desk length
Side guards (optional) adjustable and/or removable	Consider for postural support and stability Can provide protection from the wheels during use
Anti-tips	Safety feature for some environments and terrain. May be fixed, flip-up, removable
Push handles	Will the client be pushed a fair amount of the time? Can added push handles help them manoeuvre the WC before and after transfer?
Low seat-to-floor height	Required for foot propulsion or hemi-propulsion with ultra-lightweight or manual tilt-in-space chair
User-tilt option	Allows chair occupant to move in/out of posterior tilt in some manual tilt-in-space chairs
Take-apart frame	Allows caregiver to remove the seating system off the base of some manual tilt-in-space chairs for transport

* The setup of an ultra lightweight MWC demands knowledge of client's history and potential for function. Understanding wheelchair types and setup to maximise function will enhance their life and also decrease the risk for complications.

Power Assist Device

WHAT IS A WHEELCHAIR POWER ASSIST DEVICE?

A power assist device can be added to almost any type of manual wheelchair to help the user more efficiently navigate their environment. Power assist devices can be mounted on rigid, folding and manual tilt-in-space chairs. Power assist technology can assist in mitigating risk for upper extremity repetitive stress injury by reducing the number of pushes required. Power assist technology can also assist someone who is struggling
to effectively propel their manual wheelchair with hemi-propulsion.

Refer to **Permobil's Power Assist White Paper** for a systematic review of the evidence on all types of power assist devices.

Power assist can be hub-mounted, rear mounted, or front mounted. Hub mounted devices weigh significantly more than rear mounted devices. A rear-mounted power assist does not require pushing to activate it which frees the hands for function.

Rear-Mounted Power Assist

A rear PAD typically attaches underneath the wheelchair to the camber tube or between the axles of the rear wheel. Single caster or rear wheel with omni-directional rollers. Single battery and motor. Offers a variety of control methods.

Benefits
Easily removed when transferring MWC into a vehicle, for transport, and charging
On-demand function. Not necessary to have on the WC when not needed *(short distances & around the house)*
Acceleration and top speed are programmable, allows for safe operation
Programmable to meet different needs
Lightest weight option
Freewheels when off or if battery runs out; minimally increased resistance
Does not compromise configuration of the wheelchair, which is significant for pushing without the device
Allows for more user-defined settings for use in different environments and when selecting input devices *(control via dial, switch, or Bluetooth wearable)*
Weather-sealed / water-resistant
Can be used with folding or rigid MWCs
Can be used with manual tilt-in-space wheelchairs to help

Considerations
User must be able to control rate of descent down grades and ramps
Disc breaks can be added to the wheelchair to assist with deceleration, but are a separate device
Certain amount of training may be required for the user to safely operate

Front-Mounted Power Assist

Front PAD typically have a motorized wheel that is located in front of the footplate or footrest of a MWC. The system attaches to the front frame of the MWC and elevates the front caster wheels off the ground. It is then controlled by a tiller or handle-bar style system with an external motor and external battery.

Benefits	Considerations
No pushing required	Requires use of tiller for control
Improved access to different environments because front casters are floating	Can be challenging to load due to size
Braking mechanism	May not be as suitable for indoor use
Increased speeds	

Mid-Mounted Power Assist

- With a main wheel PAD, motorised drive wheels take the place of large rear wheels
- Typically contains an accelerometer that requires pushrim input
- Some models compatible with proportional joystick input (full-assist)
- Can have single or dual battery and motor
- Can have individual wheel sensitivity adjustment

Conclusion

WHY IS A MANUAL TILT-IN-SPACE OR ULTRA-LIGHTWEIGHT CRT MANUAL WHEELCHAIR BEST PRACTICE FOR FULL TIME WHEELCHAIR USERS?

A fully customizable wheelchair made of lightest high-strength materials will:

- Decrease risk of upper extremity pain or injury
- Contribute to short and long-term functional success
- Decrease the incidence of secondary complications
- Last longer than standard wheelchairs
- All of the above also make them more cost effective

WHY IS IT IMPORTANT TO CUSTOMISE FRAME DIMENSIONS?

We maximise client potential through a custom fit.

The evidence-based recommendation from RESNA's position paper The Application of Ultralight Manual Wheelchairs states that, "The person cannot conform to the wheelchair, but the wheelchair must conform to the individual." By doing this, we ...

- Optimise roll efficiency of the manual wheelchair
- Reduce risk of repetitive strain injury over time
- Aid in postural alignment
- Reduce risk of pressure injury
- Improve function

Glossary

Wheelchair & Parts	
WC:	Wheelchair
WCs:	Wheelchairs
MWC:	Manual wheelchair
MWCs:	Manual wheelchairs
STFH:	Seat-to-floor height
PMD:	Power mobility device
FSTFH:	Front seat-to-floor height
RSTFH:	Rear seat-to-floor height
STBA:	Seat-to-back angle
COG:	Center of gravity
ELR:	Elevating legrest
Client Function	
ROM:	Range of Motion
ADLs:	Activities of daily living
MRADLs:	Mobility related Activities of daily living
RR:	Rolling resistance

Body & Posture	
PPT:	Posterior pelvic tilt
ASIS:	Anterior superior iliac spine
PSIS:	Posterior superior iliac spine
IT:	Ischial tuberosity
ITs:	Ischial tuberosities
LE:	Lower extremity
LEs:	Lower extremities
UE:	Upper extremity
UEs:	Upper extremities
Process	
LMN:	Letter of medical necessity
People	
ATP:	Assistive technology professional
MD:	Medical doctor/physician
NP:	Nurse practitioner
CNA:	Certified nursing assistant
PA:	Physician assistant

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