MANUAL WHEELCHAIRS





INFORMATION RESOURCE FOR SERVICE PROVIDERS

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FEATURES OF THE MANUAL WHEELCHAIR

In recent years manual wheelchairs have improved in design and technology. It is often difficult to keep updated on all the new innovations. Therefore, this document is current for this particular period.

The process of selecting a wheelchair involves making choices and tradeoffs. Decisions are influenced by the primary use of the chair, cost restrictions, user and carer requirements (including limitations related to age, size, fitness level, motivation etc) personal preference and environment.

Each feature and option available in manual wheelchairs will be discussed in detail below.

FRAME TYPE

RIGID FRAME

This type of chair does not centrally fold – it collapses by the back folding down and removal of the rear wheels.

Advantages:

- Easier to propel and turn due to the frame rigidity; no energy lost in frame movement
- Greater strength and durability; less moving parts
- Greater adjustment ability for posture, meeting individual needs and allowing for change in wheelchair skills (seat back angle adjustment)
- Often more compact

Disadvantages:

- More difficult to transport
- More difficult to store eg in boot of cars (depends partly on width and accessories)
- Unable to use on car roof hoists
- Increased shear on body because of frame rigidity

FOLDING FRAME

This type of frame centrally folds via a cross brace underneath the seat.

Advantages:

- May be easier to transport eg used with car hoist
- Easier to store especially if rear wheels can also be removed
- Folds flatter than rigid frame wheelchair
- Some shock absorbing capability in frame

Disadvantages:

- Often harder to propel: energy is lost in frame movement
- Can be heavier due to the cross brace mechanism
- More moving parts, therefore more maintenance required
- Difficulty maintaining correct frame alignment and the frame may warp over time
- Less adjustment ability to suit the individual (no seat-back angle adjustment)

FRAME MATERIAL

The majority of manual wheelchair frames are made of either aluminium/chromoly or stainless steel. Ultralight and sports wheelchairs are often constructed from high performance aluminium, titanium or advanced composites. Titanium and composites can be considerably more expensive but are more lightweight. The choice of frame material is often a trade off between cost and intended use. Actual parts of wheelchairs eg axles are often made of stainless steel.

MATERIAL TYPE

Common alloy steel:

- Mild steel (AISI 1040 or 1060): inexpensive, easy to work, readily available, but has a low strength to weight ratio. Commonly used for attendant propelled chairs in institutions
- Chromium-molybdenum alloy steel (AISI 4130): strong, easily welded, easy to work with. Can be treated for higher strength and to resist abrasion. Used in some ultralight wheelchairs
- Chromium-nickel-molybdenum alloy steel (AISI 4340 & 6820): as for above

Aluminium:

- Aircraft grade aluminium (SAE 6061): inexpensive, versatile structural aluminium alloy which is corrosion resistant and can be welded easily. Most aluminium wheelchair frames are made of this alloy.
- High performance aluminium (SAE 7075) is one of the highest strength aluminium alloys, ideally suited for high stress but not welded parts.

Titanium:

- More expensive
- High strength to weight ratio, very lightweight, corrosion resistant
- Can only be welded using special inert gases (TIG welding), and requires special tools and skill to manufacture the wheelchair to prevent damage to the titanium

Advanced Composites:

- Carbon fibre, fibreglass, Kevlar®
- Can be moulded easily into different shapes
- Currently used in casters and rear wheels to reduce overall weight of the wheelchair and in some wheelchair frames.

FRAME RAKE / SQUEEZE

This feature relates to the seat angle (in relation to the horizontal) ie the rear seat height (lower) as compared to the front seat height (higher).

Rake is available on most rigid frame wheelchairs and some folding frame chairs. The amount of rake needs to be specified. Some models allow adjustable rake. Considerations when assessing for amount of rake include:

- Improved stability and performance as the centre of gravity is lower to the ground
- Influences posture and comfort, may need to angle the backrest further forward to prevent posterior pelvic tilt &/or increased sacral pressure
- Impacts on pressure distribution as more weight is borne on the ischial tuberosities with increased rake
- Increased rake may make transfers more difficult for the client as they need to lift up a slope and forwards in preparation for transfer
- Can increase shear forces on pelvis and soft tissue, thus increasing risk of damaging skin

FRONT FRAME ANGLE

This feature relates to the angle between the seat and the footplate hanger. The greater the angle the less overall length of the wheelchair.
Issues to consider:

- The size of the front caster will influence the front frame angle ie larger caster requires lesser front frame angle, with the footplate sitting further out in front
- A greater frame angle may improve wheelchair access by making the chair shorter but may make the chair more unstable in the forward direction
- Increased maneuverability with a shorter frame ie decreased turning circle
- Need to consider knee flexion range of movement and hamstring length
- Impacts on visual field as a client may not be able to see their feet

Front frame 70 degrees

Front frame 85 degrees

CAMBER

Camber relates to the rear wheels being set on an angle from their axle position, where the distance between the top of the wheels is less than at the bottom of the wheels. The angle can range from 0º up to an extreme 12º (most often used in sports wheelchairs).

Camber in every day use wheelchairs varies from 0º to 4º. Some wheelchair models offer adjustability in camber angles within the same chair. The camber setup can vary between different models ie either with the axle plate or with a specific camber bar.

Camber axle plate

Camber bar

Considerations include:

- The greater the camber the easier to turn the wheelchair
- The greater the camber the more stable the chair is laterally
- The available seat width is lessened with increasing camber
- Each degree of camber makes the chair approximately 2.5cm wider: access through doorways and corridors is affected as the wheel distance from the frame at floor level is greater

FRAME TAPER

This refers to the frame narrowing towards the front and continues on down to the footplates. This feature is available on some models of wheelchairs and the following need to be considered:

- Taper improves access from the front of the wheelchair eg for toilet transfers
- The narrowing frame may not be compatible with the cushion
- Cosmetically appealing as the frame conforms to body shape and assists with leg positioning
- Consider the feet width and type of shoes the client tends to wear
- May impact on ability for the wheelchair to fold

WHEELS

Typically, wheelchairs have two sets of wheels.

In a rear-wheel drive, the rear wheel is large and may have a push rim for self propulsion and the front wheels (casters) are small. This is the most common type of wheelchair.

Wheelchairs made for individuals with special needs eg people with hemiplegia, may have the large wheel at the front (front wheel drive), two push rims on the one wheel or a foot operated push mechanism.

Sport specific and some rough terrain wheelchairs may have just one small front wheel (instead of two) eg tennis or track wheelchairs.

Wheels consist of several components: wheel rim, push rim, spokes, a hub and a tyre.

REAR WHEELTYPE

Wheel rims can be made from a variety of materials including aircraft grade aluminium, plastic (usually polyurethane), fibreglass, reinforced nylon, titanium, carbon graphite or steel.
Aluminium is light, strong, rust proof, readily available and easy to work with.
Plastic wheels (MAGs) are manufactured in one piece (rim, spokes and hub) and were previously made of magnesium (thus the name).
Titanium is lightweight but expensive. Steel was the original rim component but is heavy and has now been superseded by aluminium.

Spoked Wheels

- Rim made from aircraft grade aluminium
- Spokes generally consist of thin aluminium or stainless steel wires
- Lighter than MAG wheels
- Allow smoother ride: spokes are flexible and therefore aid shock absorption
- Quality of hub and bearing will affect propulsion
- Number and size of spokes will affect shock absorption (more spokes, better absorption), weight, durability and performance
- Spokes can be bent or damaged with impact: however, individual spokes are easily replaced
- Regular maintenance is required to maintain tension in spokes, to keep wheel in alignment and to prevent wheel warp
- Higher performance spoked wheels are also available with various spoke arrangements and different sized hubs. These are usually a more expensive option. For example, “spinergy” wheels (www.spinergy.com) are ultra-lightweight wheels complete with extra wide machined alloy hubs, disc brake style rims and superior, shock resistant spokes.

Mag Wheels

- Consist of three or more (commonly 6) large spokes
- Less maintenance
- Heavier in weight
- More durable
- Less shock-absorption so gives a bumpier ride, and can crack with an active user

Carbon-graphite Mag Wheels

- Cosmetically appealing
- Expensive
- No difference in strength or weight to spoke wheels
- Allow more flex in the wheel

Power Assist Wheels

- Electric motors integrated into wheel hub to support the user's propulsion force
- Sensors convert required degree of power assistance
- Can be fitted to most manual wheelchairs
- Each wheel weights approximately 10-11 kg
- Models include the Alber E-Motion and the Quickie Xtender

REAR WHEEL SIZE

The most common size of wheel for adults is 24" (60cm) and for children 20" (50cm). There are also 22" (56cm) and 26" (66cm) sizes available, although 26" are rarely used and not easily available. Some wheels with outdoor or BMX tyres may use a wider 22" (56cm) rim to accommodate the higher and wider profile of the tyres.

PUSH RIMS

On wheelchairs intended for self propulsion by the user, hand rims are attached to the wheel rim. Commonly the rim is a tubular ring made from aluminium (lightweight) or steel (heavier), which is attached onto the wheel rim. Aluminium may be anodised or vinyl coated, steel can be chrome or vinyl plated. Aluminium often leaves hands black and can be damaged causing sharp edges on rims.

There are several different slip resistant products available from individual manufacturers which can be applied to the rim to give better grip for users with limited hand function. These products are often specific to the manufacturer and should be considered during the prescription process.

Another option now available is a product which combines the wheelrim and pushrim in a single piece. There a few current products on the market, for example, the Vulcan wheel and the Natural-Fit Handrim. These designs provide greater surface area for the entire palm, fingers and thumb to grip the pushrim during pushing and braking. There is no gap between the wheel and pushrim, so less chance of damage occurring to fingers and thumbs. Vulcan wheels are available in 24",25" and 27" wheels with quick release axles with a choice of either knobby or smooth tread tyres. There are two models of rubber grip also available for people with limited hand function.

REAR WHEEL TYRES

Wheelchair tyres can be pneumatic, puncture proof or solid. Pneumatic tyres are usually made of rubber with a variety of tread patterns available and have a thin inner tube which is filled with air

Standard pneumatic tyres

- Require lower tyre pressure eg 65 psi (pounds per square inch)
- Provide cushioned ride due to shock absorption provided by air
- Increased rolling resistance as increased surface area in contact: generally harder to propel indoors
- Reasonable traction on wet surfaces, depending on tread
- Readily available eg from bicycle retail outlets (depending on size) and wheelchair suppliers
- Easily repaired if punctured
- Airless inserts available (to reduce likelihood of a puncture)
- Inexpensive
- Regular maintenance required eg ensuring adequate air in tyre each month, replacing tyre when tread is worn or cracked, repairing or replacing tube with puncture.

High pressure pneumatic tyres

- Also known as clinchers or primos
- Higher tyre pressure required eg 110 psi
- Minimal tyre tread and less surface area (ie narrower profile) provides less rolling resistance therefore easier to propel, especially on solid surfaces eg tiles
- Less shock absorption due to small volume of air at high pressure therefore bumpier ride
- Less traction on wet surfaces
- Tread wears faster than pneumatics
- Less readily available
- Easily repaired if puncture
- Airless inserts available
- More expensive but there are variations in price and quality

Outdoor pneumatic tyres

- Available in variations of knobbie, BMX or mountain bike tyres depending on the model of wheelchair
- Much wider profile and chunkier tread
- Difficult to propel indoors
- Most suitable for rugged terrain or sand
- Most often as a second pair of wheels for outdoor use

Primo and outdoor tyres

Pneumatic and outdoor tyres

Puncture proof tyres

- Similar to standard pneumatic tyres but have inserts of foam, plastic or rubber instead of air
- The solid insert increases the weight of the tyre by about 1.5 times.

Solid plastic tyres

- Require minimal maintenance
- Cannot be punctured
- Less shock-absorption so give bumpier ride
- Generally easier to push indoors but not outdoors, therefore often used on chairs for hospitals, nursing homes etc

FRONT CASTERS

The small front wheels or casters vary in size and material. Sizes available include 3” (75mm), 5” (125mm), 6” (150mm), 7” (180mm), 8” (200mm) and 10” (250mm). The construction materials available for caster wheels include plastic, urethane and aluminium. Casters manoeuvre and steer the wheelchair.

Options for solid or pneumatic tyres are also available and the differences in performance of these features are similar to that described with the rear wheel tyres. Sizes available on a specific chair vary depending on chair design.

When considering the type of caster, the following are important issues:

- The most common type of surface the client will propel eg indoors or outdoors
- Desired front seat height
- Front frame angle of wheelchair that is available on wheelchair specification

∗*Clients who experience significant spasticity and/or discomfort when propelling their wheelchair may opt for pneumatic casters to achieve a smoother ride*

Following are features of some of the most common type of casters used:

8 inch pneumatic

- Air filled inner tubes provide shock absorption therefore more cushioned ride
- Increased surface area provides more rolling resistance and so more difficult to propel and turn
- Good for travel over rough and uneven ground
- Manages small door lips easily
- Increased resistance to turning
- High maintenance (eg punctures, require regular inflation)
- Airless inserts available
- Readily repairable if punctured - may need to keep spare tubes of the right size
- Requires less acute front frame angle eg 65° or 70°
- Allows least amount of clearance for feet position on footplates
- Aluminium or composite rims available

6 inch pneumatic

- Easier to propel (than 8") whilst maintaining some shock absorption features
- Smaller size allows more foot clearance and more acute front frame angle eg 80° or 85°
- Tubes can be difficult to change due to the small size
- Aluminium or composite rims available

5 inch urethane

- Common choice, good compromise
- Provides less rolling resistance on firm surfaces so easier to propel indoors
- Minimal shock absorption so offers bumpier ride
- Maintenance free
- Aluminium or composite rims available

5 and 8 inch urethane caster

3 inch urethane

- Ideal for sports specific wheelchairs
- Difficult to use outdoors unless client has adequate wheelchair skills (ie ability to back wheel balance over rough terrain)
- Minimal shock absorption so bumpier ride

WHEEL LOCKS / BRAKES

Wheel locks or brakes can vary in the type of action and the position they are mounted. The type and position will be influenced by:

- Clients reaching ability, balance and strength
- Clients hand function
- Impact of wheel lock position on transfers

**Some clients with good physical skills may not require wheel locks at all*

HIGH MOUNTED TOGGLE

- Mounted high on the frame ahead of rear wheel
- Push on or pull on option to engage locks
- Some models available where locks swing away when not engaged
- Easy to engage especially push on option
- Can impact on transfers
- Can get in the way for clients with good propulsion skills

LOW MOUNTED TOGGLE

- Mounted low on the frame under the seat
- Push on or pull on option to engage locks
- Require extended reach and therefore good balance abilities to access
- Good position for transfers and wheelchair propulsion

SCISSOR LOCKS

- Can be mounted high or low on the frame (as for toggles)
- Require more extended reach (and therefore good balance) to access as often placed under the wheelchair seat
- More difficult to engage
- Good position for transfers and wheelchair propulsion
- Only available on some models of wheelchairs

FOOTPLATES

Footplates are available in a variety of types and can depend on the type of wheelchair frame.

Folding frame wheelchairs offer a variety of types, sizes and materials. Some of these include:

- One piece flip up
- One piece detachable via sockets built into the frame
- Two piece flip up which can be composite plastic or aluminium hook footplates. Option for extended sizes
- Two piece swing away and removable

Rigid frame wheelchairs in the most part offer a rigid one piece footplate and can be in the shape of two bars or with a platform. Platform footplates can also be angle adjustable for optimal foot position. Some models offer the same options that are available on folding frame wheelchairs.

∗Consider the type of footplate if a client either stands or places their feet on the floor to transfer. A rigid footplate may be inappropriate and it may be best to use swing away or flip up.

VARIOUS FOOTPLATES AVAILABLE

swing away removable

hook lift up

one piece lift up

one piece lift off

rigid

rigid adjustable angle

ACCESSORIES FOR MANUAL WHEELCHAIRS

When considering accessories for wheelchairs one must always remember that these will add overall weight to the wheelchair and should only be prescribed if necessary. This concept should always be discussed with clients to assist them in making decisions about what accessories are necessary to them.

There are many different accessories available with wheelchairs and the specifications are best discussed with the individual supplier. Most accessories fall into the following categories:

- Improved handling and function
- Improved safety features
- Posture and positioning
- Ease of transport and access
- Equipment maintenance

IMPROVED HANDLING AND FUNCTION

ARMRESTS

Some clients may require armrests but it is important to remember that they should always be removable and not fixed to the wheelchair. Some considerations are:

- Assists client with transfers (especially standing transfers)
- If used by client to assist with pressure relief, may damage mounting
- Provides support for upper limbs and trunk
- Provides security and comfort for the client
- Protects clothing from rubbing on wheels
- Makes self propulsion more difficult

Armrests come in a variety of designs eg full-arm length, desk style and some models are adjustable in height. Some lift off and some flip back. If they are not height adjustable a prescriber needs to consider and specify the optimal height for the client in the prescription. Some manufacturers allow flexibility in the height that they supply.

Adjustable height

SUSPENSION – REAR / FRONT

The overall aim of suspension is to absorb some of the forces present during wheelchair propulsion and so may result in clients experiencing decreased pain and improved comfort of ride, decreased spasticity and involuntary muscle spasms and an increased rolling ability over some obstacles.

Rear suspension is available on some models of wheelchairs either in the form of a central rock-shox mechanism similar to suspension on mountain bicycles or with polymer shock absorbing bushes built within the frame. The central mechanism is adjustable but has limits with respect to client weight. Rear suspension affects the use and efficiency of wheel locks which may impact on client safety.

QUICK RELEASE HUBS

This push button mechanism allows the easy removal of the rear wheels for transportation or storage purposes. They are standard on all rigid frame and some folding frame wheelchairs but may be an additional option on others. Some models offer a large central button which some clients find easier to manage if they have poor hand function.

QUAD RELEASE AXLES

For clients with limited hand function these mechanisms allow easy use of the quick release hubs by not having to hold the button in whilst removing the wheel. They are mostly in the form of levers attached to the quick release button.

PLASTIC COATED PUSH RIMS

These provide more traction when propelling if clients have a weak grip and can be used by clients with or without gloves. They may burn hands if the client is slowing down from a considerable speed. They are therefore not recommended for clients with normal upper limb and hand function.

CAPSTANS / PROJECTIONS

These are rubber coated projections off the push rim to assist a client with limited upper limb function to propel and especially turn corners. They are often difficult to co-ordinate both sides together and tend to get in the way when propelling down hills. Due to some of the disadvantages, they are rarely used nowadays and have been replaced by plastic coated rims.

Capstans can be set vertically, obliquely or horizontally: the latter two options impact on chair width.

EXTENDED BRAKE LEVERS / WHEEL LOCK HANDLES

To decrease the force required to engage/disengage the wheel locks an option is to lengthen the lever by increasing the length of the wheel lock handle. It also minimises the forward reach required to access the wheel locks. Having removable extended handles is an important consideration if the client transfers.

GRADE AIDS

Grade aids are devices that are attached to the wheel locks to prevent the wheelchair from slipping backwards when propelling uphill. Due to their configuration they actually make it more difficult to propel forwards. They are available only on some models of wheelchairs.

PUSH HANDLES

Clients with poor sitting balance often use push handles to lock their arm behind when reaching out of their sitting base. They are also used by attendants pushing the wheelchair and for assistance on stairs and kerbs. Removable push handles are an option on rigid framed chairs and these are important to consider if the client collapses their own wheelchair into the car. Removable handles may not be strong enough to be used by attendants to pull someone up and down stairs in their wheelchair.

REAR TIP BAR

This tip bar is located at the rear of the wheelchair frame and assists an attendant tipping the wheelchair onto its rear wheels when negotiating kerbs, ledges or gutters. Often only one side is required. This is not an anti tip safety device.

IMPROVED SAFETY

ANTI-TIP DEVICES

These are designed to minimise the risk of the wheelchair tipping fully backwards when a client loses their balance. When in place they will also prevent the client negotiating kerbs and gutters. When an attendant is assisting, they often need to be removed as they may catch their legs on them and cause themselves an injury.
They are **not** designed for a client to rest on in the tipped back position and this should always be discouraged.

CASTER LOCKS

These are an option to lock the front casters in place. They may be useful in providing stability of the front wheels during transfers. The client is required to be able to handle the mechanism as well as reaching down to the front casters.

SPOKE GUARDS

Spoke guards are mostly used to prevent fingers being caught between the wheel spokes and to protect the spokes in rough outdoor situations and during sports. Some clients also like the cosmetic features and they are available in various colours and styles.

IMPROVED POSITIONING / POSTURE

CALF STRAPS

Calf straps attach to the footplate hanger on each side and prevent the feet falling backwards or hitting the casters. They are usually adjustable in length to suit the individual. They can be used on both rigid and folding wheelchairs.

HEEL / TOE LOOPS

Heel loops achieve the same aim as the calf straps but are mostly used on swing away removable footplates. Care needs to be taken that they don't cause skin problems from pressure on the heels especially if a client has severe spasticity.
Toe loops are available on some models but are rarely used in practice. If they are useful for the individual client then potential pressure areas needs to be considered.

POSITIONING BELTS

These may be required for clients who have poor balance skills in the wheelchair or severe spasticity that pulls them forward in the wheelchair. Positioning of seat belts vary from the pelvis to up high at the chest level depending on individual needs.

CLOTHING / SIDE GUARDS

These are often available in cloth or plastic. They are designed to protect clothing from being soiled by the wheels and may assist with the positioning of the cushion. Ideally they should be removable to ensure safety for transfers. Monitoring is important to ensure they do not provide potential pressure points especially in the greater trochanter area.

Can cause issues with transfers if are higher than wheel and are not removable.

SOLID SEAT BASES

Solid seat bases may be an option to consider if the client requires significant postural support or the client is very heavy and the seat upholstery sags to a great extent. It is important to remember that this will add significant weight to the wheelchair and will also impact on the chair's collapsibility, although many are removable. A solid seat base can be made from wood, plastic or aluminium.

Some products offer an adjustable height solid seat base to alter the seat height from the floor.

ADJUSTABLE TENSION UPHOLSTERY

As wheelchair back upholstery sags and stretches over time, some models offer an adjustable tension upholstery using velcro straps. Each strap can be individually tightened which may also be adjusted to facilitate a lumbar curve.

TILT-IN-SPACE

With some clients it may be beneficial to incorporate a tilt-in-space option that may assist with pressure relief, fatigue and bladder drainage. This adjustable option is available on some models for clients with high dependency but are mainly only attendant controlled mechanisms and add significant weight to the chair.

EASE OF TRANSPORT

QUICK RELEASE REAR WHEELS

These are standard on all rigid frame wheelchairs and are an option on many folding frame wheelchairs as well. The mechanism allows easy removal of the rear wheels to assist with transport and storage.

QUICK RELEASE CASTER STEMS

Quick release caster stems are an additional option to allow the easy removal of the front casters. They provide extra ability for transport and storage especially into a small vehicle or where there is a large family travelling.

They may also be used for easy interchange of two types of casters. With this scenario, it is important to remember that two different sizes and types of caster will alter the ride and position of the wheelchair frame in relation to the ground and to the client.

TRAVEL WHEELS

Some models offer the option of travel wheels. These are small wheels that are mounted to the wheelchair behind the frame and close to the ground. Once the rear wheels are removed the wheelchair may be pushed through narrow doorways or down the aisles of trains or aeroplanes. They should be removable as they are not always used.

EQUIPMENT MAINTENANCE

FRAME PROTECTORS

These are designed to protect the wheelchair frame from damage and are supplied in various materials eg plastic, cloth or neoprene depending on the wheelchair model. They can be either fixed in place or removable.

TOOL KIT

As it is recommended to adjust the wheelchair to suit the individual and their needs at any time, having the appropriate types and sizes of tools is useful. Wheelchair parts may be metric or imperial in size depending on the manufacturer.
The tools should also be used to maintain the wheelchair and parts in good working condition.

TOUCH UP PAINT

This is a small can of wheelchair frame paint to maintain the paintwork in a good condition and thus may assist in minimising rust.

ASSESSMENT AND PRESCRIPTION PROCESS

The assessment and prescription process for selecting the appropriate wheelchair for clients is a long and time consuming process for both the client and the prescriber. However, this process is vital to ensure that the most appropriate equipment is supplied to achieve both client satisfaction and financial efficiency.

Some of the general issues to consider:

- Wheelchairs are becoming more disability specific and some models are more suitable than others for a particular individual client.

- A different approach is often required if the client is a first-time user or an experienced user. First time clients and carers often need more education and guidance with wheelchair assessment and prescription.

- As a wheelchair is a mobility aid, it is important to consider wheelchair propulsion biomechanics and efficiency. Refer to chapter on propulsion.

- 'Trade offs' is an important concept to consider when prescribing wheelchairs. For any feature or accessory that is chosen there is always a consequence that may not be as positive for the client needs. These need to be discussed with the client and weighed up against each other to ensure the optimal decision is made. Following are some common examples:
    - to have a significant rake on a wheelchair to enhance performance and ease of propulsion will make it more difficult to transfer from the wheelchair and may have an impact on seating pressure distribution
    - increasing the camber of the wheelchair to assist with propulsion and turning will cause the wheelchair to be wider and may limit access through narrow doorways
    - adding accessories such as side guards and spoke guards will add weight to the wheelchair when propelling

The following steps should be completed to achieve the optimal outcome:

- Assessment – of client, carer, environment of use, product and accessories available on script form
- Trial period
- Prescription
- Follow-up post supply of equipment
- Adjustment of wheelchair to suit the client
- Client/carer education in use

ASSESSMENT

To complete a thorough assessment of a wheelchair for a client many different factors need to be considered. These are described below and are guidelines for the assessment process.

CLIENT

- Client goals - includes intended use of equipment, preferences, importance of cosmesis, likes/ dislikes of current chair (if applicable)
- Client profile – this includes client attributes such as physical strength and functional abilities, balance, pain, contractures or deformities, postural issues, experience of the client with the equipment
- Seating requirements – for example this will include the type of cushion or back support that will be used – **never assess the wheelchair in isolation**
- Environment – includes the home, community and the workplace/study facility etc. Consider the clients life style with respect to leisure and recreation
- Portability and transport – ability for the client to collapse the wheelchair into the car, ability for storage in the vehicle with the rest of the family etc
- Geographical location of client– access to repair centres, rural and remote issues

CARER

- Carer goals and comments
- Manual handling issues
- Issues with any current equipment
- Maintenance issues and abilities

WHEELCHAIR

- Reliability and durability – can the equipment withstand the intended use, issues of rust close to the coast, remote and rural uses
- Level of maintenance required
- Options and accessories available
- Supplier service and follow-up
- Availability for the wheelchair to be trialled from supplier
- Cost - the selection of wheelchair will depend upon the funding source and the client's capacity to pay. This will vary on an individual basis.

It is often of value to complete a generic prescription form outlining client needs and wheelchair dimensions and features. This will assist in streamlining possible trial options. (See Appendix 1).

TRIAL PERIOD

Following the assessment a selection of possible wheelchairs should be compiled and a process of trial commenced. It is **not** recommended that any equipment be prescribed and ordered without trialling by the client.

Wheelchair companies most often have a variety of chairs incorporating different available features, in a limited range of widths available for trial. Often the exact features desired will not be available together on one chair. To cater for a variety of clientele, companies often spread available features over several different width chairs and a client may need to trial a wider chair to experience different desirable features. A chair that is too wide will be more difficult to propel, and the client needs to be made aware of this.

All chairs should be trialled with the clients' cushion of choice, to simulate as closely as possible their usual seating arrangement. See Appendix 2 and 3 for Trial record documents for both client and prescriber.

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Specific issues to consider through this process include:

- **Client centred approach** – this will encourage the client to take ownership of the selection process and therefore facilitate an optimal outcome for them
- **Informed decision making** – supplying the client with adequate information about the equipment is an important factor. The client should be encouraged to discuss the equipment with suppliers and peers etc. Information should be given on issues such as use, maintenance and adjustment features of the wheelchairs.
- **Time allocation** – it is important to trial equipment for an adequate period so that the client will be able to incorporate all their regular activities. This time frame will vary depending on the individual and it is important to be flexible with the time period. Some clients may require additional time to accommodate to what could be a very new concept whereas other clients are more definite and decisive about their needs. As far as is possible, a client should trial the wheelchair in as many different environments as they are likely to encounter. As a guide, the average recommended time for trial is one week.
- **Appropriate adjustment of trial equipment** – to ensure the client is achieving the optimal use of the trial wheelchair it is important to have the appropriate adjustments completed so the wheelchair is setup specifically for the individual. This can be done either by the prescriber or the supplier representative.

PRESCRIPTION

Once the decision is made on the wheelchair and options, a prescription needs to be completed to forward to the funding source and supplier. Important considerations in this period include:

- All wheelchair models have their own specific prescription form and this should be completed at all times
- Different wheelchairs may have varying methods of measurement and it is important to ensure the correct measurement of the particular wheelchair. It may be useful to have the supplier representative present to assist or adequate written information to complete the process.
- If there are any queries with the prescription follow through with the supplier or a colleague etc. **Don't** assume if you don't know. An incorrectly prescribed wheelchair which requires modifications or replacement is a loss of resources for the funding body and frustrating for the client.
- Once the prescription is completed forward to the supplier for an itemised quote. Request acknowledgement of the receipt of the prescription.
- Ensure all funding submission requirements are completed before forwarding to the funding body. It is important to request acknowledgement of the receipt of the submission and request notification of approval and ordering.

FOLLOW UP

Once the client receives their wheelchair, the prescriber should followup to ensure the chair is as ordered. This is part of one's duty of care to the client. If the equipment is not as ordered, the prescriber should follow through with the supplier, and perhaps the funding source, on behalf of the client.

Sometimes there is a long time between placing the wheelchair order and its' delivery, so followup in these circumstances is especially important. Time can be lost waiting for funding approval and availability, and in the manufacture and supply of the chair.

Follow up is also necessary to ensure the chair is adjusted appropriately and is suitable for the client, and to confirm the client has an understanding of basic wheelchair maintenance, with necessary referral details in case something goes wrong.

WHEELCHAIR ADJUSTMENT

- Ensures safety and optimal performance
- Needs to suit the individual at the time
- Encourages client to continue adjustment if necessary
- Education of equipment and the adjustment features

WHEELCHAIR MEASUREMENT

Following are some guidelines on measuring the parameters when prescribing a wheelchair.

SEAT WIDTH

The measurement is between the lateral aspects of greater trochanters in sitting, taking into account any soft tissue. On the wheelchair the measurement is generally from outside of frame to outside of frame (check supplier requisites).

Consider:

- Measurement should be as narrow as possible to ensure optimal access and propulsion efficiency
- Cushion width
- Allow for any customised seating: may need extra width
- Issue of possible weight gain

SEAT DEPTH

This measurement is taken from the back of the pelvis to the rear of the knee. Subtract 4 to 5 cm to allow clearance. On the wheelchair the measurement is from the front of the upholstery to the back upright (where the upholstery is attached).

Consider:

- Impact of the front frame angle
- Shorter frame will improve access
- Firm based cushion can be up to 3 cm longer than upholstery without any detrimental effects
- Increased length of seat may increase length of frame, therefore affecting manoeuvrability / turning circle

BACK HEIGHT

Back height is measured from the top of the seat rail to the top of the upholstery (at the side). Back height for an individual will vary according to their physical attributes.

As a guide only, the back height is rarely higher than the apex of the thoracic kyphotic curve. For those with less

balance and trunk control such as a person with tetraplegia, an approximate height is the inferior angle of the scapula. For those with more function the back height may be lower.
Consider:

- Client skills eg balance
- Client posture
- Customised seating requirements eg back support
- Clearance required for wheelchair propulsion

SEAT TO FOOTPLATE DISTANCE

This measurement is from the top of the seat rail at the front of the chair to the rear of the footplate below. As a general rule, to achieve correct footplate height, lower the footplates until the heels just touch, then raise them approximately 2.5cm.

Consider:

- Adequate thigh support to ensure optimal seating pressure distribution
- Cushion height
- Adequate clearance from the casters
- Adequate clearance from the ground (minimum 5cm clearance required) – if too low a tall frame may need to be ordered
- Impact of a slung or solid seat
- Different types of shoes or heel heights worn by client

REAR SEAT TO FLOOR HEIGHT

This measurement is from the top of the seat rail (at the rear) to the floor. This will influence mobility and stability.
Consider:

- Clients technique of propulsion as will impact on distance from seat to top of wheel
- Clients transfer ability
- Comparison with front seat height ie amount of rake and influence on seating pressure distribution

FRONT SEAT TO FLOOR HEIGHT

This measurement is from the top of the seat rail (at the front) to the floor.
Consider:

- Rake and transfer ability of client
- Footplate clearance and access under tables
- Lowered or drop seats are an option as are tall frames on some models

FRONT FRAME ANGLE

This is an angle measurement from the seat to the footplate hangers from the floor. There tends to be standard measurements on wheelchairs which can vary from 60 – 85 degrees.
Consider:

- Knee range of movement and hamstring length
- Size of caster and caster clearance
- Compact frame will improve access
- Poor client visual field of legs and feet

WHEELCHAIR ADJUSTMENT

All clients are unique in their body size and shape, functional abilities, recreation and work needs. Their wheelchair should be able to be adjusted to accommodate these factors. This will facilitate optimal wheelchair performance for that particular individual. Clients should be educated about the adjustment features of their wheelchairs and be encouraged to adjust them as their needs or abilities change but also be educated in any safety concerns eg wheelchair stability.

Types and methods of adjustment will vary from one model to another, but the basic principles are the same. Many models of wheelchairs will include a user manual on supply to assist with wheelchair adjustments for that particular model.

Below are some of the most common adjustments.

BACKREST HEIGHT

The appropriate backrest height is largely a trade-off between posture, comfort and freedom of movement. Some factors that may influence the decision are:

- Type and degree of disability (muscle power and sensation)
- Balance
- Posture
- Current level of skill
- Pain

Generally, a high backrest will be more comfortable and offer more postural support and a lower backrest will allow more movement of trunk if desired. It is rare that the back will need to be higher than the scapula in someone who self propels – this will make it more difficult to propel the wheelchair.

Many models of wheelchairs offer adjustability in backrest height. Therefore backrest height can be adjusted as a clients balance and level of skill improves. Providing adequate postural support needs to be considered in this process. Inadequate backrest height can lead to long term postural and skin related problems and pain.

If a rigid back support is being considered it is important to ensure that the back rest height will allow this to be fitted.

BACKREST ANGLE

The backrest angle is adjustable on most rigid frame wheelchairs, and may need to be adjusted to achieve good postural alignment and comfort. This option is usually **NOT** available on most folding frame wheelchairs.

Adjustment of this feature is also particularly important if the angle of the seat is altered.

FOOTPLATE HEIGHT ADJUSTMENT

Adjustment of footplate height can affect seating in two main areas:

- Posture – if footplates are too low then the pelvis may slide forward encouraging a posterior pelvic tilt. If they are too high this causes inadequate thigh support and the legs and pelvis may rotate to one side.

- Seating pressure distribution - good pressure relief relies on distribution of pressure over the largest possible surface area. If the footplates are too high, pressure may be concentrated over the ischial tuberosities, potentially leading to pressure problems. If the footplates are too low, excessive pressure may be exerted on both the coccyx and the back of the thigh.

As a general rule, to achieve correct footplate height, lower the footplates until the heels just touch the footplate, then raise footplates approximately 2.5cm.

THE CASTERS

To achieve optimal wheelchair performance, the caster pintle angle must always lie at right angles to the floor to ensure the casters track correctly.

If casters are incorrectly adjusted, they may:

- 'flutter' when the wheelchair is pushed, especially at higher speeds
- cause the front of the wheelchair to rise and fall during turning
- 'float' above the floor at times

Caster angle is usually adjusted through a series of offset bolts, although this may vary according to the model. A carpenter's square is useful in attaining correct alignment. **Ensure this adjustment is performed on flat ground.**

If flutter persists, the nut at the top of the caster stem may need to be tightened. Be careful not to over tighten it, as this may restrict movement of the caster. There may also be horizontal play between the caster fork and wheel. Again, the nut should be tight but not restrict movement.

Always check caster alignment when any adjustments are made to the angle of the seat. If the caster angle is not adjustable, adjustment of the seat angle will cause the wheelchair to perform less efficiently.

REAR AXLE ADJUSTMENT

With adjustments to the rear axle of a wheelchair, it is important to consider how the centre of gravity will be affected. Adjustments to the centre of gravity will impact on the wheelchair's stability and performance. A client's safety and stability in the wheelchair is paramount, so careful consideration should be given to these adjustments before they are made. It is possible to alter the centre of gravity in two ways:

- Up or down in relation to the ground
- Forward or backward

UP OR DOWN

This is usually achieved by moving an axle block up or down the frame in a series of pre-drilled holes or by clamps on the down tubes. Some models do not have this adjustment option.
Adjustments up or down will affect the rear seat-to-floor height, causing the seat to be more raked. Usually, lowering the rear seat height will make the wheelchair more stable. However, it may also change the wheelchair propulsion biomechanics eg elbows may be more bent when pushing the wheelchair. With an increased slope in the seat, it may be more difficult to transfer.

With this adjustment, the caster and backrest angles will also need to be adjusted and efficiency of brakes checked.

FORWARD OR BACKWARD

Moving the axle towards the front of the wheelchair will make the wheelchair significantly easier to push and turn, as it reduces the weight through the front casters. However, this will also make the wheelchair much easier to tip backwards. There is also less space available at the front frame of the chair which may impact on transfers It is important to find the right balance, and this may take some time and patience. It may be safer to use anti-tip devices initially if unsure.

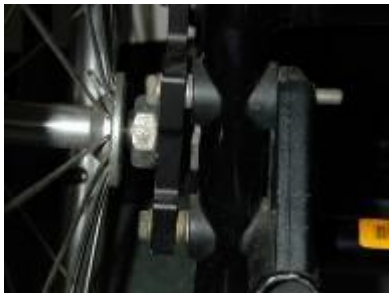
Moving the axle backwards will result in the wheelchair being harder to push and turn, but less likely to tip backwards. It is also important to note that moving the wheel forward or backwards will also change the amount of push-rim available to push on. This may in turn change the propulsion biomechanics, making it more or less efficient.

This adjustment is usually made by sliding the axle forward in a slot, moving the axle to another hole, or sliding a clamp along the wheelchair tubing. Occasionally, this adjustment will be achieved by changing the seat position with respect to the axle. Again this varies according to the model.
Brakes will need to be adjusted.

REMEMBER:	**Exercise caution when adjusting the centre of gravity. It is best to do it a little at a time.**

WHEEL CAMBER

Camber refers to the slant of the wheels, usually towards the frame at the top. In wheelchairs with an axle block, camber is achieved by placing washers between the axle block and frame at the bottom of the axle block. In wheelchairs without an axle block, it may be necessary to replace an entire axle to adjust the camber of the wheels. Some more recent models offer an adjustable camber through interchangeable camber tubes.



Some of the benefits of camber include:

- Greater side to side stability due to increased width of the base of the wheelchair
- Quicker turning
- A more natural pushing action (it is easier to push down and out)

It is important to note that by adding camber to the wheels, the total width of the wheelchair will be increased. This may affect access through doorways or other narrow spaces. It may also reduce the areas available for the client to sit in, as the top wheel distance will be less.

WHEELCHAIR MAINTENANCE AND TROUBLESHOOTING

A regular maintenance program for a manual wheelchair is important to ensure it is functioning properly and to maximise durability. The frequency with which maintenance should be carried out will vary according to how the wheelchair is used, the environment in which the wheelchair is used, and also the relative age of the wheelchair. Most wheelchairs should be supplied with manufacturer's instructions for regular maintenance and some may actually provide a small tool kit. Many procedures are simple, requiring minimal mechanical experience. However, some should be carried out only by an experienced professional eg wheel spoke maintenance. The client should be aware of the terms and conditions of the warranty and the funding body procedures.

Below are some general guidelines for wheelchair maintenance and troubleshooting problems.

UPHOLSTERY

- Cloth upholstery fabrics and vinyl upholstery should be cleaned weekly by wiping with a damp cloth and a mild detergent.
- Cloth upholstery fabrics may be treated with a commercially available fabric protectant.
- Vinyl upholstery should be treated monthly with a commercial upholstery protectant such as those used for car seats.
- Upholstery should be checked regularly for wear and tear. Sagging or torn upholstery in the backrest or seat sling can cause significant deterioration in posture, and impact on pressure relief. Upholstery should be replaced approximately every 12 months or sooner if stretching or sag is significant.

FRAME

- Chrome or painted surfaces should be wiped over weekly with a chamois or cloth to remove dirt and maintain the finish. Commercially available 'spray on-wipe off' surface cleaners (like those used in the kitchen) are usually suitable as the moisture evaporates off the frame quickly. Abrasives may damage the finish.
- Chrome surfaces should be treated with a silicone loaded car polish to inhibit the formation of rust.
- The frame should be checked monthly for early signs of rust and any evidence of metal fatigue or cracks in the welds. If these are caught early, they can usually be repaired more easily and inexpensively than if they are left to

worsen. Any repair of the frame should be carried out by a qualified person recommended by the manufacturer or funding body.

- In folding frame wheelchairs, the folding mechanism should be checked for ease of use. Any stiffness may be alleviated by using a small amount of silicone spray.
- If the wheelchair becomes difficult to fold, or begins to veer in one direction, the frame may be bent or warped and will need review.

WHEEL TOE-IN/TOE-OUT

The terms toe-in and toe-out refer to the alignment of the rear wheels. Incorrect alignment may cause the wheelchair to veer in one direction or affect how the wheelchair rolls. It may need to be adjusted if the rear seat height is altered.

Toe-in or out can be diagnosed by measuring the distance between the wheelrims, both front and back at the level of the axles. If the distance between the rims at the back is greater than that at the front, then toe-in occurs. For toe-out, the distance at the front is greater.

Adjustments to correct this are usually achieved by using washers to space the axle block, either at the front or the back, whichever is appropriate.

It may be possible for one wheel alone to be toe-in or toe-out in relation to the other. This situation may cause the wheelchair to veer in one direction. For example, if the right wheel has toe-out, the wheelchair will veer to the right. If toe-in is present, it will veer to the left. It may be necessary to measure the distance from the wheelrim to a fixed point on the frame to determine this.

It is important to note that on some wheelchairs, adjustment of toe-in or toe-out is achieved through rotation of the axle bar.

REAR WHEELS

- The wheels should be checked monthly to see if they spin freely and stop smoothly. There should be little sideways movement present. If there is some movement present, or the wheel does not spin well, the bearings may be loose or worn and will need review.
- Excessive sideways movement of the wheel may also be caused by loosening of the nuts holding the axle or axle block in place. The tension of these nuts should be checked and tightened if necessary.
- Spoke tension should be checked every few months, more frequently if the client is an active user. Loose, broken or bent spokes may cause the wheel to buckle or warp, leading to deterioration in performance. Tensioning and

replacing spokes requires skill and should be performed by a qualified person eg bicycle shop mechanic.

CASTERS

- Lint and hair can build up quickly around the inside and outside of casters. This may restrict free movement, making it harder to push and turn the wheelchair. This should be removed by removing the caster from the caster fork assembly. Care should be taken not to over tighten the nuts when replacing the caster.
- Grinding noises or excessive sideways movement may be due to worn bearings. Replacement may be necessary by a qualified person.
- Excessive caster wobble may also be due to the loosening of the nuts on the caster fork or stem bolt. Check these nuts for tension, but take care not to over tighten them, as this may restrict free movement of the caster.

TYRES

- Tyre pressure should be checked weekly and kept inflated to the manufacturer's recommended levels. Flat tyres will make the wheelchair significantly harder to push and turn. Take care not to over inflate the tyres, as this can be dangerous. Manufacturer's recommended maximum pressures are usually printed on the side wall of the tyre itself. It may be worthwhile for the client to invest in a tyre pressure gauge, or even a pump with a gauge in-built. Pressure gauges at service stations are often inaccurate.
- Tyres should be replaced if worn. If fabric or canvas is showing through, they should be replaced immediately. Worn tread may result in poor traction, particularly in the wet, and may affect the efficiency of brakes. The tyre will also be more susceptible to puncture.

BRAKES

- Brakes should be checked weekly to ensure that they are operating at their best. As brakes are a safety feature of the wheelchair, malfunction may result in injury. The mechanism should not be excessively loose, but should not be so tight that it makes them difficult to operate.
- Remember that tread and tyre inflation can affect the efficiency of brakes.

PROPULSION BIOMECHANICS

The ability of an individual to propel their own wheelchair efficiently is influenced by many inter-related factors which can be summarised into three main categories:

1. Individual characteristics:
    - Type and degree of disability, body dimensions, weight, co-morbidities, age, method of propulsion chosen by client, confidence and motivation

2. Properties of the wheelchair:
    - size and weight of wheelchair, size and type of wheels and tyres, adjustability of chair in relation to axle position, backrest height, footplate height and position, use of armrests

3. Wheelchair / client interface:
    - the individual fit and set up of the wheelchair for an individual

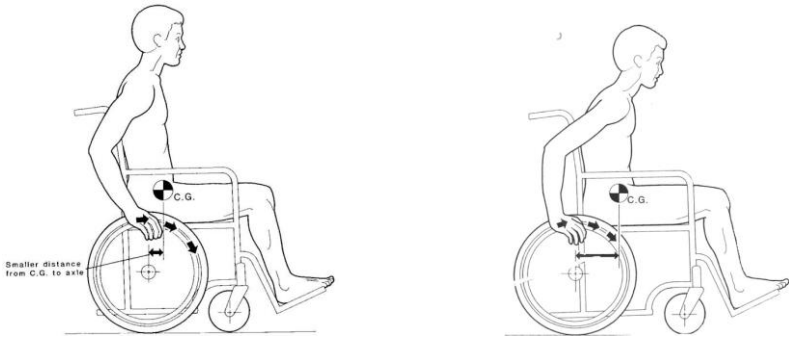
Beekman (1999) reported that both clients with paraplegia and tetraplegia showed improved propulsion efficiency in lightweight wheelchairs as compared to standard wheelchairs.

A wheelchair that is not optimally set up for the user, may over time contribute to the development of repetitive strain injuries. Shoulder pain from rotator cuff tears and aseptic necrosis, and wrist pain from nerve transmission injuries (eg Carpel Tunnel Syndrome) are common findings in long term manual wheelchair users (Boninger, 1999).

Below are considerations when preparing a client for optimal propulsion efficiency in a manual wheelchair

- Shoulder to axle alignment – the shoulder should be positioned over the rear wheel axle or slightly in front of the axle. This allows for the body's centre of gravity to be slightly anterior to the axle resulting in minimal shoulder extension at the beginning of the push phase.
- If the wheel axle is placed too far back the individual must reach into the extremes of shoulder extension and wrist deviation to initiate an effective push.
- Rolling resistance increases as the axle is set further back, thus increasing the energy required to push the chair.
- A more forward axle has a detrimental effect on stability - in this situation anti-tip bars may be useful for client confidence
- Width of wheelchair compared to body - it is easiest to push a wheelchair if the wheels are close to the body, thus minimising shoulder abduction throughout the movement. Camber in the wheelchair is an advantage in propulsion

- Distance of shoulder to axle of wheel – in the resting position with hands resting on the apex of wheel, shoulders should not be elevated and elbows should be flexed to approximately 60-70 degrees (from extended position)
- Stability of trunk in the wheelchair – this is especially important in high thoracic and cervical lesions
- Controlled slight forward trunk movement occurs in propulsion and aids in the application of force to the pushrim



Wheelchair propulsion is a two phase activity: the push and the recovery.

PUSH PHASE

The push rim is gripped between the thumb and index finger. The remaining fingers should be curled in to the palm to prevent getting caught in the spokes.
With the hand positioned just behind the apex of the curve of the wheel, the user flexes at the shoulder and brings the hand (& wheel) forwards. The last segment of the push incorporates elbow extension and shoulder external rotation (10 to 2 o'clock). The wrist moves from radial to ulnar deviation. This combination of muscle activity enables maximum force to be exerted. Force is to be applied tangentially rather than vertically downwards.

Wheelchair propulsion patterns can change as speed increases.

For clients with tetraplegia where shoulders and triceps are weak eg C6 tetraplegia the pushing action is different:

- inability to grip alters pushrim contact and clients use extremes of wrist extension during push
- increased use of shoulder elevators and external rotators to compensate for weak triceps

RECOVERY PHASE

Recovery of the arm involves release of grip from the wheelchair rim, extension and internal rotation of the shoulder, flexion of the elbows and replacement of the hand behind the apex of the wheel ready for the next push.

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WEBSITES

These are some websites relating to manual wheelchairs that have an education focus.

Note: This is not an all inclusive list

www.calder.med.miami.edu/pointis

www.wheelchairnet.org

www.craighospital.org/SCI

www.spinalcord.uab.edu

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