بهم استاد الرحمن الحليم
Workshop on:
Crutch, Cane, Walker & Wheelchair

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Learning Outcomes

At the end of this workshop, the assistant should:

- Describe three main ambulation devices (Crutch, Cane and Walker)
- Cite the indications and contraindications of each device.
- Be able to prescribe the proper ambulation aids.
- Teach the appropriate gait sequences to the injured athlete.
- Know different types of wheelchairs and their components.
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<table>
<thead>
<tr>
<th>شرح</th>
<th>ساعت</th>
<th>ردیف</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walker کلیات تجویز عصای زیر بغل، عصای معمولی و</td>
<td>۹-۸/۳۰</td>
<td>۱</td>
</tr>
<tr>
<td>کار گروهی پیرامون سناریوهای بالینی</td>
<td>۹-۱۰/۳۰</td>
<td>۲</td>
</tr>
<tr>
<td>استراحت و پذیرایی</td>
<td>۱۰-۱۰/۳۰</td>
<td>۳</td>
</tr>
<tr>
<td>ارائه گزارش کار گروه‌ها</td>
<td>۱۰-۱۱/۳۰</td>
<td>۴</td>
</tr>
<tr>
<td>کلیات ویلچر</td>
<td>۱۲-۱۱</td>
<td>۵</td>
</tr>
</tbody>
</table>
Roles:

- Decreased strength of trunk & lower limbs
- Weight bearing restrictions
- Decreased functional mobility, stability, balance, coordination
- Increased pain during ambulation; neurological deficits; amputations; new orthotic & prosthetic devices
Ambulation Aids
(Assistive Devices)

Types:
• Canes and Crutches – use outside clinic
• Walkers – most stable – use outside clinic
• Parallel bars – most stable – use only in clinic

Purpose:
• to increase the area of support for patients who have difficulty maintaining their center of gravity safely over their own support area.
• Redistribute weight-bearing area
Gait aids
Gait aids
Ambulation Aids

- Improve balance
- Redistribute and extend the weight bearing area
- Reduce lower limb pain
- Provide small propulsive forces
- Provide sensory feedback
- Assist with acceleration and deceleration during locomotion
- Compensate for weak muscles

They should be considered an extension of the upper limb.
Weight Bearing Categories

- **MD establishes WB status**
- **NWB** – 0% patient’s weight
- **PWB** – toe touch to 20% to 50% patient’s weight
- **TTWB** – light touch to patient’s heel
- **WBAT** – as much weight as tolerated
- **FWB** – no weight bearing restrictions
Body weight transmission

- Unilateral cane opposite the affected side: 20-25%
- Forearm or arm cane: 40-50%
- Bilateral crutches: up to 80%
Requirements

- Good ROM, muscle strength and endurance, coordination, trunk balance, sensory perception, mental status
- Amount of weight-bearing permitted on lower limb
Requirements

- **Shoulder depressor** – latissimus dorsi, lower trapezius, pectoralis minor
- **Shoulder adductor** – pectoralis major
- **Shoulder flexor, extensor and abductor** – deltoid
- **Elbow extensor** – triceps
- **Wrist extensor** – ECR, ECU
- **Finger flexor** – FDS, FDP, FPL, FPB
Crutches

- Increase BOS – increase lateral stability
- Reduce weight bearing on lower limbs
- Awkward small areas – leaning creates damage radial nerve/axillary artery
- Made of wood & aluminum
Types of Crutches

q **Axillary** – standard
q **Non – axillary:**
  n Lofstrand/forearm crutches
  n Platform crutch
  n Wooden forearm orthosis (Kenny stick)
  n Triceps weakness orthoses (arm orthoses) eg. Warm Spring, Everett, Canadian crutch
Crutches

- Body weight transmission with bilateral axillary crutches = 80% of BW, nonaxillary crutches = 40-50% of BW

- Good strength of upper limbs usually required – more weight bearing and propulsion
Axillary crutches Adjustment

- **Crutch length**: measure anterior axillary fold to point 15 cm anterolateral or lateral to foot (fifth toe) or to heel plus 2.5-5 cm or 5 cm below axilla to 15 cm in front and 5 cm lateral to patient’s foot or 2-3 FB from apex of axilla.

- **Hand piece**: elbow flexed 30 degree, wrist max extension, finger fist (this is measured after the total crutch height is determined with the crutch 3 inches lateral to the foot.) The handgrips of the crutches should be even with the top of your hip line.
Measure of Crutches

Never rest your weight on your arm!
Crutches

q Gait sequences: 2 point, 3 point, modified 3 point, 4 point, swing to, swing through
- Unilateral non/partial weight bearing eg fracture, amputee -> 3-point gait
- Bilateral partial weight bearing or incoordination/ataxia -> 2 or 4-point gait
- Bilateral weakness of lower extremities eg paraplegia -> swing-to or through gait
Points

- The patient should be able to raise the body 2.5 – 5 cm by complete elbow extension.
- Despite the popularity of padding the axillary area of the crutch, this should not be done.
- It needs to be emphasized to the patient that crutches are not designed to be rests for body support. This point should be made to the patient in order to reduce the incidence of compressive radial neuropathies.
Lofstrand/forearm crutches

- Single aluminum tubular adjustable shaft, handpiece, forearm piece 1-2 inches below back of elbow, forearm cuff anterior opening (hinge)
- Elbow flexion 15-30 (20) degree
- The proximal portion of the orthosis is also angled at 20 degrees to provide for a comfortable, stable fit.
- Requires great skill, good strength of UEs & trunk balance
Advantages:

- Shorter than axillary crutch
- The forearm cuff pivots to allow the patient to lean on the crutch for hand activities.
- The patient can release hand without losing crutch.
Wooden Forearm Orthosis (Kenny Stick)

- A leather band around the proximal portion of the forearm.
- It was designed for polio patients who had satisfactory proximal upper limb musculature but were weak distally and unable to effectively hold and control the orthosis.

**Advantages:**
- The presence of a closed leather band
- This assures the patient (more so than the Lofstrand forearm orthosis does) that he/she will not drop the ambulation aid.
Platform crutch

- Painful wrist and hand condition or elbow contractures, or weak hand grip
- The distance from the ground to the forearm rest is the proper length.
- Platform, velcro strap
- Elbow flexed 90 degrees
Triceps Weakness Orthosis (Arm Orthosis)

- Were originally developed for poliomyelitis patients.
- The metal version is known as a Warm Spring crutch or Everett crutch.
- The wooden version is known as a Canadian crutch.
- These crutches resemble the “axillary” crutches in style, but end proximally with a cuff at the mid-arm level.
- These ambulation aids help prevent flexion (buckling) of the elbow during gait.
Weight Bearing Categories & Gait Sequences
Weight Bearing Categories and Gait Sequences

- MD establishes WB status
- **NWB** – 3 point gait – assistive device advances simultaneously with affected limb
- **PWB** – 3 point gait & 2 point gait – assistive device advances simultaneously with affected limb
- **WBAT** – 2 point, 3 point, modified 3 point, 4 point
- **FWB** – 2 point, 3 point, modified 3 point, 4 point
**Gait Sequencing Patterns**

**Point gait** – stability, slow

- 4 point gait – slow - stable – weakness lower limbs - WBAT/FWB – crutches or 2 canes
- 3 point gait – NWB gait – one affected lower extremity – patient good strength upper limbs, trunk, and unaffected lower limb – NWB/PWB/TTWB/WBAT – walker or crutches
- Modified 3 point gait – not strength/energy – WBAT/FWB – walker or crutches
- 2 point gait – closest to normal gait – FWB/PWB/TTWB/WBAT - crutches or 2 canes

**Swing gait** – more energy, fast

- Swing to & swing through – paralysis both limbs – trunk instability - crutches
The Tripod Position

The tripod position is the position in which you stand when using crutches. It is also the position in which you begin walking.

To get into the tripod position, place the crutch tips about 4” to 6” to the side and front of each foot, then stand on your "good" foot (the one that is weight-bearing).
Four-point gait

- Good stability - at least 3 point contact ground
- Useful in ataxic patients and those with marked lower limb weakness.
- Slowest, difficulty

Left crutch ⇧ right foot ⇧ right crutch ⇧ left foot ⇧ repeat
Indication

This is most commonly used to provide assistance with walking when both legs are in a weakened condition.
4-point gait

It is used when the patient can bear some weight on both lower extremities. Place the patient in the tripod position and instruct him to do the following.

1. Move the right crutch forward.
2. Move the left foot forward.
3. Move the left crutch forward.
4. Move the right foot forward.
5. Repeat this sequence of crutch-foot-crutch-foot for desired ambulation.
Tripod position
Step 1: Right crutch advances
Step 2: Left foot advances
Step 3: Left crutch advances
Step 4: Right foot advances
Three-point gait/alternating two-point gait

- Non-weight-bearing gait for lower limb fracture or amputation
- 3-point PWB gait -> required 18-36% more energy per unit distance than normal
- NWB required 41-61% more energy per unit distance than normal

Both crutches and the weaker lower limb "good" lower limb repeat
Characteristics:

- All weight bearing on the affected lower limb is eliminated.
- This gait is commonly used by patients with lower limb fractures or amputations. It is also known as the non-weight bearing gait. The patient should have good balance to perform this gait.
Types:

- **Partial Weight-Bearing Three-Point Gait**
  This is used when your injured foot can bear some weight, but you still need the assistance of crutches. To do this, put both crutches in front at a 45 degree angle, just like the tripod stance. Step with your bad foot up to the crutches and then step with your good foot past the crutches.

- **Three-Point Swing-Through Gait**
  This is used to keep all pressure off your injured foot. Starting from the tripod stance, swing both feet through, placing your good foot in front of the crutches. Make sure you “swing through” so that you’re giving your body the proper support when stopping.
3-point gait

It is used when the patient should not bear any weight on the affected leg. Place the patient in the tripod position and instruct him to do the following.

1. Move the affected (non-weight bearing) leg and both crutches forward together.
2. Move the unaffected (weight bearing) leg forward.
3. Repeat this sequence for desired ambulation.
Tripod position

Step 1
Both crutches and affected leg advance

Step 2
Unaffected leg advances.
Two-point gait

- Faster than 4-point gait but less stability
- Decrease both lower limbs weight-bearing

Left crutch and right foot ⇒ right crutch and left foot ⇒ repeat
Characteristics:

- This gait pattern provides stability and is useful for ataxic patients and with decreased lower limb weight-bearing capabilities.
- It is faster than the 4 point gait and provides some weight bearing relief to both lower limbs.
2-point gait

- It is used when the patient can bear some weight on both lower extremities. Place the patient in the tripod position and instruct him to do the following.

  1. Move the right leg and left crutch forward together.
  2. Move the left leg and the right crutch forward together.
  3. Repeat this sequence for desired ambulation.
Tripod position.

Step 1
Left crutch and right leg advance

Step 2
Right crutch and left leg advance
Swing-through gait

- Fastest gait, requires functional abdominal muscles
- Required increase of 41-61% in net energy cost (= 3-point NWB)

Both crutches ‡ advancement of both lower limbs past the crutches ‡ repeat
Characteristics:

- It is very energy-consuming and its use requires functional abdominal muscles.
- The swing through gait is the fastest gait (even faster than able-bodied body walking)
Swing-to gait

- Both crutches -> both lower limbs almost to crutch level
Drag to gait

- The alternative sequence:
  - Left crutch \( \dagger \) right crutch \( \dagger \) drag to crutch level.
- The simultaneous sequence:
  - Both crutches \( \dagger \) drag to crutch level.
- These are useful as initial gait patterns for paraplegic patients.
- They can advance to another gait pattern.
- These patterns provide stability during gait but are slow and laborious methods of ambulation.
General Rules
Standing

- The tripod stance is what provides your body with the most support and keeps weight off of your injured leg when standing still.
- Keep your good foot firmly on the ground and place the crutches in front of your body at a 45 degree angle to the good foot.
- Be careful not to move the crutches too far away or too close to your body since this will not provide the support you need.
**Walking**

- Lean forward slightly and put your crutches about one foot ahead of you.
- Begin your step as if you were going to use the injured foot or leg, but shift your weight to the crutches instead of the injured foot.
- Your body swings forward between the crutches.
- Finish the step normally with your non-injured leg.
- When the non-injured leg is on the ground, move your crutches ahead in preparation for the next step.
Walking

- Move both crutches forward together
- Follow by weak leg
- Then your strong leg

**Note:** when making 180 turns use three steps
Sit to Stand

Technique 1:
- Place crutches on weak side
- use the other hand for support from the chair
- stand up
- bring one crutch to the other side
- place both crutches beneath your armpit

Technique 2:
- Inch yourself to the front of the chair.
- Hold both crutches in the hand on your good leg side.
- Push yourself up and stand on the good leg.
Sitting

- Back up to a sturdy chair.
- Put your injured foot in front of you and both crutches in one hand.
- Use the other hand to feel for the seat of your chair.
- Slowly lower yourself into it.
- Lean your crutches upside down in a handy location. (Crutches tend to fall over when they are stood on their tips.)
**Stairs with handrails**

- Facing the stairway, hold the handrail with one hand and tuck both crutches under your armpit on the other side.

- When you're going up, lead with your good foot, keeping the injured foot raised behind you.

- When you're going down, hold your injured foot up in front, and hop down each stair on your good foot.

- Take it one step at a time.

- You may want someone to help you, at least at first.
Stairs with handrails

**Up:**
1. Place both crutches on the side opposite the railing.
2. Holding onto the railing and crutches, step up with the stronger leg.
3. Then bring up the weak/operated leg and crutches to the same step.
4. Continue to go up, always with the stronger leg first.

**Down:**
1. Place both crutches opposite the railing.
2. Bring the crutches down first.
3. Step down with the weak/operated leg.
4. Put the weight on the railing and crutches.
5. Next step down with the strong leg.
Stairs without handrails

If you're facing a stairway with no handrails, use the crutches under both arms and hop up or down each step on your good leg, using more strength.
Up Stairs

- Get close to stair case
- Step up with your strong/good leg first
- Follow with crutches and weak leg
Down stairs

- Get close to the stair case
- bring crutches down to next step first
- weak leg should immediately follow
- strong/good leg should step down last
Stairs without handrails

- An easier way is to sit on the stairs and inch yourself up and down each step.
- Start by sitting on the lowest stair with your injured leg out in front.
- Hold both crutches flat against the stairs in your opposite hand.
- Scoot your bottom up to the next step, using your free hand and good leg for support.
- Face the same direction when you go down the stairs this way.
Canes
The cane (or walking stick) is one of the oldest biomechanical devices developed. The cane has four main parts:

- **Handle**
  - Almost any shape (e.g. knob, L-shaped, pistol grip, hook)

- **Shaft**
  - Straight part of the cane

- **Collar**
  - Attachment between the handle and shaft

- **Ferrule**
  - Tip of the cane
The tradition design is the single point, straight cane. It offers improved stability when the user either has mildly disturbed gait or balance, endurance problems, or pain is present but does not prevent weight bearing. However, users with poor balance or one-sided weakness (hemiparesis) from stroke or other injury typically have difficulties with this type of cane.
Ferrule Design

- The quad cane was designed for users that require additional balance and has four points of contact to provide maximal stability. The span between the tips can be adjusted for more/less stability.

- The major drawbacks of the design is that the ferrule can interfere with the user’s foot while walking and stair climbing.
Rubber Tip

- All canes should be fitted with a deeply grooved 2.5-5 cm wide rubber tip for good traction and safety.
- The clinician should check these regularly for wear.
Canes

- Widens BOS - increases balance & stability – pain relief - does not reduce weight bearing
- Alters the biomechanics of walking in a way that may relieve painful joints.
- Cane eliminate necessary gluteus medius force and reduces compressional force on hip
- Use opposite hand of affected lower limb
Cane Biomechanics

- The load is increased by 4 times the body weight on the stance side during gait due to the gravitational forces and the gluteus medius – minimus force exerted across the weight bearing hip.

- The cane helps decrease the force generated across the affected hip joint by decreasing the work of the gluteus medius – minimus complex. This occurs when the upper limb exerts force on the cane to help minimize pelvic drop on the side opposite the weight bearing lower limb.
Canes

- Body weight transmission for unilateral cane opposite affected side is 15-25%
- Canes are made of wood or aluminum, with the aluminum alloy cane having adjustable notches so that “one cane fits all”.
Common types

Basic or C cane (most commonly used):
- crook top cane or a J cane,
- difficult to grasp, especially for those with hand problems.
- Additionally, the weight bearing line falls behind the shaft of the cane, thus reducing its supportive value.
- Usually used for balance issue or leg injury
Common types

- Functional grip cane:
  - conforms to the natural angle of the hand, and is more comfortable
Quad canes:
- Provides more support than basic cane
- Is more awkward than basic cane
- Allows greater freedom than walkers
- Narrow and wide based forms for different degrees of support.
- Wide-based canes are prescribed for persons with greater degrees of impaired balance, preferably only for temporary use (heavy and awkward).
Cane Measures

- The preferred measurement is from the ground to the wrist crease or ulnar styloid.

- If this is not possible, measure from the floor (the bottom of the heel of the shoe or 25 cm lateral to border of patient’s toes) to the greater trochanter.

- The elbow should be flexed approximately 20-30 degrees, which is a desirable elbow position for all ambulation aids. Both shoulders should be level.
Indications

- Small problem with balance or instability
- Some weakness in the leg or trunk
- An injury or pain at knee or ankle
- Gluteus medius weakness
- In the elderly, a single point cane may also help to keep living independently.
Contraindications

- Arm weakness
- Moderate to severe gait or balance deficit
Proper cane selection is key, as a poorly fitted cane may aggravate the user's limitations, impede healing or increase the risk of injury from a fall.
Cane Gait Sequences

1. Simultaneous affected lower limb and cane → unaffected lower limb
2. Cane → affected lower limb → unaffected lower limb
General Rules
Walking

- When you walk, the cane and your injured leg swing and strike the ground at the same time.

- To start, position your cane about one small stride ahead and step off on your injured leg. Finish the step with your normal leg.

- The patient should have the “good” lower limb assume the first full weight bearing step on level surfaces.
Stairs

To climb stairs, grasp the handrail (if possible) and step up on your good leg first, with your cane in the hand opposite the injured leg. Then step up on the injured leg.

To come down stairs, put your cane on the step first, then your injured leg, and finally the good leg, which carries your body weight.

The pneumonic “up with the good and down with the bad” serves as an easy reminder.
FOLDING WALKING STICKS

- These are lightweight metal sticks with sectioned shafts that enable them to be folded up for storage, for example in a handbag.

- Strong elastic runs inside the shaft to ensure that in its open position the stick remains stable. Fixed height or adjustable height versions are available. Some are provided with a plastic, storage wallet.
Walker/Walkerette

- Wider and more stable base of support, but slow gait (interfere smooth reciprocal gait)
- For patients requiring maximum assistance with balance, the elderly, the fearful, and uncoordinated
Types of walkers

- **Pick Up Walkers (4 post):** walker is picked up and moved after each step
  - Harder to use because it requires strength and coordination

- **Wheeled Walkers** [2 wheel/2 post, 3 wheel, 4 wheel, 4 wheel with seat and hand brakes (Rollator), 4 wheel with safety bars and sling seat (Merry Walker)]
  - Less energy required
  - 2, 3, 4 wheeled available to accommodate different needs
  - Suitable for who lack coordination or power in upper limbs
Comparison

- Pick up walker is more stable
- Walker with wheels is easier for patients who have difficulty with lifting or balance, however can roll forward when weight is applied.
Advantages of Wheeled Walkers

- Wheeled Walkers can be accessorized with:
  - Shelves, or baskets to carry groceries or personal items
  - Seats for resting
A Case Study

4 wheeled walkers: improving lives in Sweden
Walker

- Supports ~30% of weight
- Provides wide BOS – increases anterior & lateral stability -easy to use
- Reduces weight bearing on lower limbs
- Cumbersome small spaces – no stairs
Walker Gait

- Front of walker 15-30 cm in front of patient
- Shoulder relaxed and elbow flexed 20 degrees
- 3 point or modified 3 point gait
- Ambulate standard walker: lift walker forward (walker back legs at same level of patient’s toes) → weight on arms → Partial weight on affected leg first
Gait Sequence

- First, put your walker about one step ahead of you, making sure the legs of your walker are level to the ground.
- With both hands, grip the top of the walker for support and walk into it, stepping off on your injured leg.
- Touch the heel of this foot to the ground first, then flatten the foot and finally lift the toes off the ground as you complete your step with your good leg.
- Don't step all the way to the front bar of your walker.
- Take small steps when you turn.
Walker measures

- Height – upper bar of walker should be slightly below the client’s waist or on greater trochanter with arms flexed 15-30 deg
- The top of your walker should match the crease in your wrist (or ulnar styloid) when you stand up straight.
Indications

- These are prescribed for people who need more support than canes (typically elderly)
- Less dangerous than crutches, require less upper body strength
- Can completely support only one lower limb, not the whole body weight. So, Patient should have at least one weight bearing leg and arm
Contraindications & problems

Contraindications:

- Environmental hazards
- Severe arm and gait weakness

Problems:

- Slows gait
- Low maneuverability
Sitting & Standing

To sit, back up until your legs touch the chair. Reach back to feel the seat before you sit.

To get up from a chair, push yourself up and grasp the walker's grips.

Make sure the rubber tips on your walker's legs stay in good shape.
Stairs

Never try to climb stairs or use an escalator with your walker.
سناریوی ۱: یک دونده تفریحی دو های استقامتی ۴۰ ساله در پی افزایش شدید میزان تمرینات خود دچار شکستگی جونز در مراتب ۵ شده است. در چهت راهاندازی فرد چه وسیله و چه روشی را پیشنهاد می‌کنید؟
سناریوی 2: یک بسکتبالیست 19 ساله در هنگام مسابقه دچار درجه 2 شده استه است. در مورد وسیله کمکی مناسب او را راهنمایی کنید.
سناریویی 3: یک خانم 28 ساله که اخیراً تشخیص بیماری MS برابری مطرح شده است، برای دریافت نسخه ورزشی به شما مراجعه نموده است. اخیراً علائم آتاکسی را ذکر می کند. قدرت اندام فوقانی مناسب است، وسیله کمکی مناسب برای راه افتادن وی را به انتخاب وی تجویز کنید.
سناریوی ۴: در ارزیابی بالینی یک مرد 70 ساله متوجه تست ترندلنبرگ مثبت و ضعف عضلات گلوتئوس مذیویس در سمت راست می‌شویم. راه رفتی‌ا تا حدا پرای این فرد دردنگ امت. در مورد وسیله کمکی مناسب این فرد را راهنمایی کنید.
سناریوی ۵: یک خانم ۷۸ ساله با استئوپوروز شدید و شکستگی گردن فمور که ۱ ماه پیش جراحی شده، مراجعه کرده است. از ضعف عمومی شکایت دارد. در مورد وسیله کمکی مناسب این فرد را راهنمایی کنید.
Wheelchair
A wheelchair is a wheeled mobility device in which the user sits. The device is propelled manually by turning the wheels or through a motorized propulsion system.

Although the basic design of the wheelchair hasn’t changed much over the years, there have been some modifications to improve handling and reduce the rate of injuries:

- Chair Weight
- Adjustability
- Wheel Camber
Wheelchair

- Supports full body weight
- Options: manual/motorized; accessories; lower to ground or one-sided drive (hemi-chair); racing, handcycle
- Fitting: 1-1.5 inches around hips and under knees; footplates clear floor by 1-2 inches; armrest at elbow height; removable footrests and armrests
- Contraindications: unable to sit, or able to walk safely
- Problems: deconditioning, contractures, pressure sores
Wheelchairs

**Purposes:**
- Correct and straighten deformity
- Increase and maintain level of function
- Allow patient maximum functional use

**Proper WC seating/positioning:**
- Prevents deformity & pressure ulcers
- Normalizes tone
- Promotes efficient use of upper limbs
- Enhances respiratory function
- Body alignment
- Increases sitting comfort/tolerance
1. Arm pad
2. Desk-style removable arm rest
3. Clothes guard
4. Sling seat
5. Down tube
6. Foot rest
7. Bottom rail
8. Cross brace, X bar, or X frame
9. Caster
10. Caster fork
11. Footplate
12. Tipping lever
13. Axle
14. Seat rail
15. Arm rest bracket or hole for non-wrap-around arm rest
16. Arm rest bracket or hole for non-wrap-around arm rest
17. Handrim
18. Wheel
19. Wheel lock, brake lever
20. Back post
21. Sling back
22. Push handle
Research has shown that manual wheelchair users are at high risk for developing pain and repetitive strain injuries at the shoulder and wrist:
- Carpal tunnel syndrome
- Shoulder pain
- Rotator cuff disease
- Distal clavicle osteolysis
Manual Wheelchair Propulsion

- Greater incidence of median nerve damage has been associated with higher propulsion forces and increased rate of applied forces.

- Also, users who push with a greater number of strokes at a given speed are more likely to develop median nerve injury.
Seat position has a profound influence on propulsion. This is accomplished by changing the horizontal and vertical position of the rear wheels. Positioning the seat so more of the user’s weight is centered over the rear wheels versus the front casters reduces rolling resistance and required propulsion forces.

In general, wheelchair users are advised to position the seat as far rearward as possible without compromising stability in their chair.
Wheel Camber

- Camber is the angle that the vertical axis of the wheel makes with the road surface.
- Negative camber is when the top of the wheel leans towards the centre of the chair. Positive camber is when the top of the wheel leans out.
Negative Wheel Camber

- If a chair's rear wheels have a negative camber, the effort required to propel the chair across a slope in a straight line is reduced dramatically.
- Also, negative cambered wheels also increase the ease with which the user can turn the wheelchair.
Negative Wheel Camber

Advantages:

- The wider footprint adds lateral stability to the wheelchair
- Redirects forces to soften the ride
- Places the pushrims in a more ergonomic position for pushing
- It is more natural to push down and outward
- Protects the hands when pushing in tight areas since the bottom of the wheels will make contact first with walls and doorframes
- Less strain on shoulders since the plane of the wheel is closer to that of the shoulder
- Makes turning quicker
- Gives the wheelchair a sportier look
Negative Wheel Camber

Disadvantages:

- Wheelchair will be wider
- May add cost to the chair
- Excessive camber may cause the wheels to rub against the armrest side panels or against the user
- Diminished traction and uneven tire wear on a conventional tire.
Standard measures

A) Seat width: 2.5 cm wider than the width of the widest part of the buttocks

B) Seat height: 5 cm higher than the distance from the bottom of the heel to the popliteal area

C) Seat depth: 2.5 – 5 cm shorter than the distance from the popliteal area to the back of the buttocks

D) Back height: 5 cm less (may vary) than the distance from the bottom of the scapula to the sitting surface

E) Armrest height: Distance from bottom of buttocks to elbow
Wheelchair Measurement Problems

- **Excessive seat width** – difficult to reach drive wheels & maneuver tight places
- **Narrow seat width** – pressure/discomfort
- **Short seat depth** – no support thighs
- **Long seat depth** – less blood circulation posterior knees
- **Low footplates** – pelvis slides forward
- **High footplates** – pressure ischial tuberosities
- **Short leg length** – pressure sores ischial tuberosities
- **Long leg length** – patient slides forward
- **High back** – can not reach projection hand rims – WC can not fit in car
Wheelchair Training

  - Wheelies – balance rear drive wheels
  - Ascend curb: caster wheels up on curb – push rear drive wheels using momentum
  - Descend curb: forward wheelie; backward leaning head/trunk forward
  - Fall forward – reach forward upper limbs – bend elbows – turn pelvis land on one hip
  - Fall backward – bend trunk/head reaching forward – fall on buttocks- protect head
<table>
<thead>
<tr>
<th>TABLE 30-1. The SEAT × 2 checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Support (SCALPS)</strong></td>
</tr>
<tr>
<td>for Safety and Comfort/Cosmesis</td>
</tr>
<tr>
<td>of Arms, Legs, Pelvis, Spine and head</td>
</tr>
<tr>
<td><strong>Skin</strong></td>
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<tr>
<td><strong>Easy propulsion</strong></td>
</tr>
<tr>
<td><strong>Easy transfers</strong></td>
</tr>
<tr>
<td><strong>Alteration of tone</strong></td>
</tr>
<tr>
<td><strong>Accommodation (GrOW FAST)</strong></td>
</tr>
<tr>
<td>of Growth,</td>
</tr>
<tr>
<td>of Other (i.e., miscellaneous requirements, such as feeding, suctioning, and ventilation equipment),</td>
</tr>
<tr>
<td>of Worsening medical condition,</td>
</tr>
<tr>
<td>of Functional Activities,</td>
</tr>
<tr>
<td>of Structural deformities,</td>
</tr>
<tr>
<td>of Technology</td>
</tr>
<tr>
<td><strong>Transportability with safe tie-downs</strong></td>
</tr>
<tr>
<td><strong>Terrain</strong></td>
</tr>
</tbody>
</table>
THE SEAT X 2 CHECKLIST

- Support
- Skin
- Easy Propulsion
- Easy Transfers
- Alteration of Tone and Reflexes
- Accommodation
- Transportability
- Terrain
Support

The first S in SEAT is for support. The SCALPS acronym, for safety, comfort and cosmesis, arm support, leg support, pelvic support, and spinal/head support, reminds the team to consider how to support all body parts in the safest, most comfortable, most cosmetic, and most functional manner possible.

If deformities are mild, the goal usually is to support the patient with the body aligned in the normal symmetric sitting posture. This often is not the most functional or comfortable sitting posture for a person with a severe disability.
Arm Support

- If upper extremity function is normal, the goal may be to eliminate all parts that interfere with arm movement and hand function or with manual propulsion of the wheelchair.

- Athletic wheelchair users may want to eliminate arm rests and may even choose to eliminate wheel locks because they present a hazard to the thumbs and hands during vigorous pushing.

- For other users, arm rests can aid significantly in transfers, weight shifts, reducing ischial pressure by bearing some of the body weight on the arms, maintaining balance, and increasing comfort. For those who bear weight on the arms, selecting arm rests that are supportive and adjustable in height facilitates weight-shifting maneuvers. Patients with poor trunk control may need arm rests for stability.
Leg support

The height of foot rests should enable the foot to be supported sufficiently to maintain circulation to the lower extremities and keep the ankle in a neutral position but not so high as to force more weight backward onto the ischial tuberosities and increase the risk of pressure sores.
Pelvic support is considered the key to proper support of the entire body for most patients with brain disorders. A firm seat is indicated for many but not all patients. A fabric sling or hammock seat is lighter and may be more functional for some. An ischial ledge may be built into the seat or cushion to prevent the ischial tuberosities from sliding forward. Cushions affect pelvic support, pressure distribution, and stability. Most patients with a significant pelvic obliquity require a custom-molded seat.
Spinal and Head Support

- Support of the spine and head may vary from a very short fabric sling back that provides almost no support at all for the patient with no spinal deformity, normal trunk control, and strong arms, to a custom-molded back with special head supports.

- Wheelchair back height should be sufficient to support the user in good posture and prevent fatigue over an extended time while affording as much movement as possible. In all cases, the back should provide good support for the lumbar spine.
Easy Propulsion

- Easy self-propulsion is essential to make the patient as functional as possible.
- Pushing with any combination of arms and legs is possible for manual mobility, and there are a wide variety of configurations and accessories to facilitate various capabilities and limitations.
- If manual propulsion is impossible or is too difficult or slow to be functional, power mobility should be used if the patient is otherwise competent. For example, manual propulsion by most persons with complete C6-spared quadriplegia or higher is too slow to be functional, so powered wheelchairs should be prescribed for these persons.
Weight & Frame

- Although all agree that wheelchair weight is important when considering transportability, some research shows that weight has little effect on the overall energy cost of wheeling.

- This may be true for wheeling on level surfaces, but wheelchair weight does have an effect on ease of propulsion uphill.

- If folding frames are used, precise wheel alignment may be difficult to maintain, with a resultant increased rolling resistance and decreased efficiency of pushing.
Alteration of Tone and Reflexes

- Alteration of abnormal tone and primitive reflexes is an important goal for many patients with brain disorders.
- Strategies to reduce hypertonicity include providing enough stability for the patient to feel posturally secure, correct position of the head, comfortable correct position of the lower extremities, and correct use of gravity.
- Hypotonicity requires support and use of gravity.
### TABLE 30-3. The SEAT × 2 checklist of goals of special seating for specific disabilities

<table>
<thead>
<tr>
<th>Goal</th>
<th>SCI paraplegia</th>
<th>SCI quadriplegia</th>
<th>Brain lesion</th>
<th>Muscular dystrophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety (restraints and stability)</td>
<td>+</td>
<td>+/−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Comfort and cosmesis</td>
<td>+/-</td>
<td>+/−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Arms</td>
<td>−</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Legs</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pelvis</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Spine and head</td>
<td>Depends on level</td>
<td>+/−</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Skin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure distribution</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
<td>+ (for comfort)</td>
</tr>
<tr>
<td>Pressure relief</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
<td>+ + (for comfort)</td>
</tr>
<tr>
<td>Easy propulsion</td>
<td>+</td>
<td>+ + to − (may need power)</td>
<td>+ to −</td>
<td>+ + (need power)</td>
</tr>
<tr>
<td>Easy transfers</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ + (for attendant)</td>
</tr>
<tr>
<td>Alteration of tone</td>
<td>−</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Accommodation (GrOW FAST)</td>
<td>+/−</td>
<td>+/−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>of Growth</td>
<td>Individualize</td>
<td>Individualize</td>
<td>Individualize</td>
<td>Individualize</td>
</tr>
<tr>
<td>of Other</td>
<td>−</td>
<td>Individualize</td>
<td>Individualize</td>
<td>Individualize</td>
</tr>
<tr>
<td>of Worsening (i.e., progressive)</td>
<td>−</td>
<td>Individualize</td>
<td>Individualize</td>
<td>Individualize</td>
</tr>
<tr>
<td>disease</td>
<td>−</td>
<td>Individualize</td>
<td>Individualize</td>
<td>Individualize</td>
</tr>
<tr>
<td>of Functional Activities (i.e., ADL needs)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>of Structural deformities and contractures</td>
<td>+/−</td>
<td>+/−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>of Technology</td>
<td>+/−</td>
<td>+</td>
<td>+/− to ++</td>
<td>+</td>
</tr>
<tr>
<td>Transportability</td>
<td>For patient</td>
<td>For patient or attendant</td>
<td>For attendant</td>
<td>For attendant or family</td>
</tr>
<tr>
<td>Terrain</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

+ + , usually important; + , often important; +/− , sometimes important; − , usually not important
ADL, activities of daily living; SCI, spinal cord injury.
## Types of Frames and Their Common Uses

<table>
<thead>
<tr>
<th>Uses</th>
<th>Common Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid</td>
<td>Institutions</td>
<td>More stable, energy efficient</td>
</tr>
<tr>
<td>Folding</td>
<td>Community mobility</td>
<td>Compact transport</td>
</tr>
</tbody>
</table>
Rigid chair. A. Assembled. B. Disassembled with casters, wheels and footrest removed and set back folded.
Folding chair: A. open; B. folded
## Types of Wheels and Their Common Uses, Advantages, and Disadvantages

<table>
<thead>
<tr>
<th></th>
<th>Common Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mag</td>
<td>Community mobility</td>
<td>Durable, low maintenance</td>
<td>Heavier</td>
</tr>
<tr>
<td>Spokes</td>
<td>Community, institutions, sports</td>
<td>Lighter</td>
<td>Greater maintenance, less durable</td>
</tr>
</tbody>
</table>

- **Mag**: Suitable for community mobility, offers durability and low maintenance but is heavier.
- **Spokes**: Suitable for community, institutions, and sports activities, lighter than Mag, but requires greater maintenance and is less durable.
# Types of Tires and Their Common Uses, Advantages, and Disadvantages

<table>
<thead>
<tr>
<th>Type</th>
<th>Common Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard rubber</td>
<td>Institutions</td>
<td>Low rolling resistance</td>
<td>Harsh ride on rough terrain, heavy</td>
</tr>
<tr>
<td>Pneumatic</td>
<td>Community mobility</td>
<td>Best all-around ride, lightweight</td>
<td>Tendency to develop flats</td>
</tr>
<tr>
<td>Pneumatic with flat free inserts</td>
<td>Community mobility</td>
<td>Good ride with no flats</td>
<td>Moderately heavy</td>
</tr>
</tbody>
</table>

![Diagram of tire types and their characteristics](image-url)
<table>
<thead>
<tr>
<th>Types of Hand Rims</th>
<th>Common Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large diameter</td>
<td>Community, institutions</td>
<td>Easy to propel</td>
<td>Less distance per stroke</td>
</tr>
<tr>
<td>Small diameter</td>
<td>Active individual, sports</td>
<td>Greater distance per stroke</td>
<td>More force required</td>
</tr>
<tr>
<td>Thick</td>
<td>Poor hand grip</td>
<td>Easier to grip</td>
<td>More weight and width</td>
</tr>
<tr>
<td>Knobby</td>
<td>Poor hand grip</td>
<td>Easier to push</td>
<td>More weight and width</td>
</tr>
</tbody>
</table>
### Types of Casters and Their Common Uses, Advantages, and Disadvantages

<table>
<thead>
<tr>
<th>Types</th>
<th>Common Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Community, institutions</td>
<td>Rough terrain</td>
<td>Increased rolling resistance</td>
</tr>
<tr>
<td>Small</td>
<td>Sports</td>
<td>Maneuverability</td>
<td>Poor outdoor performance</td>
</tr>
</tbody>
</table>
### Types of Cushions and Their Common Uses, Advantages, and Disadvantages

<table>
<thead>
<tr>
<th>Types of Cushions</th>
<th>Common Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foam</td>
<td>General use</td>
<td>Good stability, low cost</td>
<td>Pressure relief not optimal</td>
</tr>
<tr>
<td>Coated, contoured foam</td>
<td>General use</td>
<td>Excellent stability, cleanability, durability</td>
<td>Heat buildup, expensive</td>
</tr>
<tr>
<td>Gel-filled</td>
<td>General use</td>
<td>Good pressure relief, cleanability, heat dissipation</td>
<td>Expensive</td>
</tr>
<tr>
<td>Contoured foam with gel insert</td>
<td>When improved pressure distribution needed</td>
<td>Good pressure relief, stability, cleanability, durability</td>
<td>Expensive, heat buildup</td>
</tr>
<tr>
<td>Air-filled villous</td>
<td>Optimal pressure relief needed</td>
<td>Excellent pressure relief, cleanability, heat dissipation</td>
<td>Expensive, suboptimal seating stability</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Causes</th>
<th>Possible Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis</td>
<td>Posterior tilt (sacral sitting or sliding out of chair)</td>
<td>Hypotonia, Tonic labyrinth prone (TLP) reflex (producing flexed posture)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited active hip flexion (causing compensatory loss of low lumbar curve)</td>
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<tr>
<td></td>
<td></td>
<td>Tight hamstrings with seat too long or with too high a wedge in seat, footrest preventing knee flexion</td>
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<tr>
<td></td>
<td></td>
<td>Improper positioning in seat</td>
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<tr>
<td></td>
<td></td>
<td>Lap belt located too high</td>
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<tr>
<td></td>
<td></td>
<td>Asymmetrical muscle tone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scoliosis with pelvic obliquity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dislocated or subluxated hip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“Hammock” of wheelchair seat</td>
</tr>
<tr>
<td>Trunk</td>
<td>Scoliosis</td>
<td>Postural</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Position of pelvis not midline</td>
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<tr>
<td></td>
<td></td>
<td>Hypotonia-hypertonia asymmetrical muscle tone (asymmetrical tonic neck reflex, asymmetrical distribution of tone, hemisphere, etc.)</td>
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<tr>
<td></td>
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<td>Environmental or functional demands</td>
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<td></td>
<td></td>
<td>Structural</td>
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<tr>
<td></td>
<td></td>
<td>Persistent asymmetrical posture (fixed deformity)</td>
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<td>Kyphosis</td>
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<td>Postural</td>
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<td></td>
<td>Structural</td>
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<td></td>
<td>Fixed deformity</td>
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<td></td>
<td></td>
<td>Kyphosis</td>
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<td></td>
<td></td>
<td>Thoracolumbar scoliosis</td>
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<td>Extensor thrust</td>
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<tr>
<td></td>
<td></td>
<td>Asymmetrical tonic neck reflex</td>
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<td></td>
<td></td>
<td>Instability of upper trunk</td>
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<td></td>
<td>Retraction</td>
<td>Thoracolumbar scoliosis</td>
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<td>Extensor thrust</td>
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<td>Asymmetrical tonic neck reflex</td>
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<td>Instability of upper trunk</td>
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<td>Protraction</td>
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<td>Kyphosis</td>
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Table continued on following page
References:

Good Luck