Fall Prevention & Wheelchair Seating

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Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

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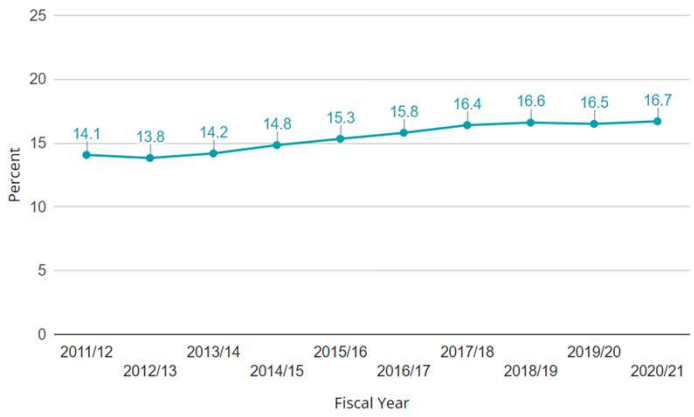
Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



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British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

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British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

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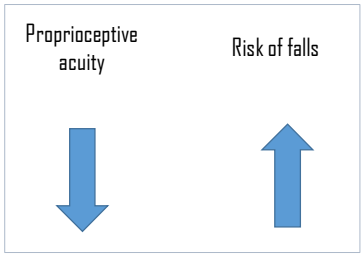
Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

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Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

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Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

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Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

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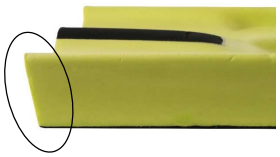
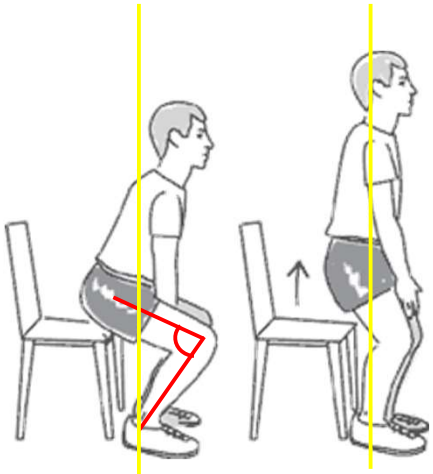
Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

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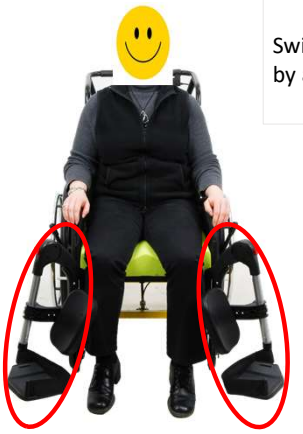
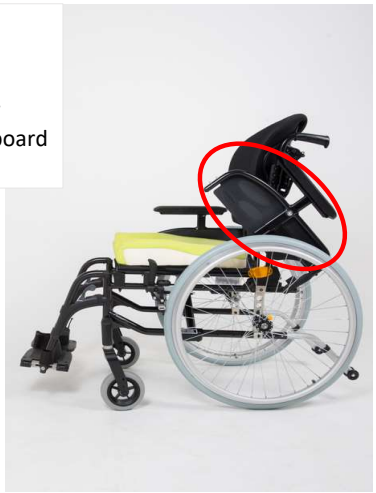
Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



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Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

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Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

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Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

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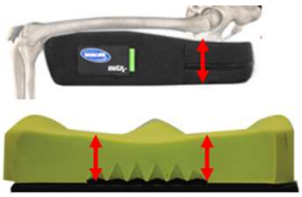
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

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Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

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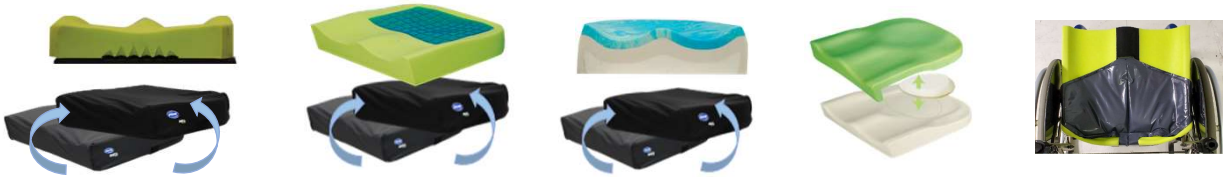
MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

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Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

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Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

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Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

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Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

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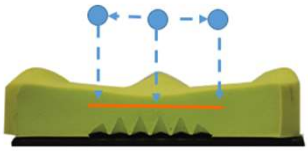
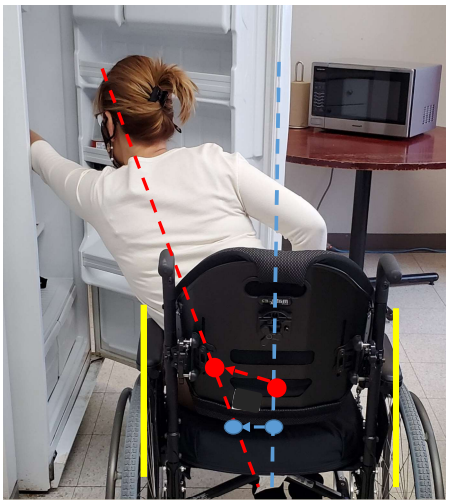
Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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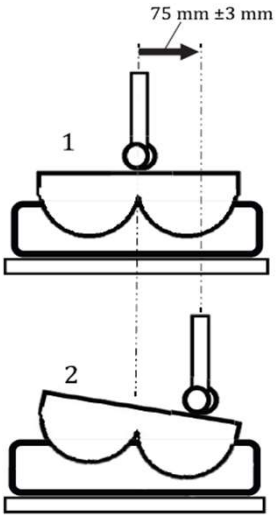
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

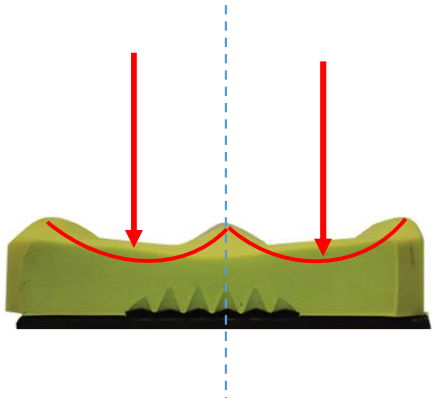
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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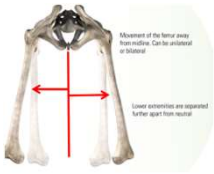
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

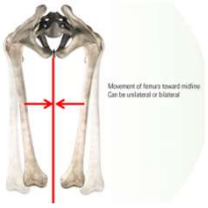


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

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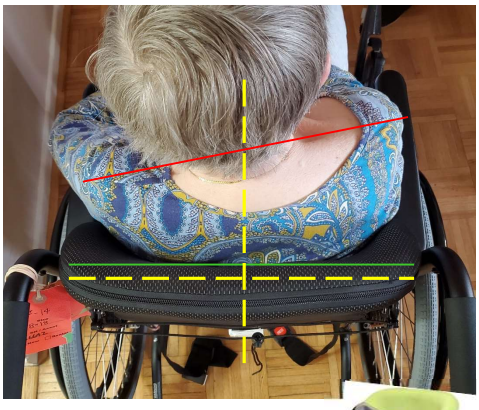
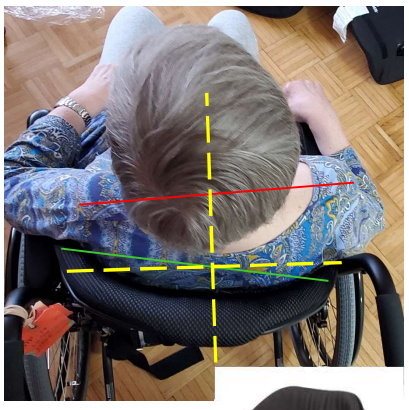
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

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Wheelchair-related risk factors: rigid backrest vs upholstery back

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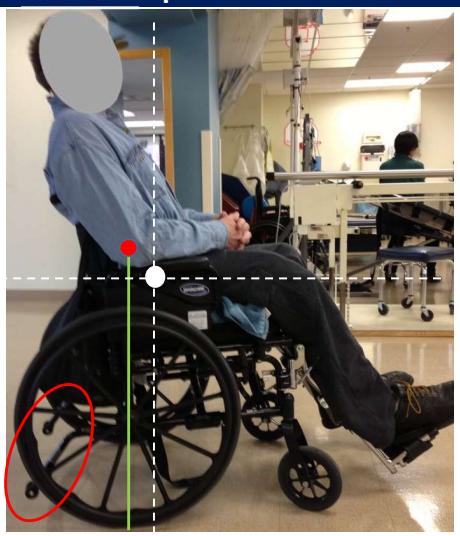
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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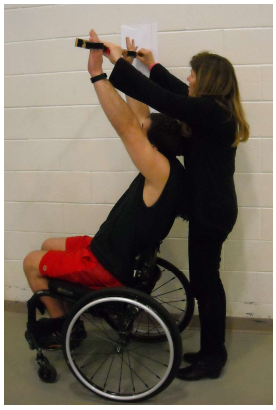
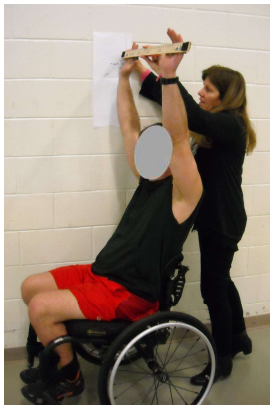
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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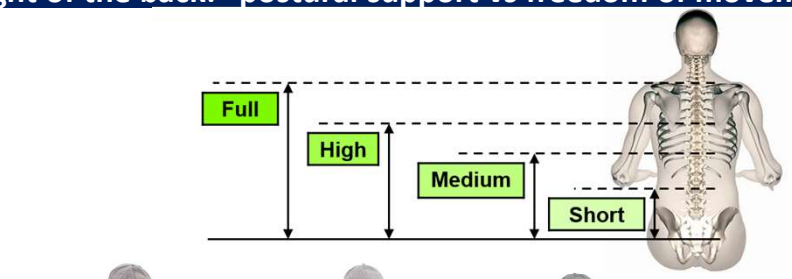
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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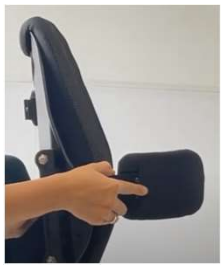
Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

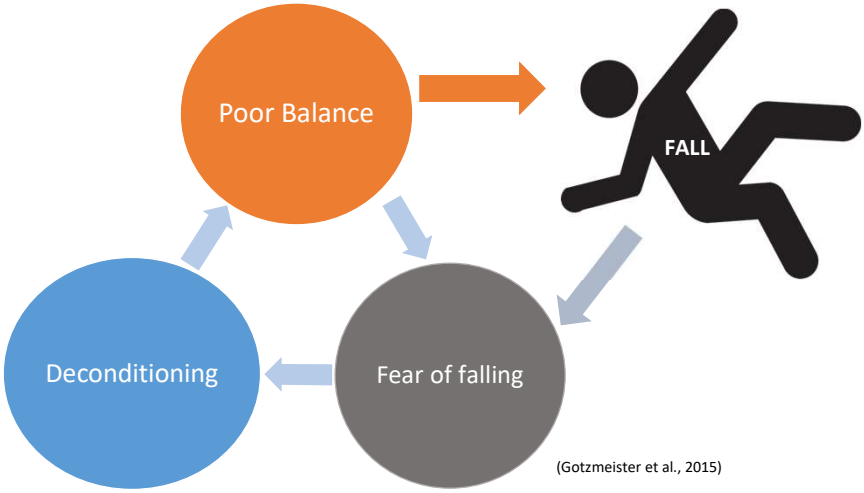
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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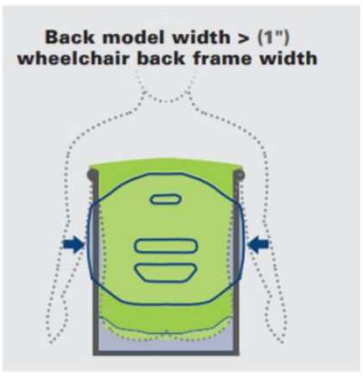
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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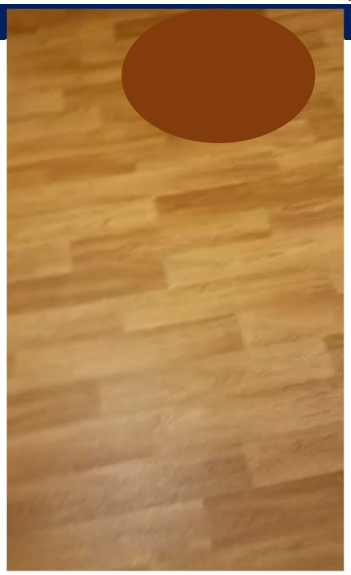
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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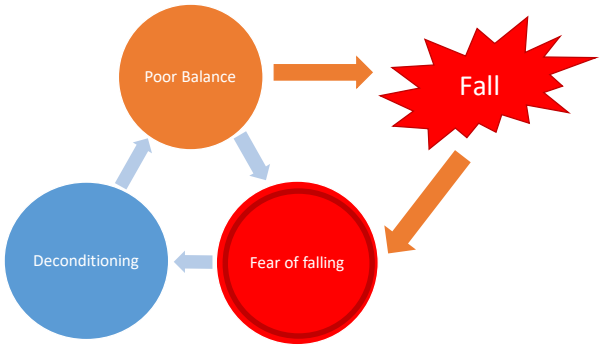
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

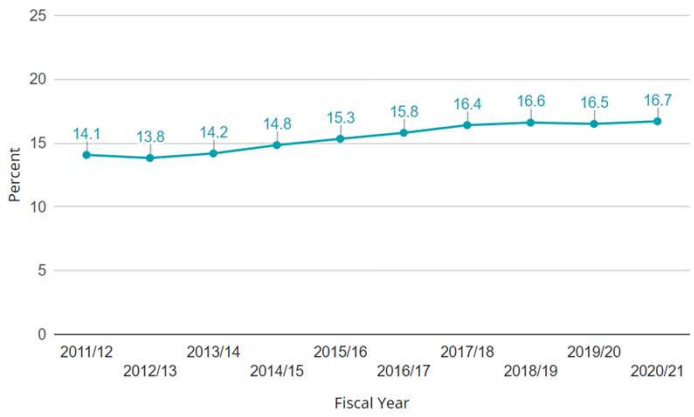
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



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British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

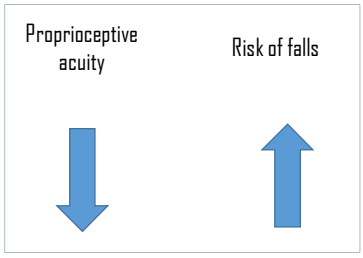
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

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Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering — Getting up or rising

Seat-to-stand

Stand-to-seat

9

Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

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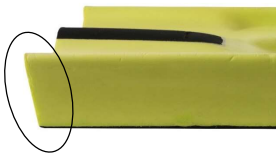
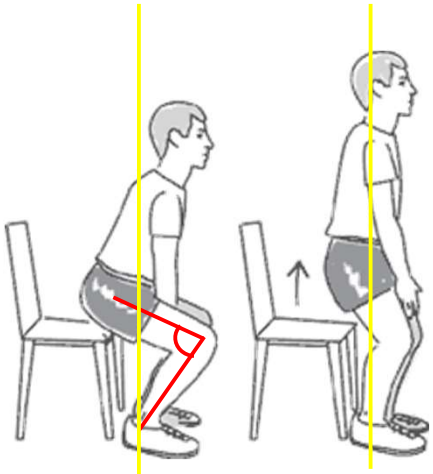
Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

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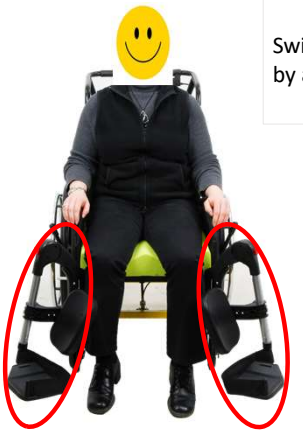
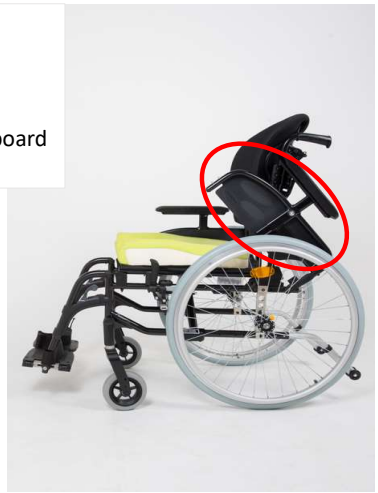
Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

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Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

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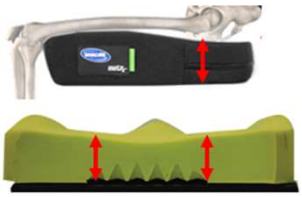
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

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Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

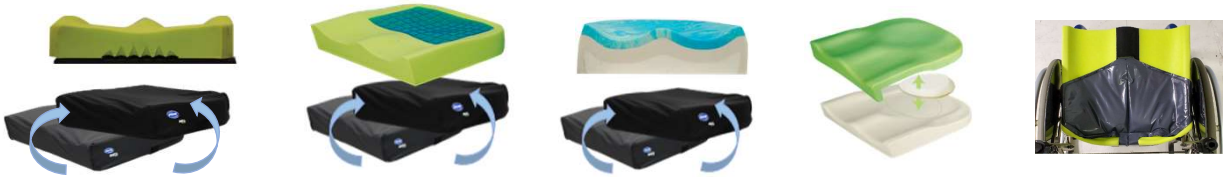
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

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Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

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Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

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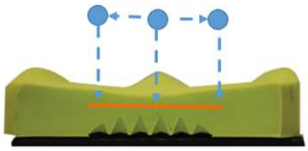
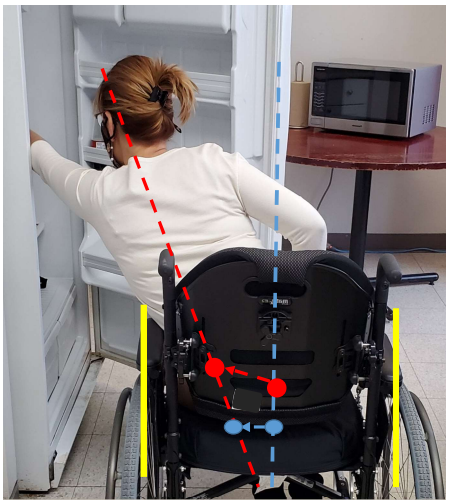
Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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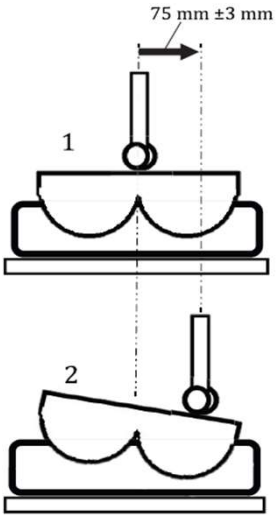
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

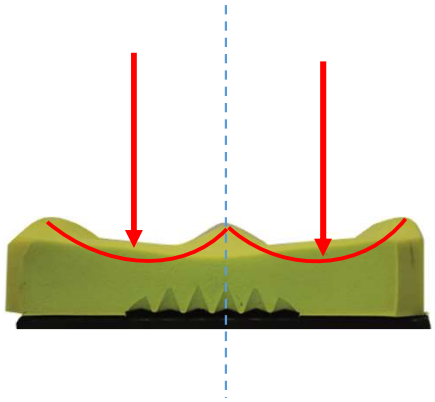
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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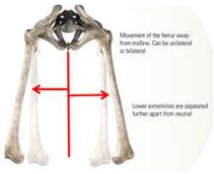
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

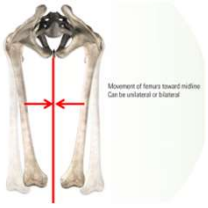


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

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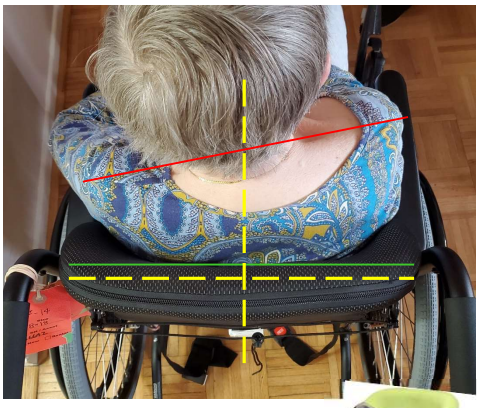
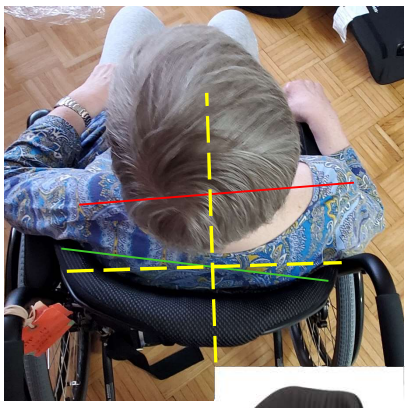
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

34

Wheelchair-related risk factors: rigid backrest vs upholstery back

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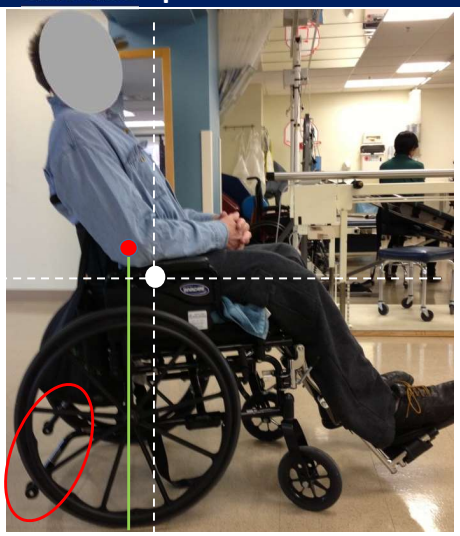
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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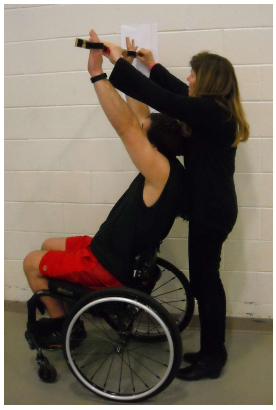
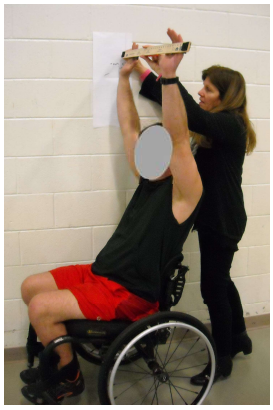
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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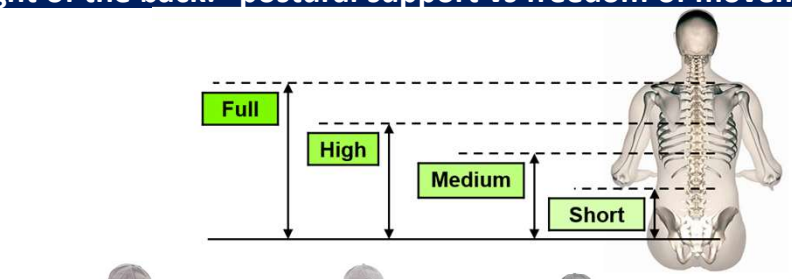
Height of the back: postural support vs freedom of movement



42

42

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

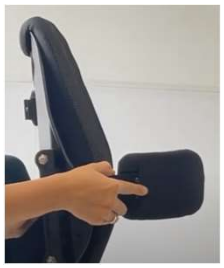
How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

44

Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

46

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

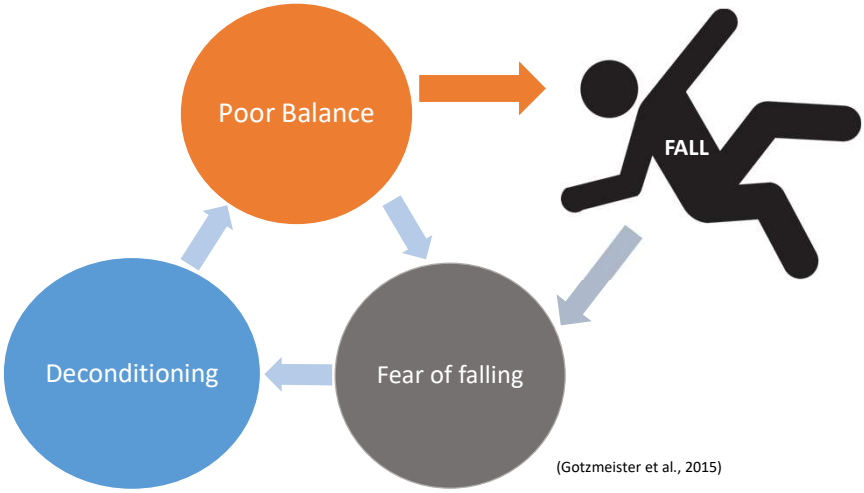
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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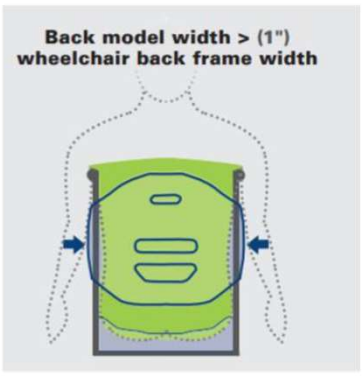
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



53

Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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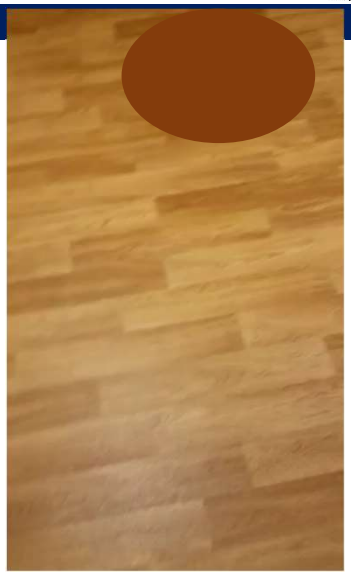
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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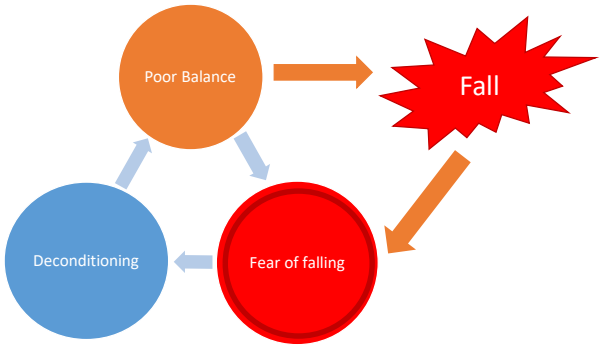
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

59

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

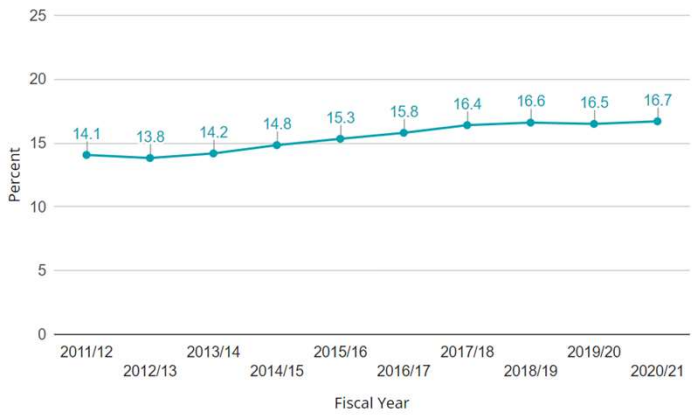
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

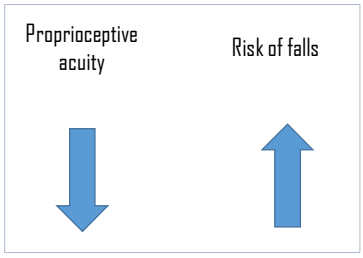
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

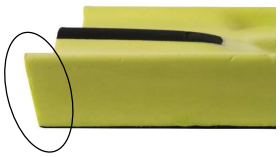
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

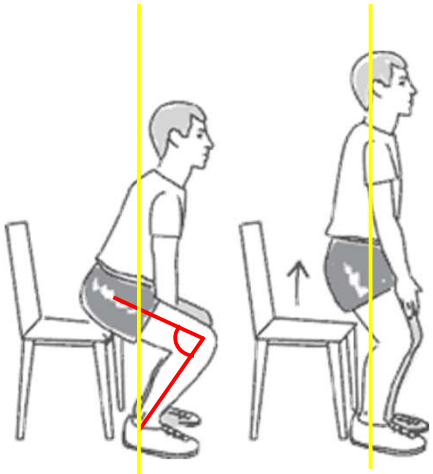
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

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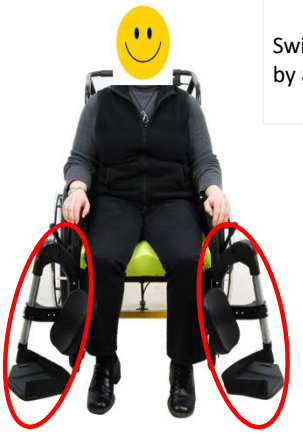
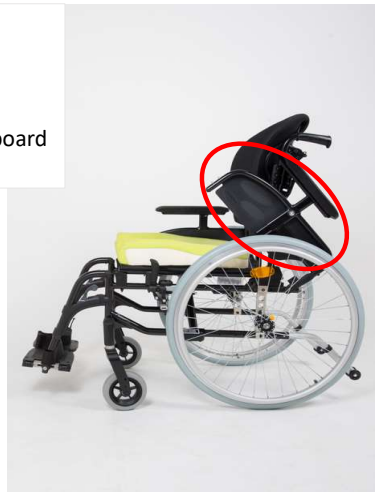
Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely

- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

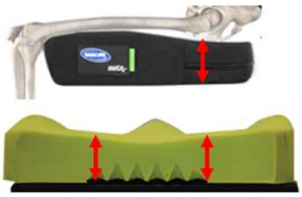
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

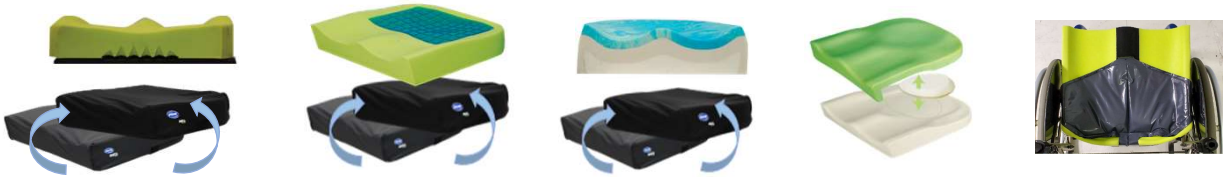
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

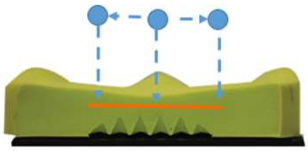
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

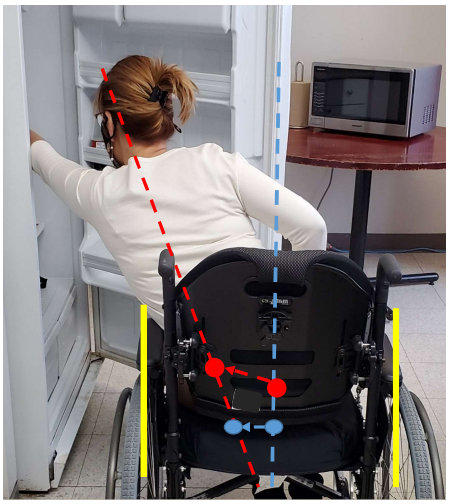
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

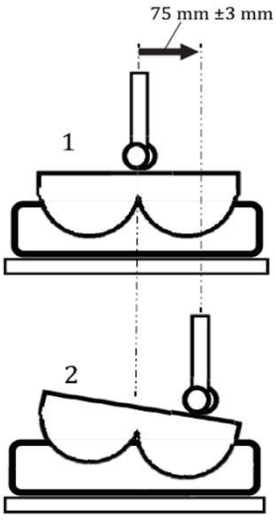
26

Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

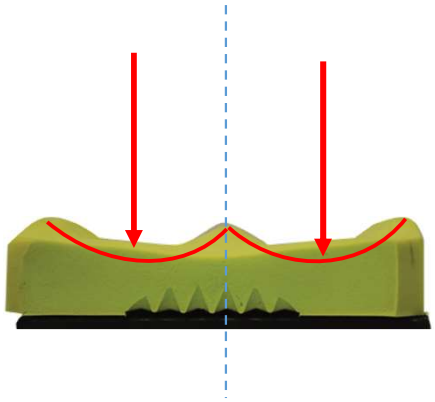
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

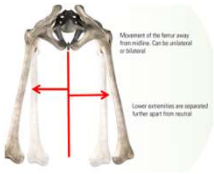
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

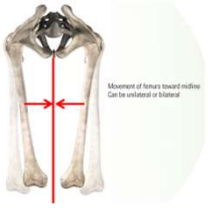


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

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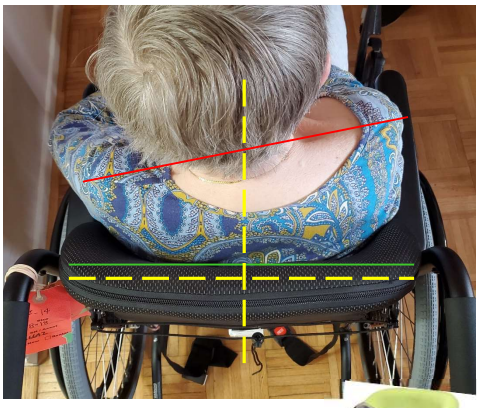
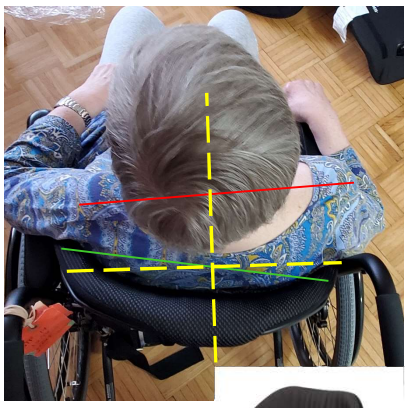
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

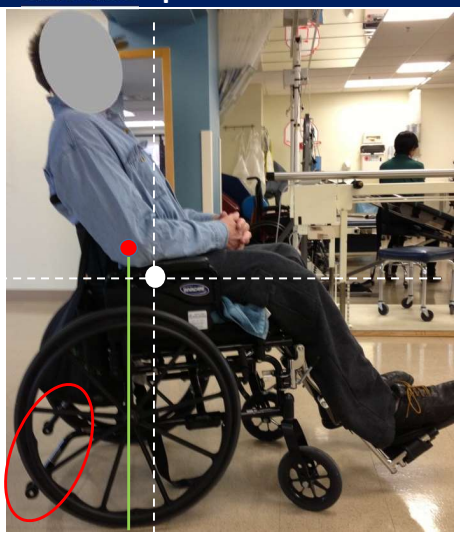
34

Wheelchair-related risk factors: rigid backrest vs upholstery back

38

Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

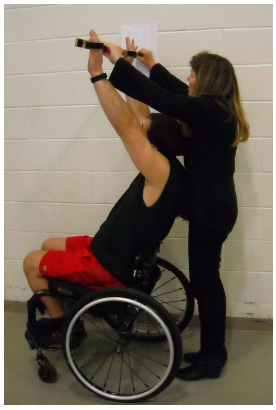
Solid posterior thoracic support with more height

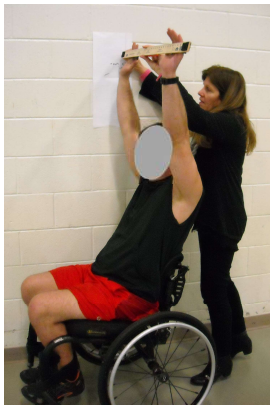
Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

39

RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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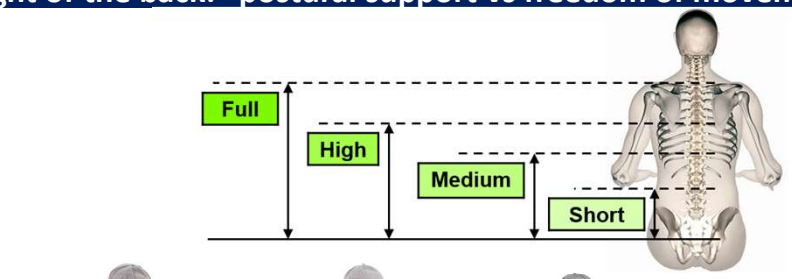
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

43

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

44

Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

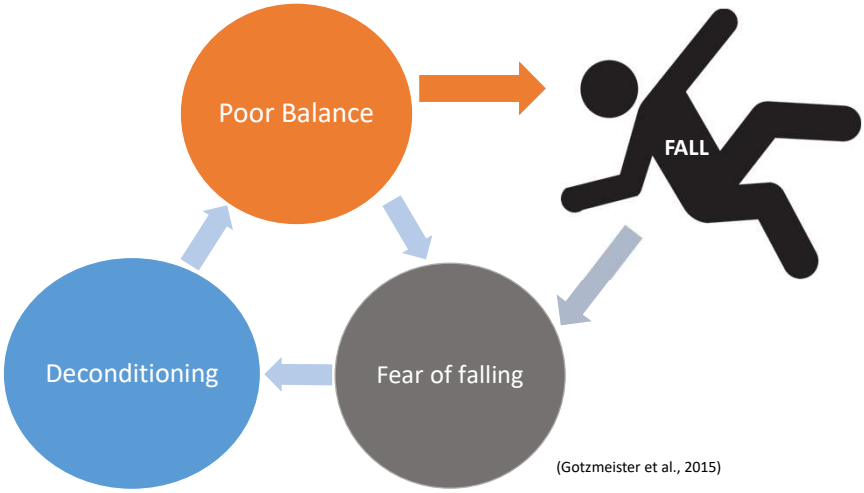
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

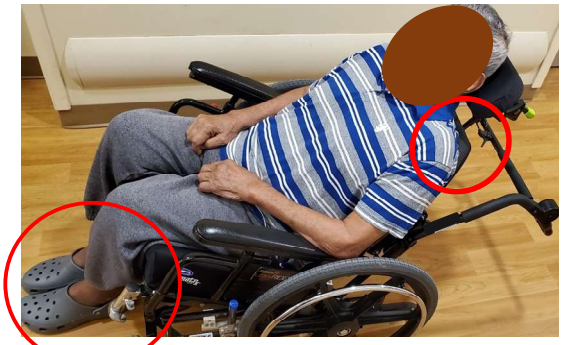
Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

52

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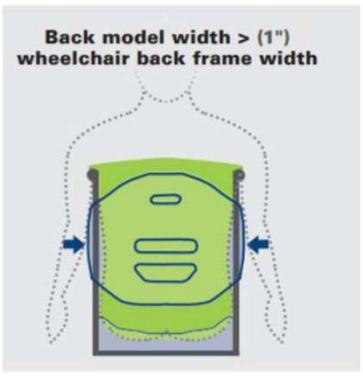
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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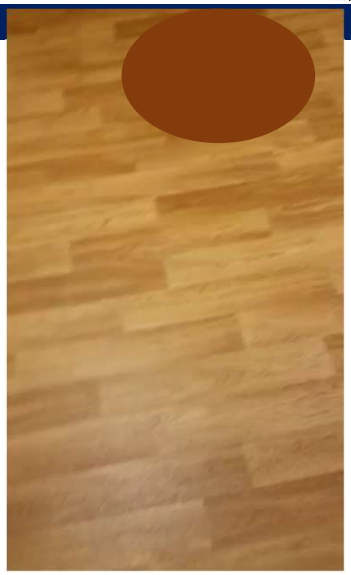
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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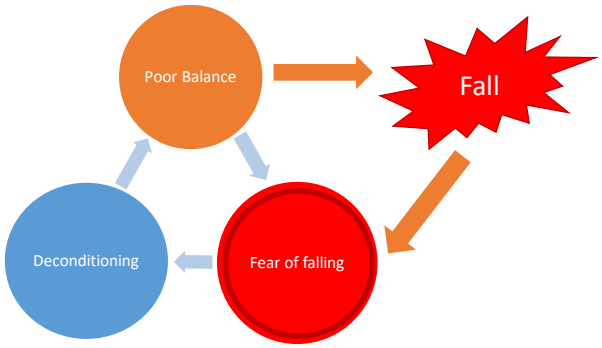
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

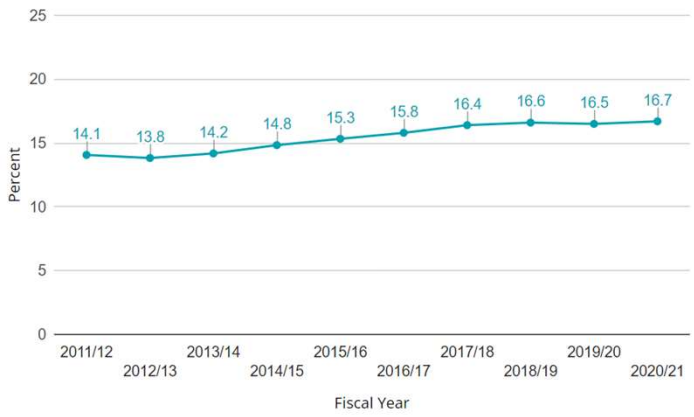
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

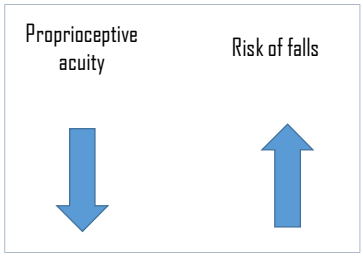
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

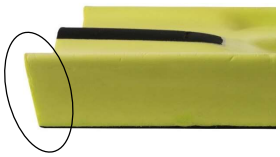
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

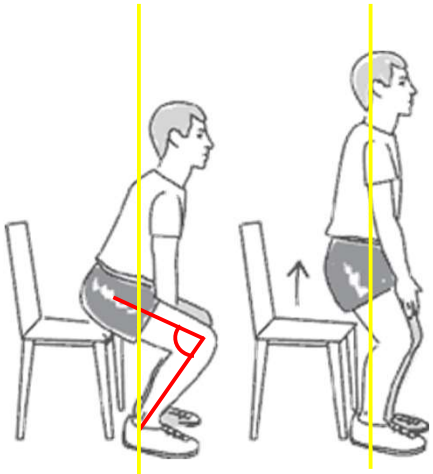
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

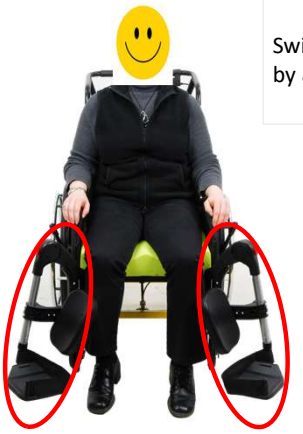
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

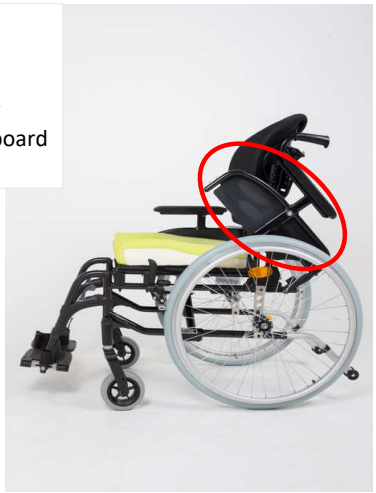
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

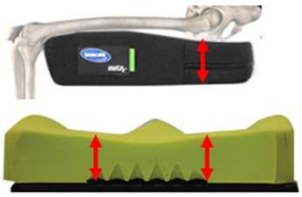
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

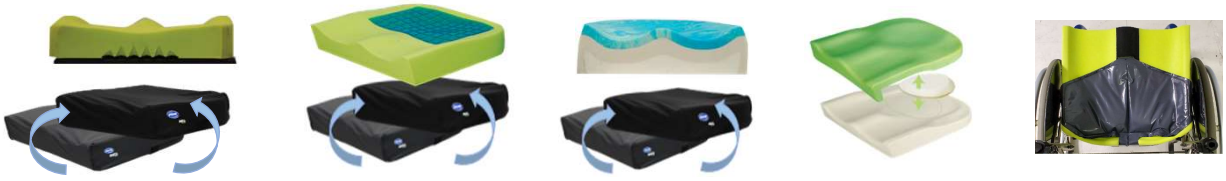
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

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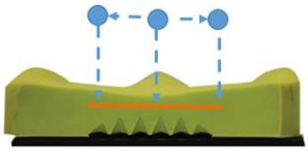
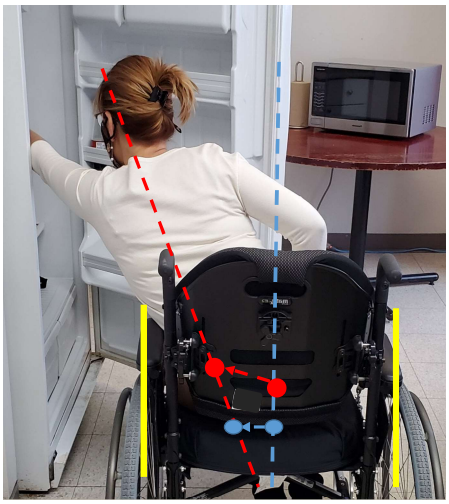
Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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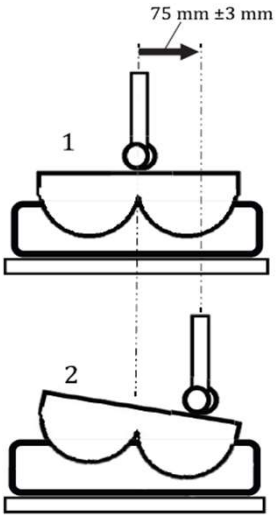
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

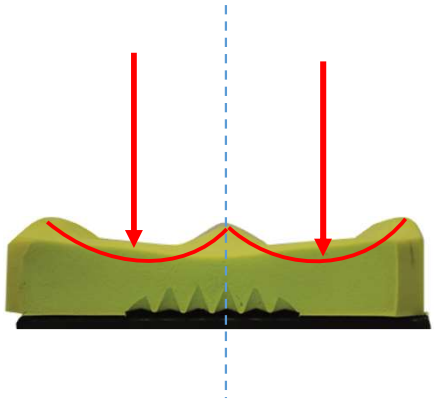
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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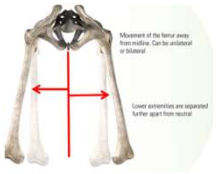
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

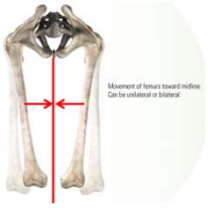


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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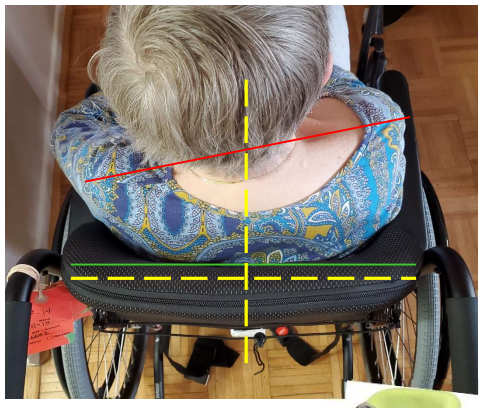
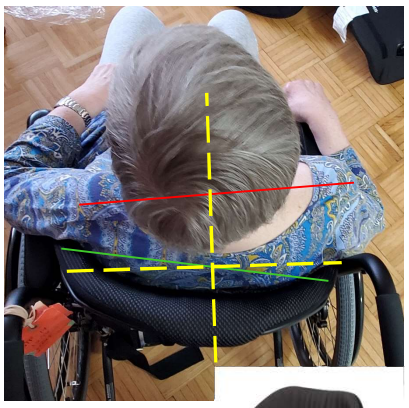
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

34

Wheelchair-related risk factors: rigid backrest vs upholstery back

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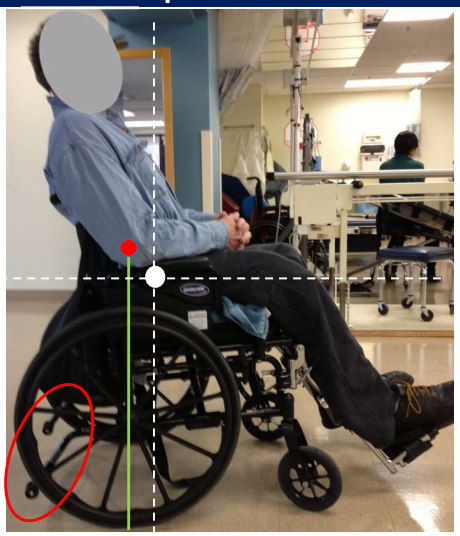
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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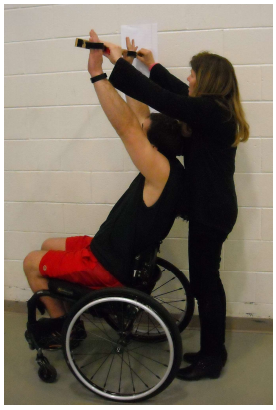
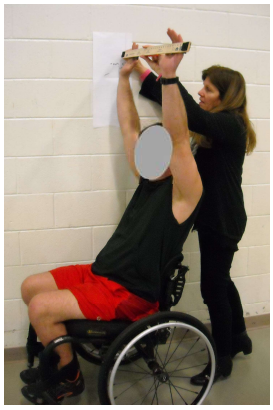
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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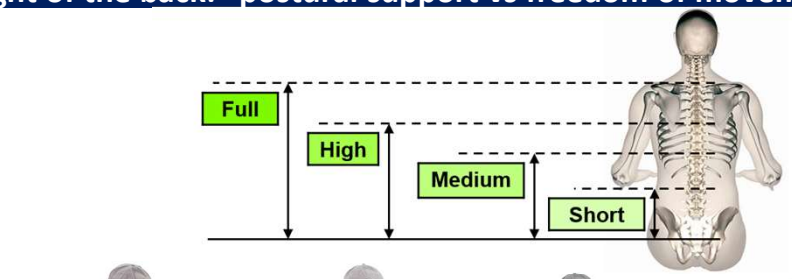
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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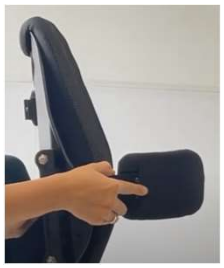
Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

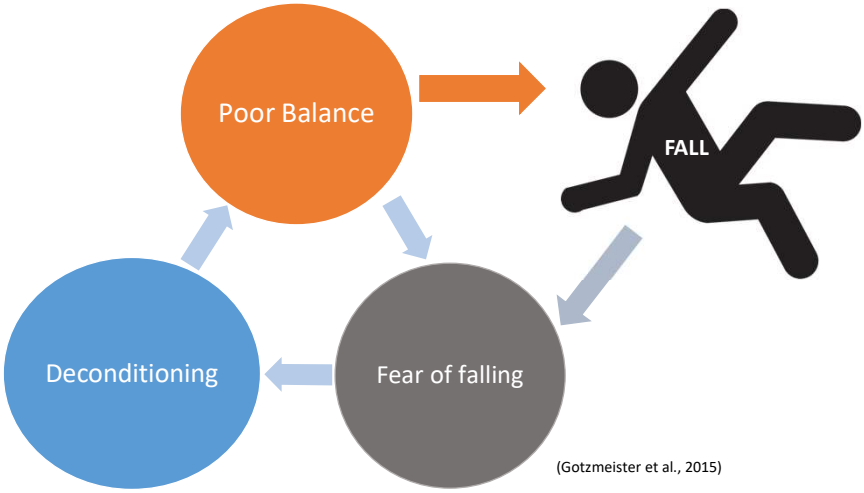
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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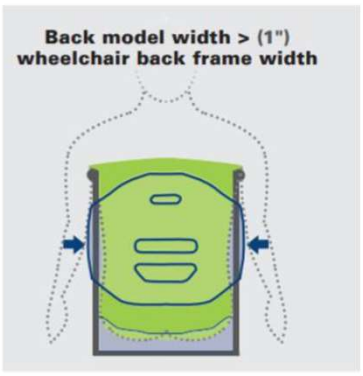
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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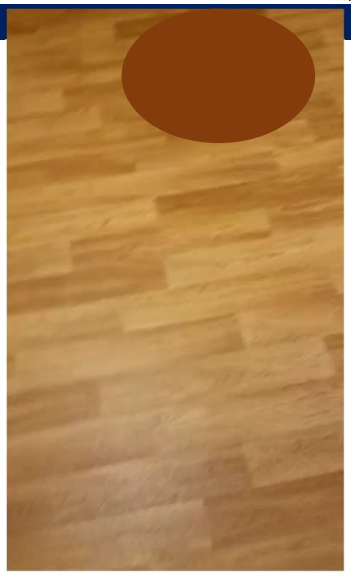
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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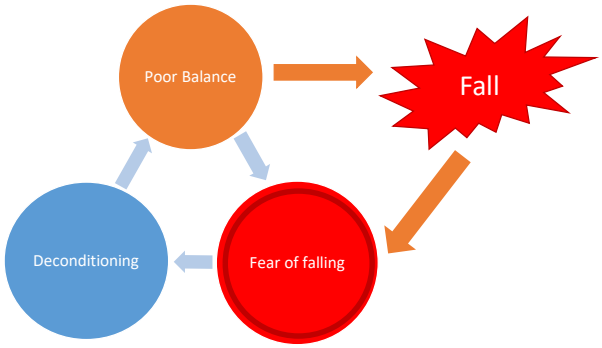
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

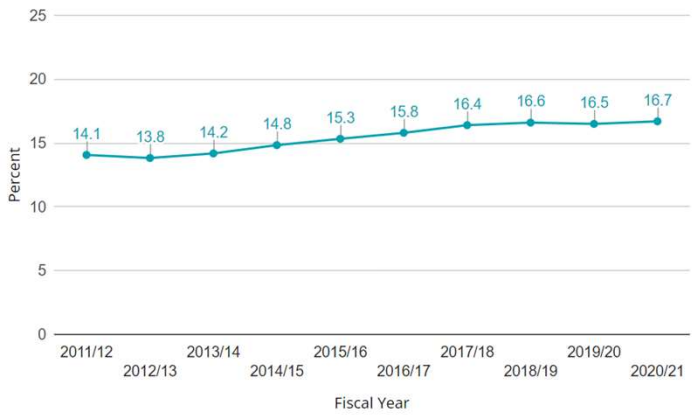
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

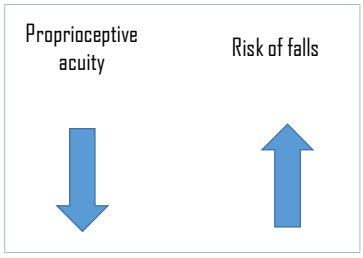
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

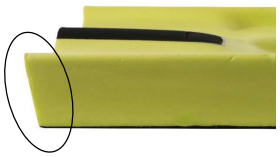
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

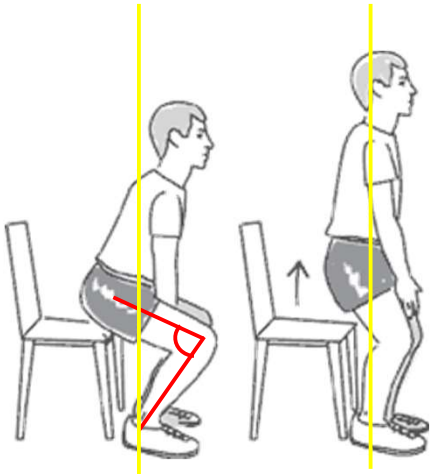
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

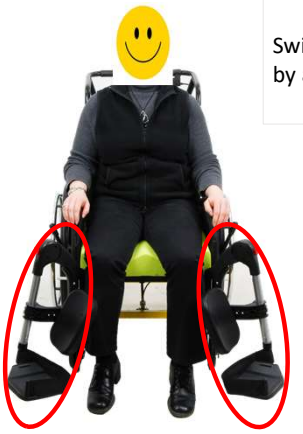
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

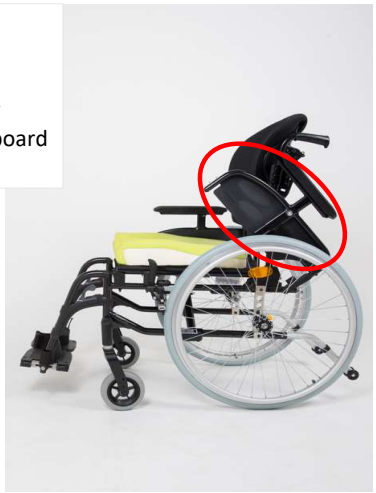
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

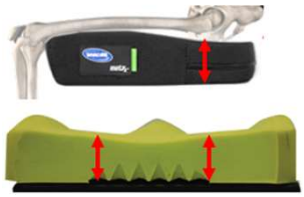
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

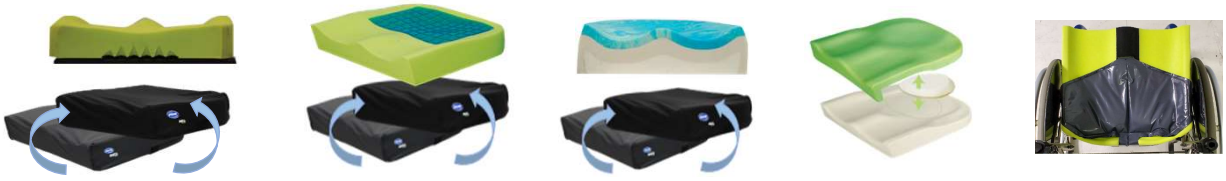
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

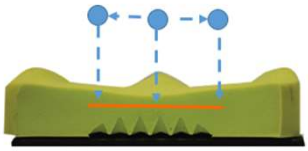
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

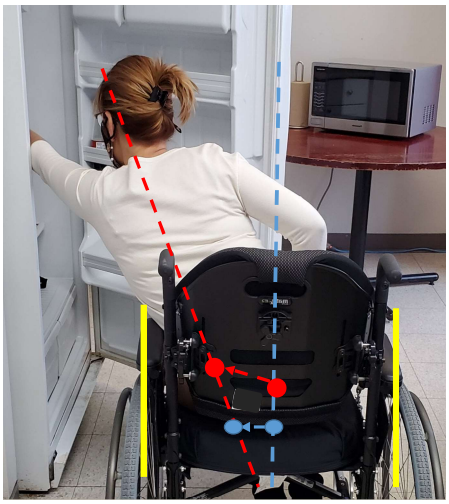
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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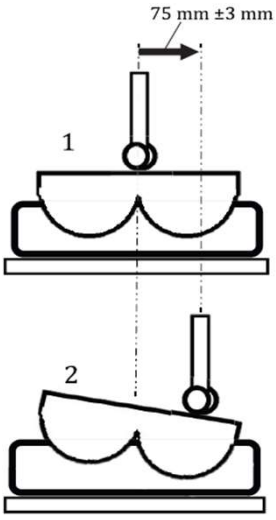
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

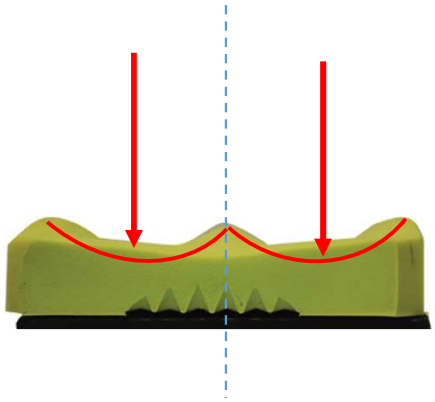
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

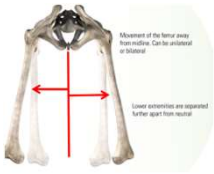
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

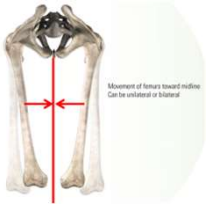


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

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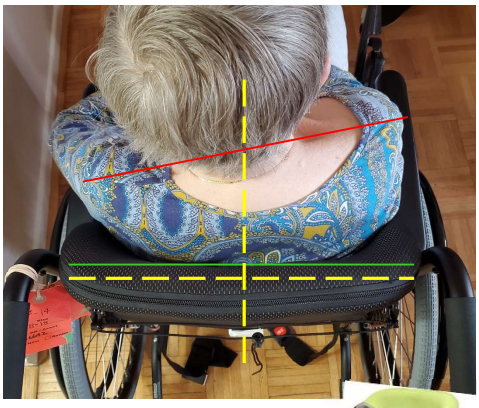
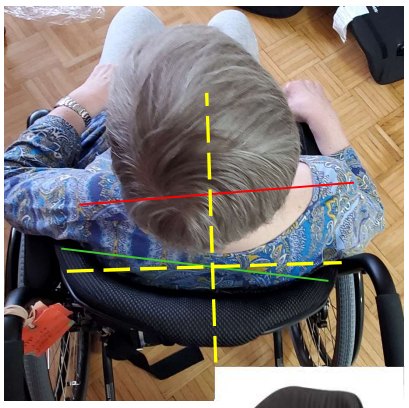
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

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Wheelchair-related risk factors: rigid backrest vs upholstery back

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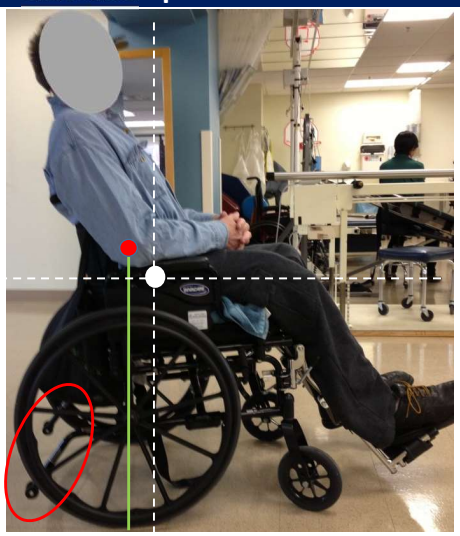
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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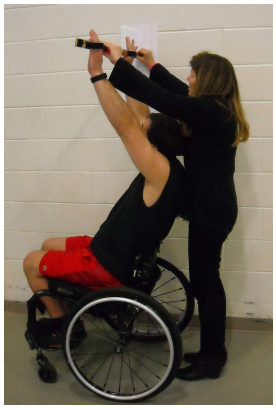
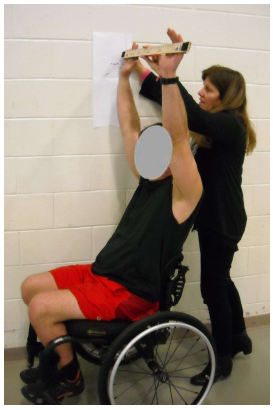
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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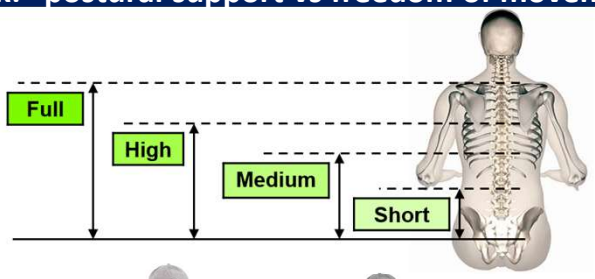
Height of the back: postural support vs freedom of movement

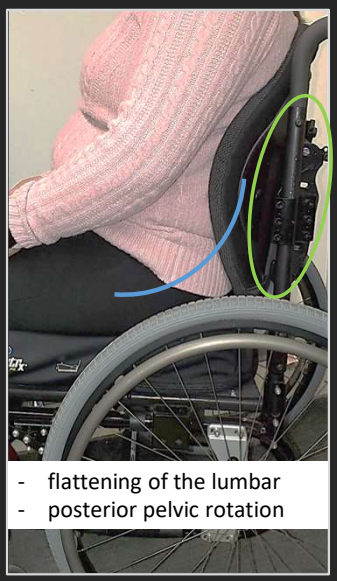


42

42

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet



- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

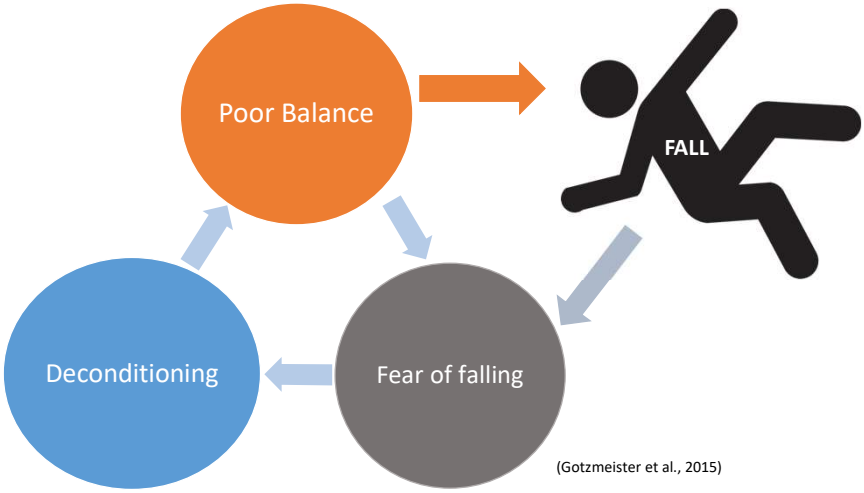
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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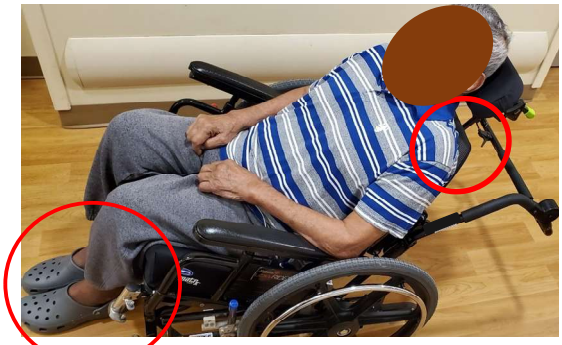
Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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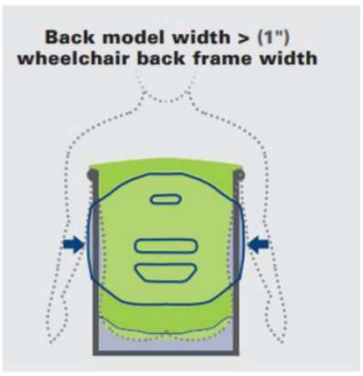
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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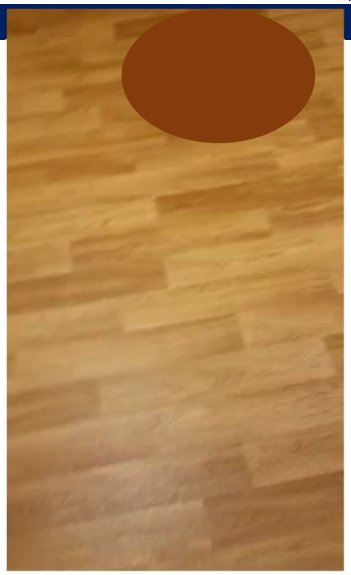
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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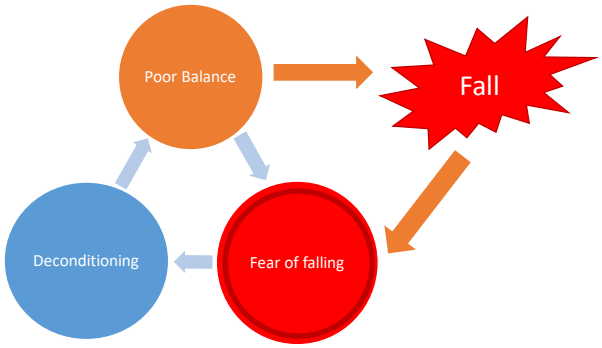
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

Anna Sokol, RN, MN, BScKin, BScN, WOCC(C)
Clinical Education Specialist
Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)

3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

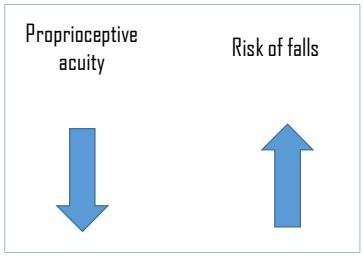
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

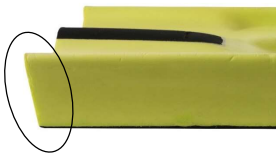
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

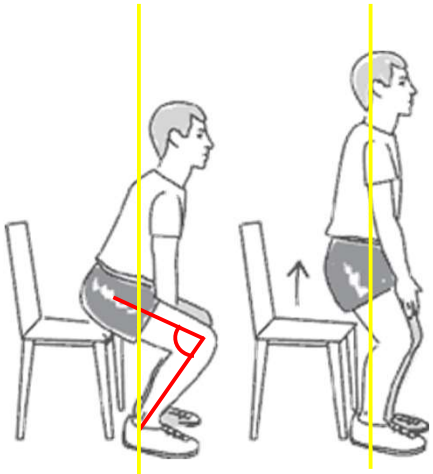
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

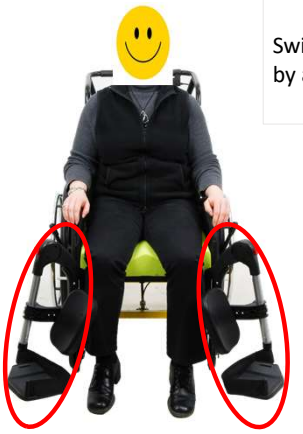
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

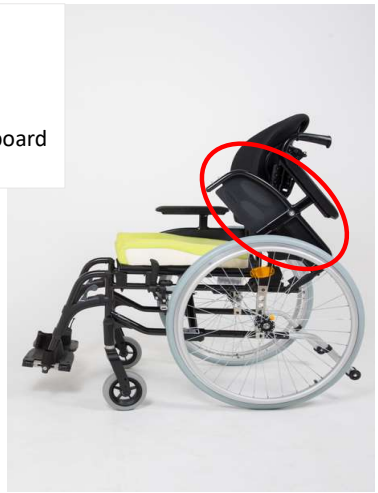
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely

- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

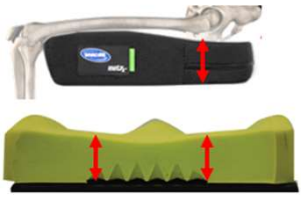
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

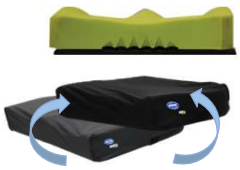
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion

Invacare® Matrx® PSP Cushion

Invacare® Matrx® Multi Cushion

Invacare® Matrx® Vi Cushion

Libra/Libra Adjust Cushion

Positioning

Skin Protection and Positioning

Skin Protection and Positioning

Skin Protection and Positioning

Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

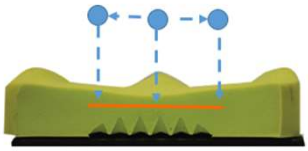
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

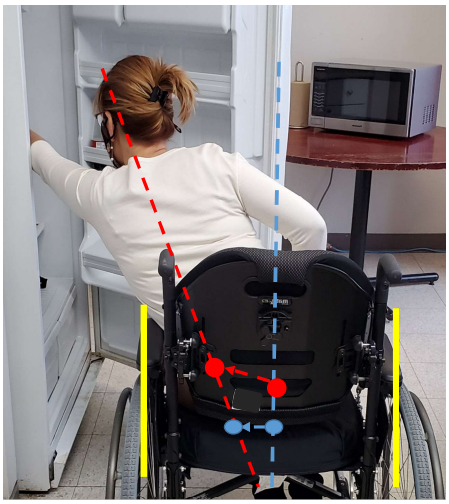
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

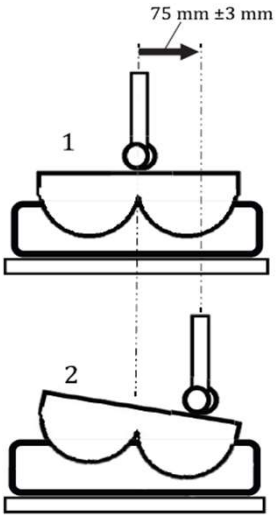
26

Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

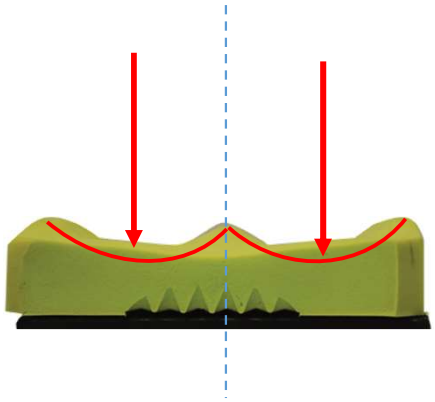
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

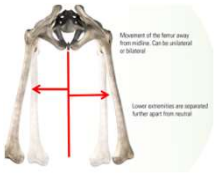
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

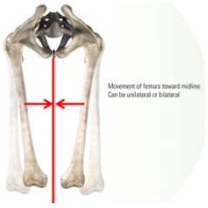


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

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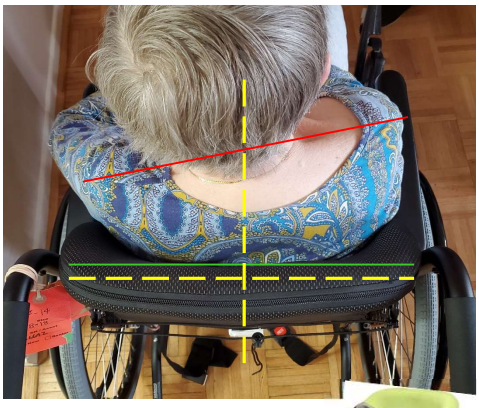
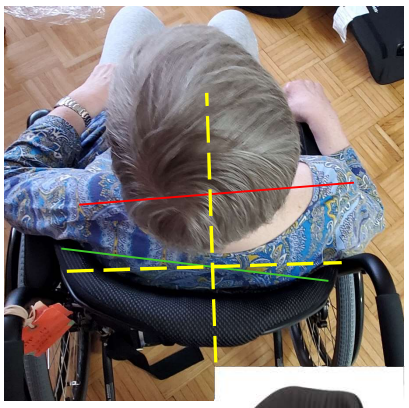
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

34

Wheelchair-related risk factors: rigid backrest vs upholstery back

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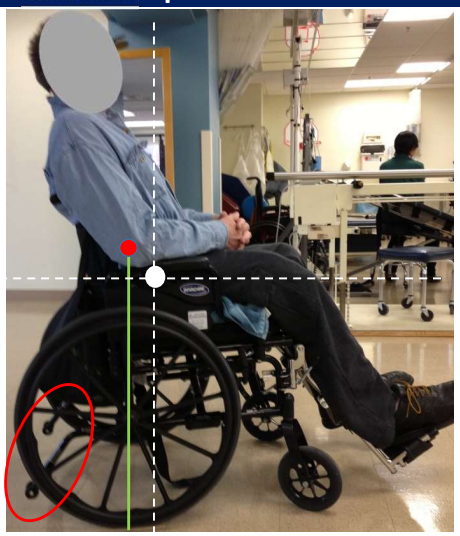
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

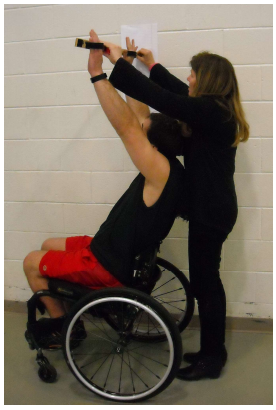
Solid posterior thoracic support with more height

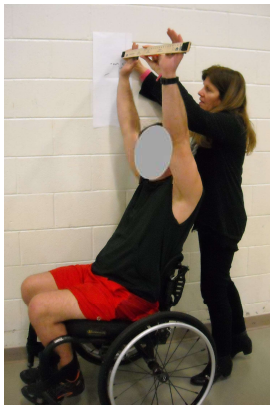
Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

39

RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

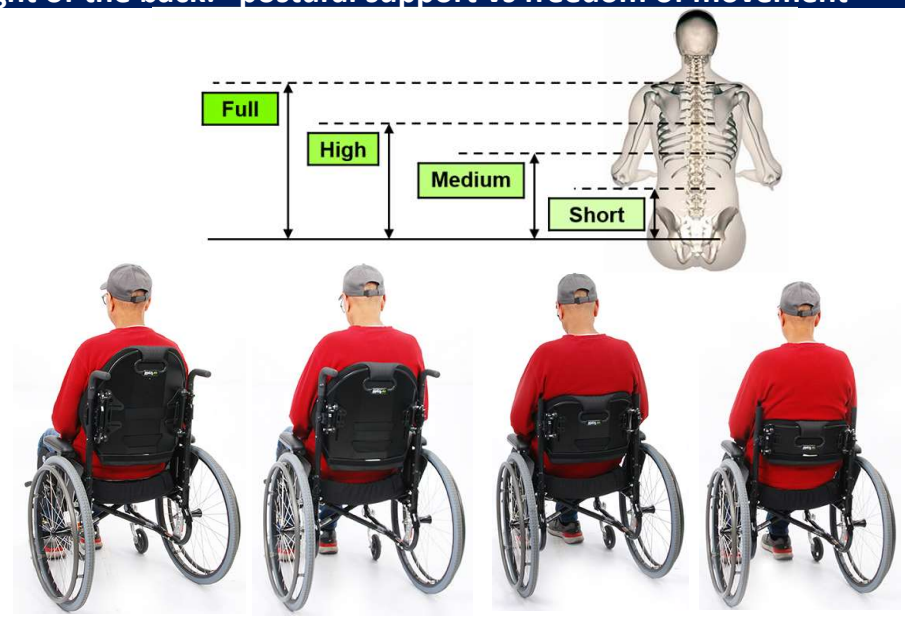
• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

41

Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

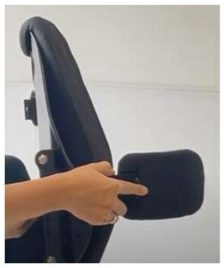
How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

44

Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

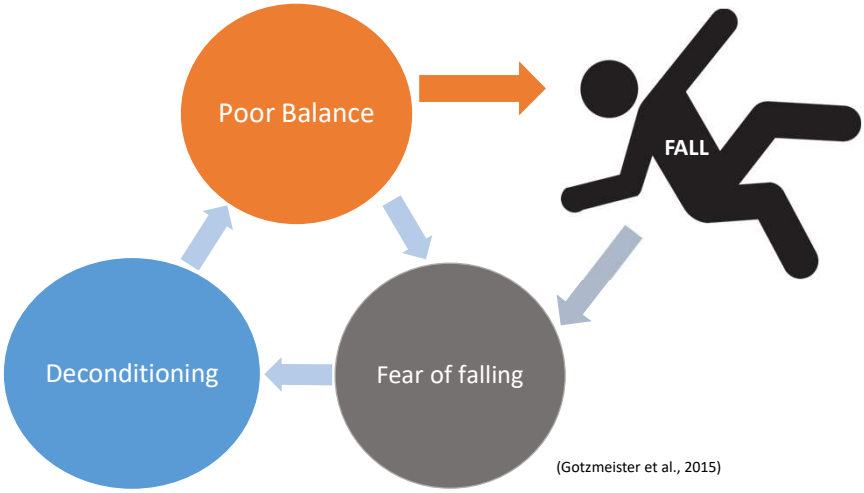
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

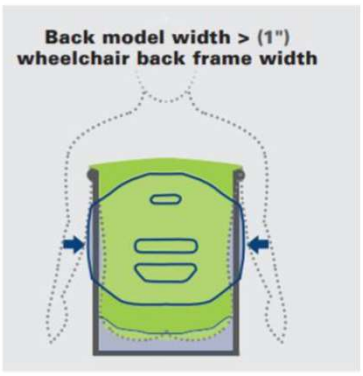
52

52

Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



53

Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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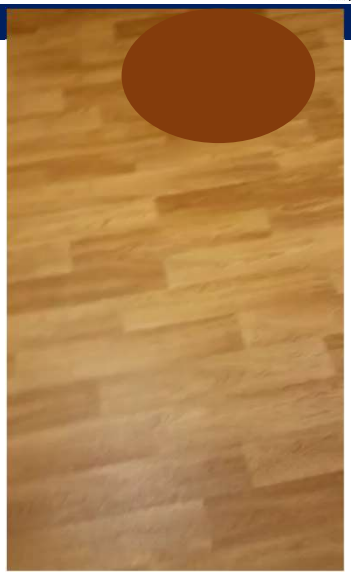
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

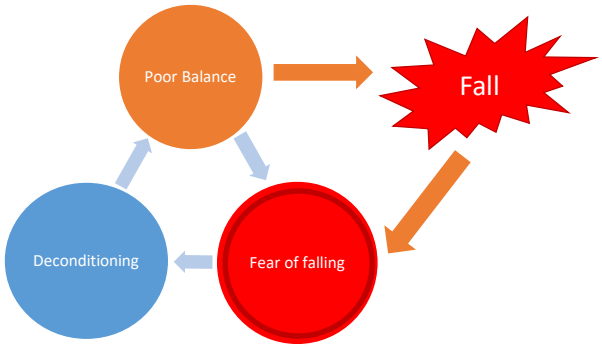
Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



55

Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

59

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

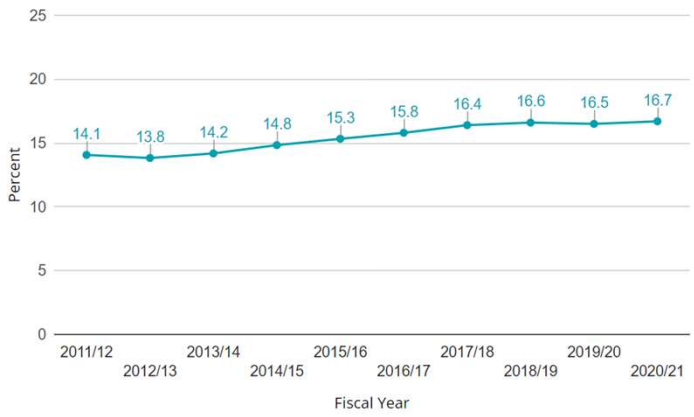
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

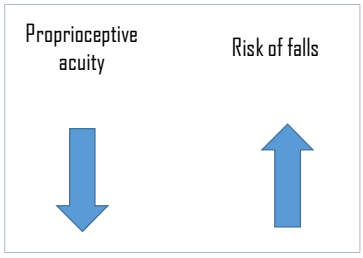
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

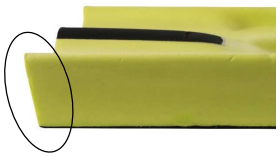
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

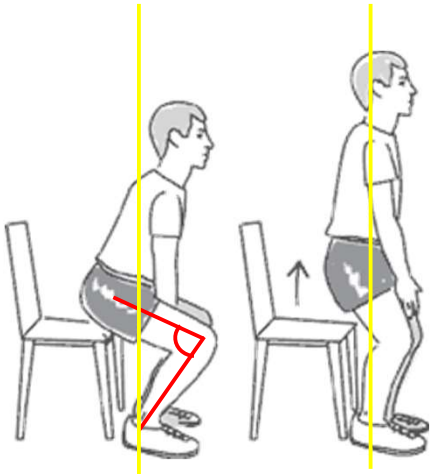
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

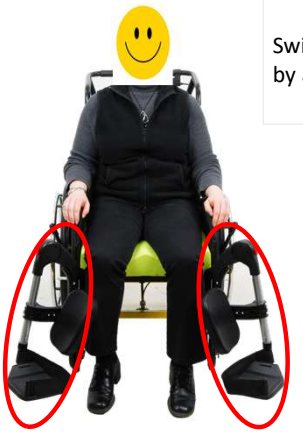
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

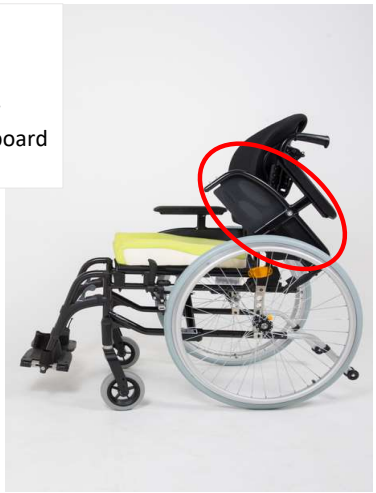
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

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16

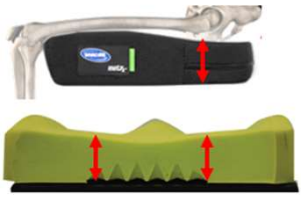
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

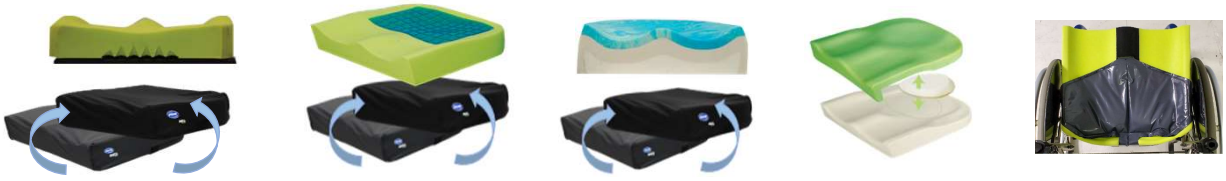
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

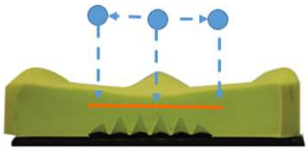
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

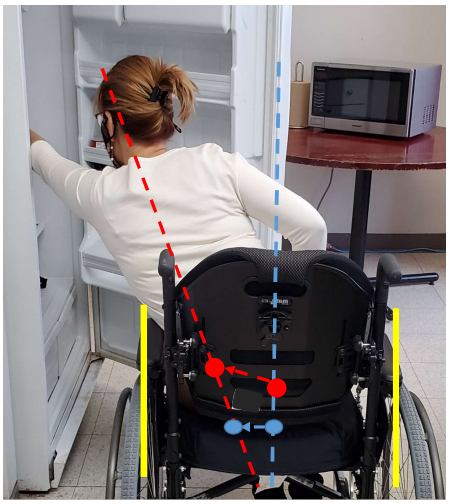
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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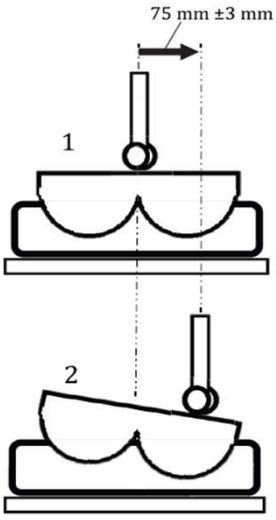
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

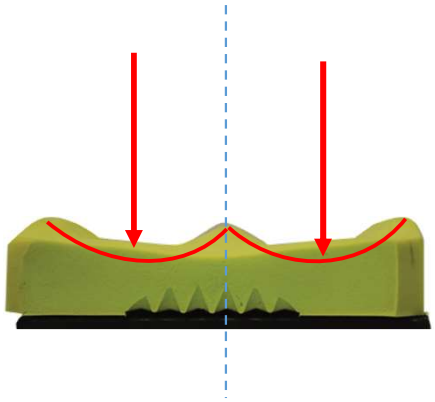
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

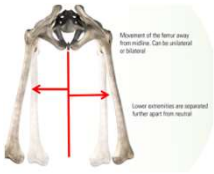
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

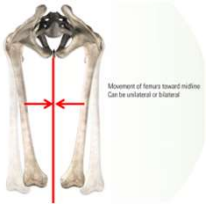


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

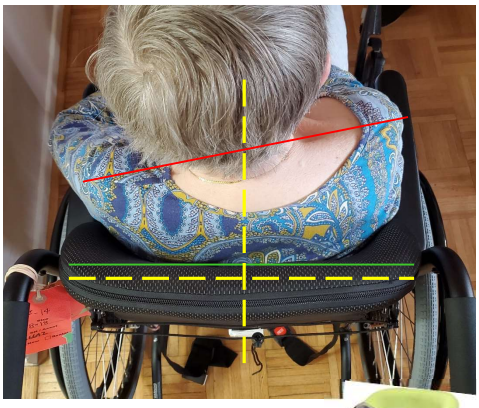
29

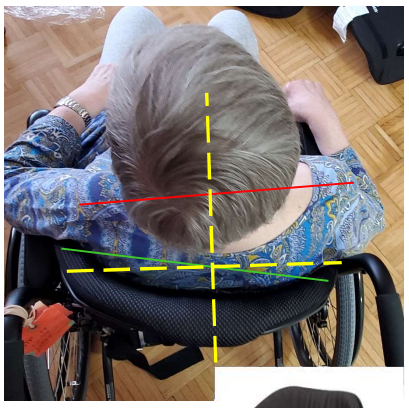
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

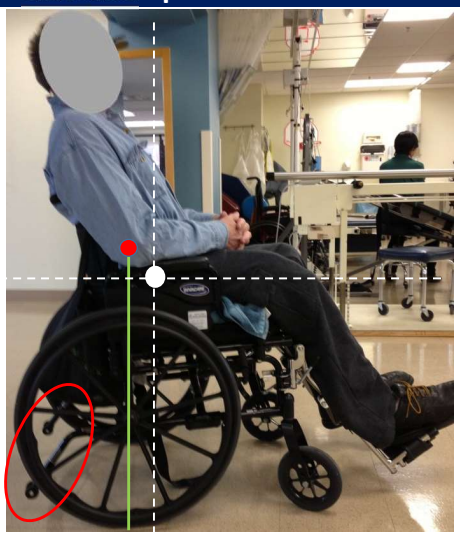
34

Wheelchair-related risk factors: rigid backrest vs upholstery back

38

Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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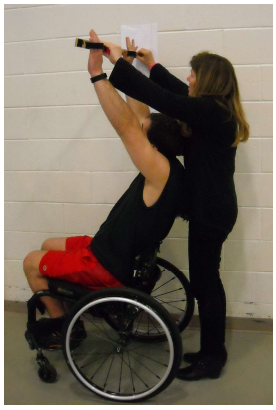
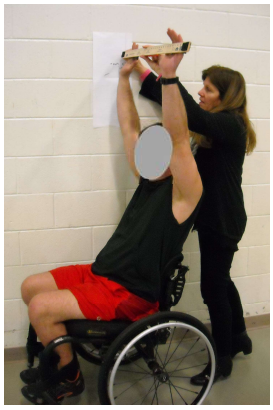
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

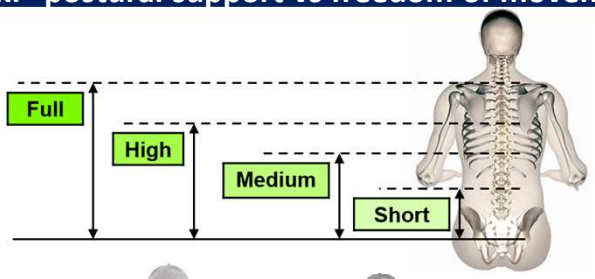
• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

41

Height of the back: postural support vs freedom of movement



42

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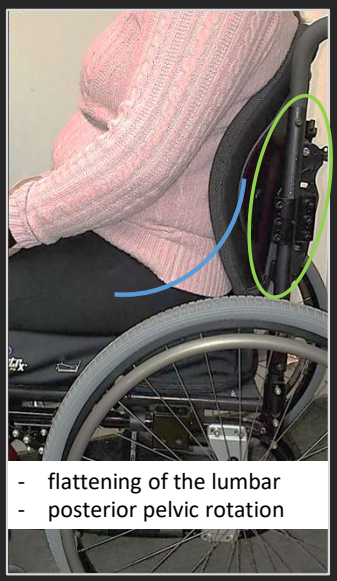
How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet



- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

43

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

44

Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

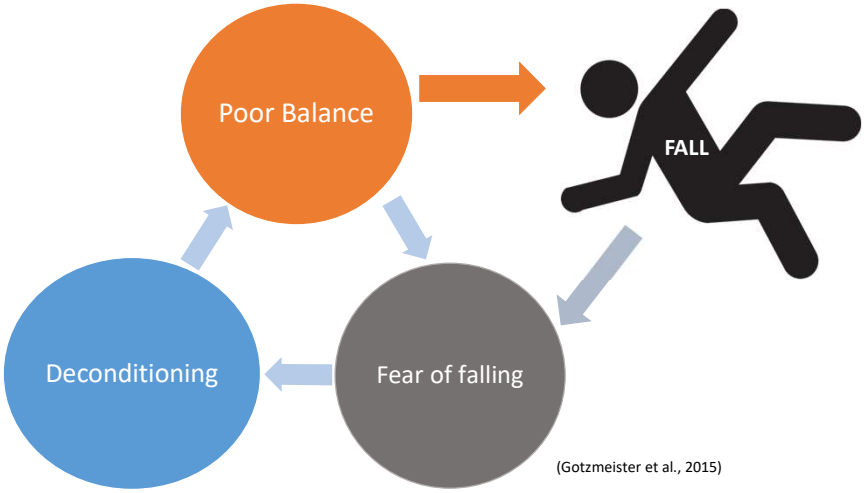
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

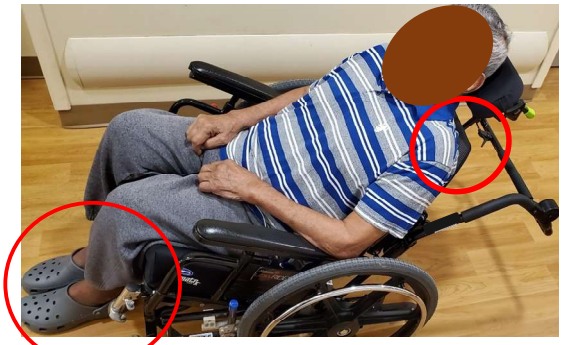
Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

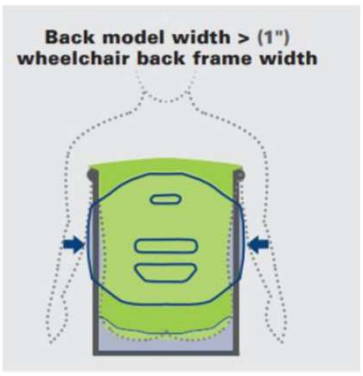
52

52

Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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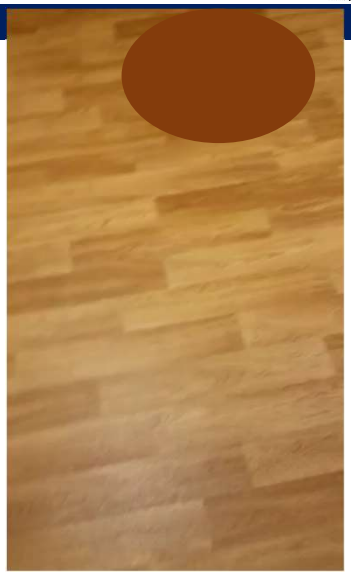
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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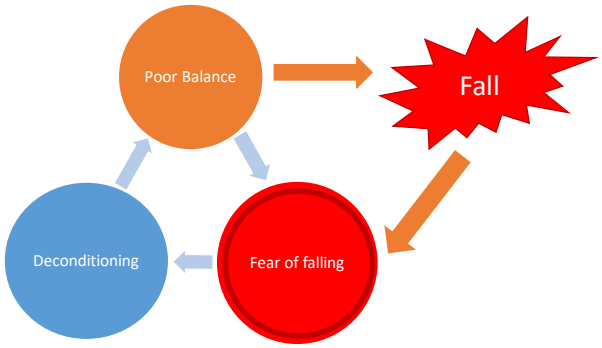
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)

3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

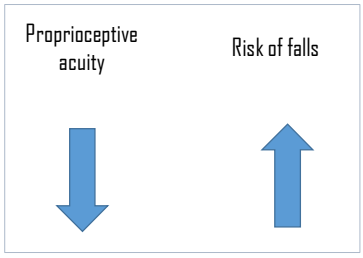
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

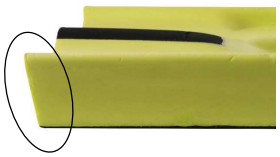
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

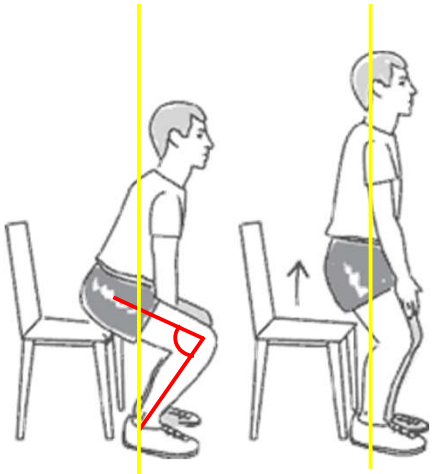
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

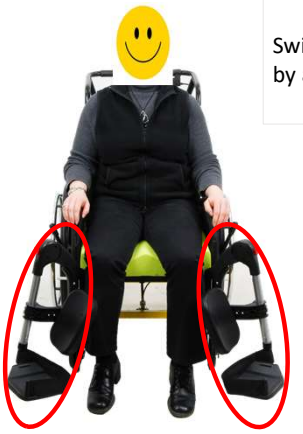
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

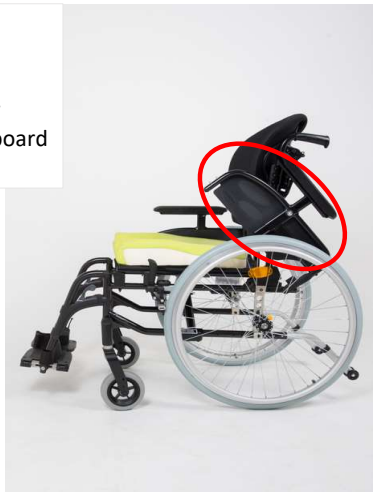
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

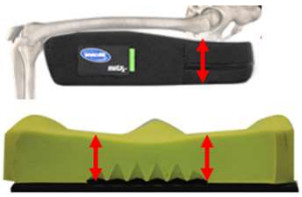
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

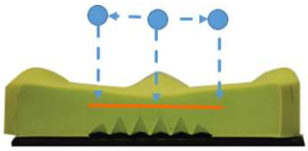
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

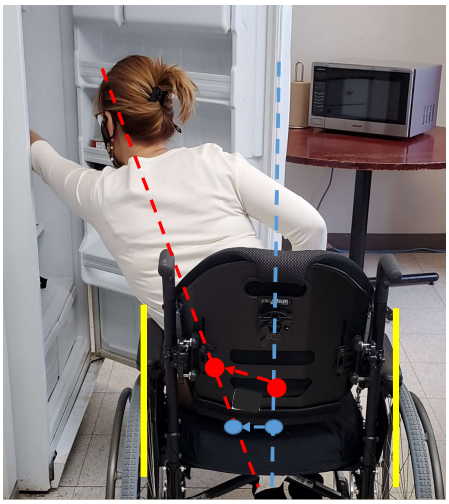
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

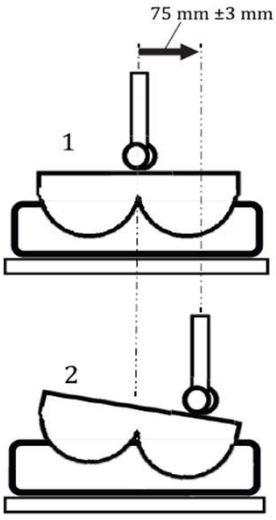
26

Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

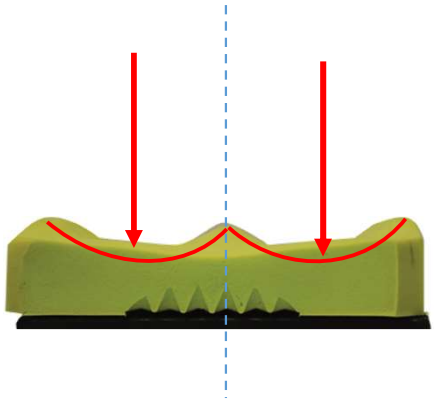
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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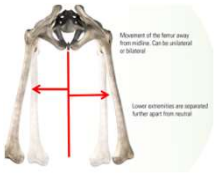
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

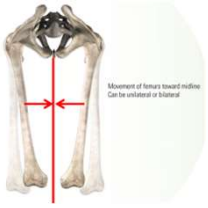


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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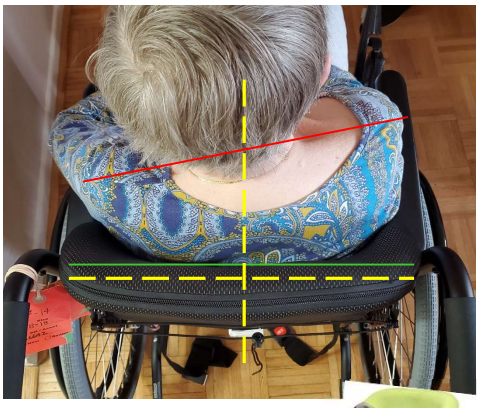
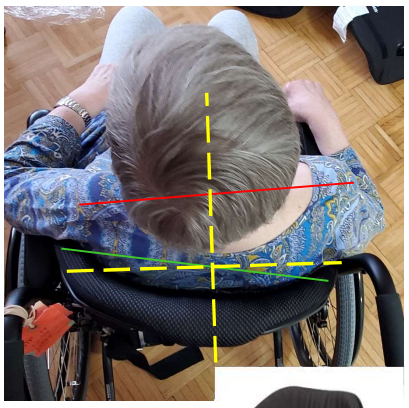
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

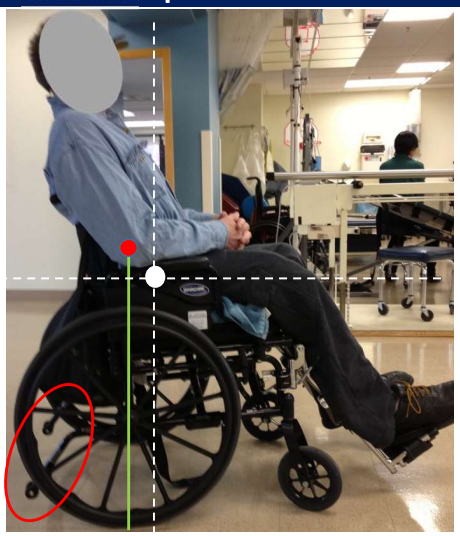
34

Wheelchair-related risk factors: rigid backrest vs upholstery back

38

Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

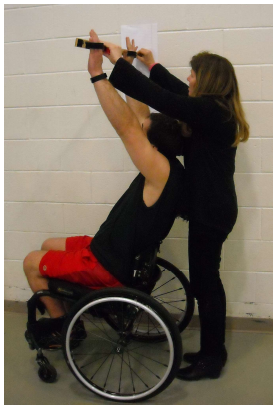
Solid posterior thoracic support with more height

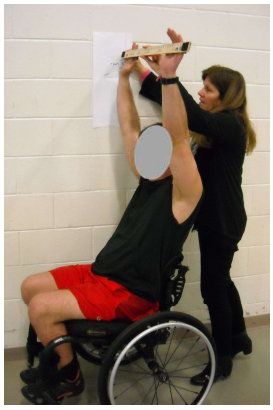
Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

39

RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

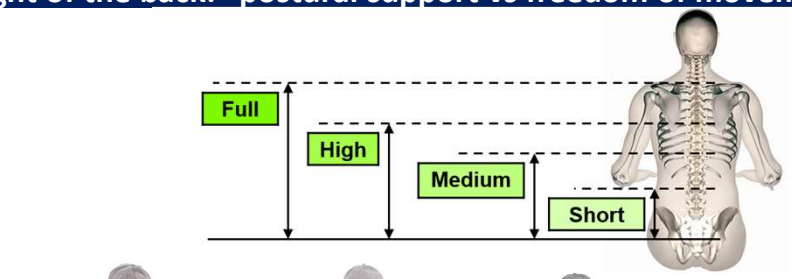
• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

41

Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

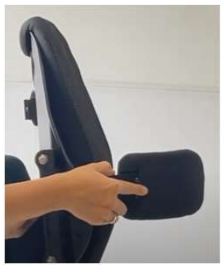
How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

44

Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

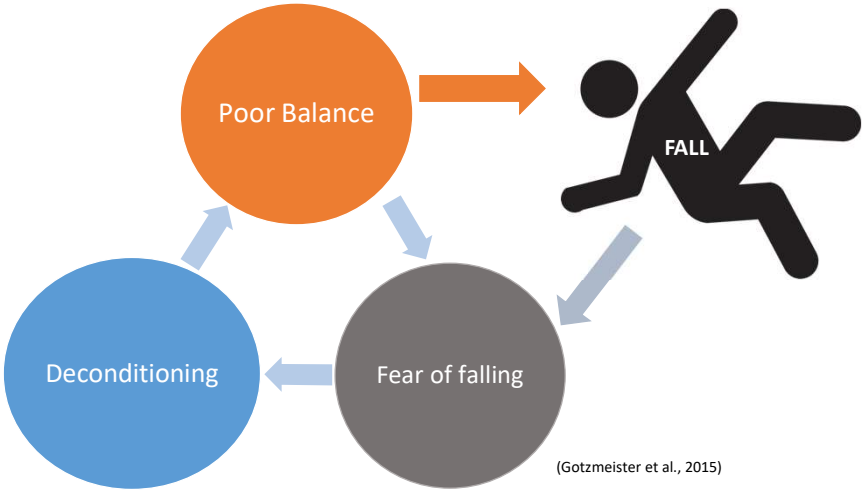
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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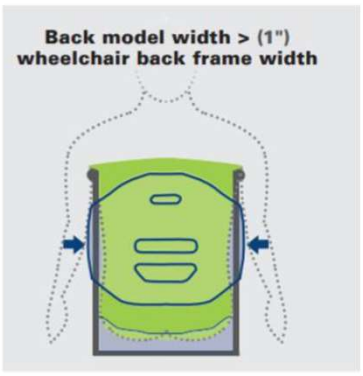
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



53

Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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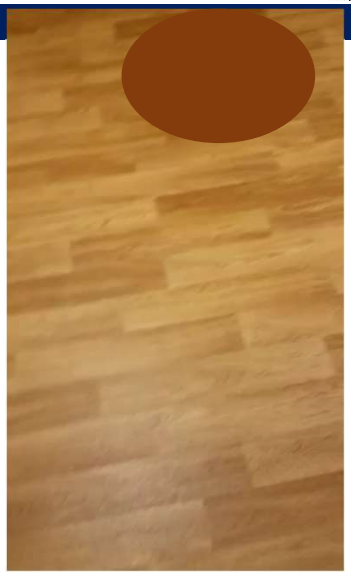
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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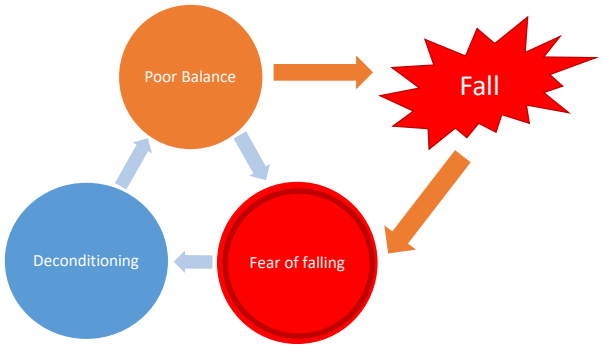
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

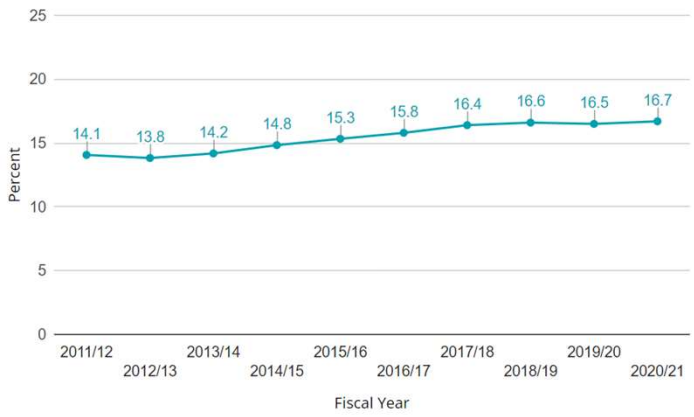
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

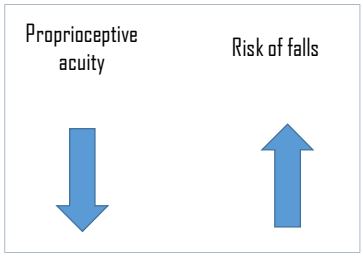
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

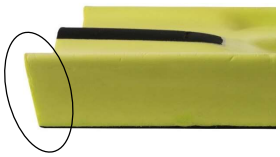
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

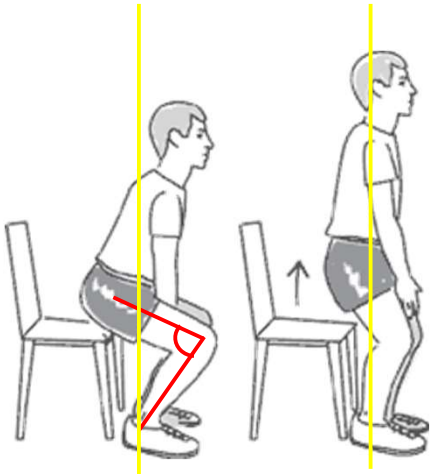
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

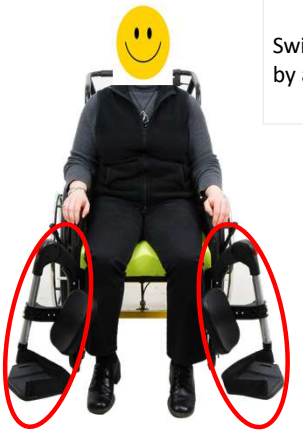
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

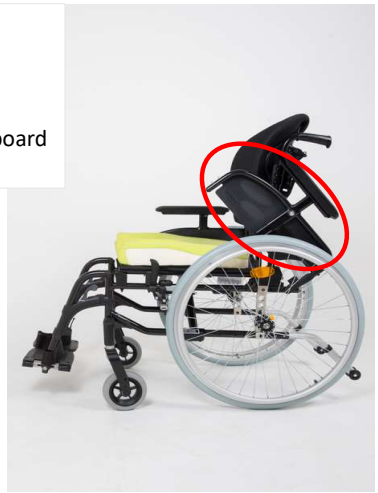
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely

- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

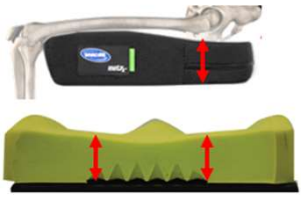
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

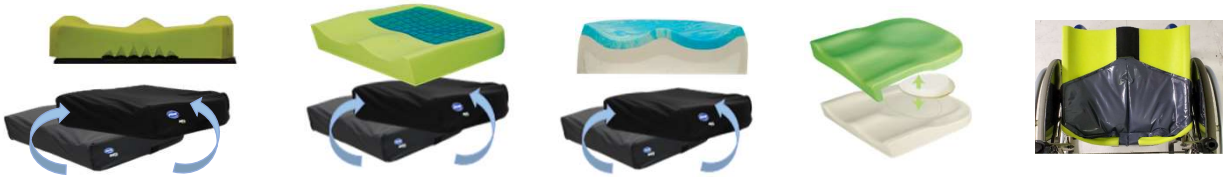
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

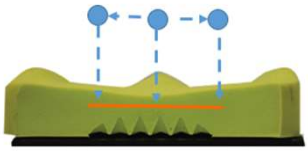
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

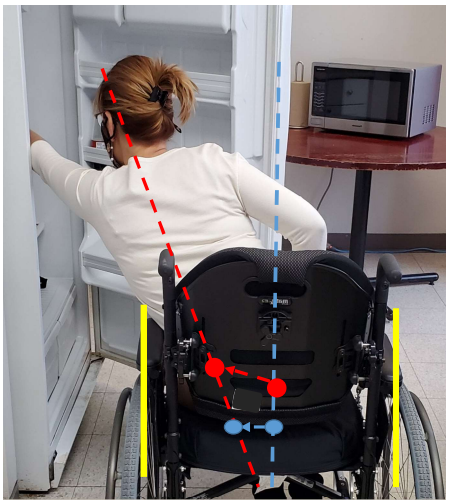
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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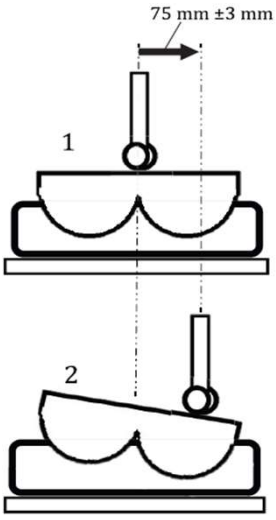
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

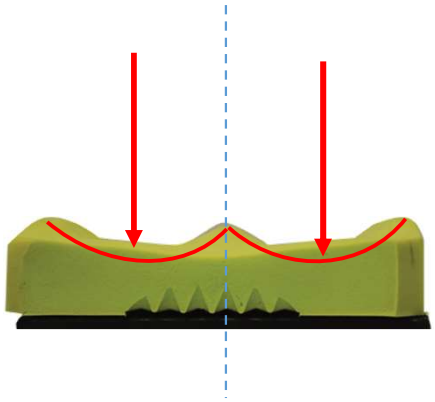
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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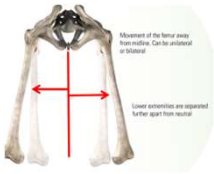
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

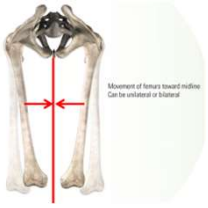


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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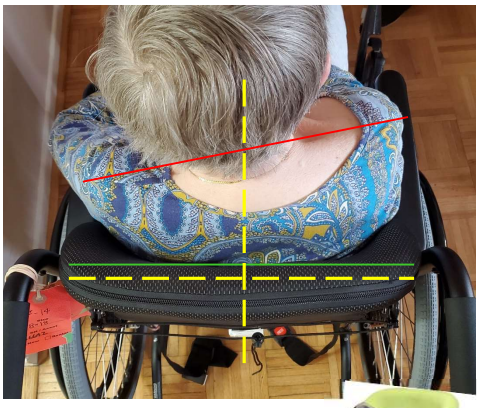
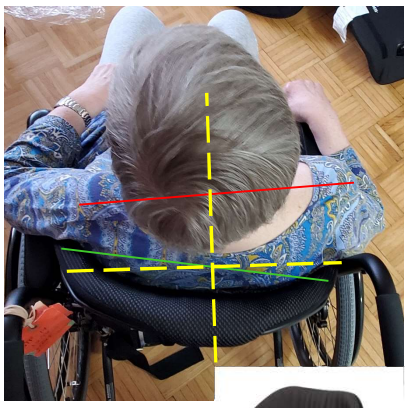
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

34

Wheelchair-related risk factors: rigid backrest vs upholstery back

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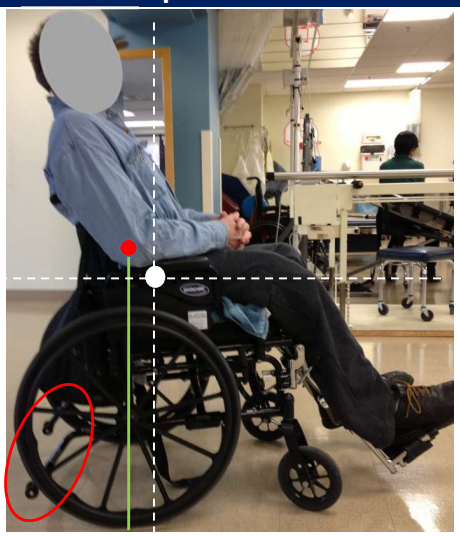
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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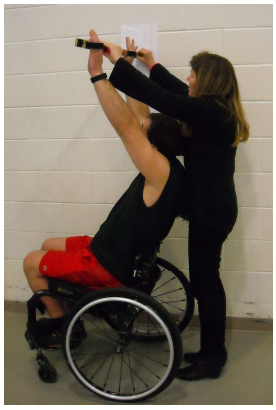
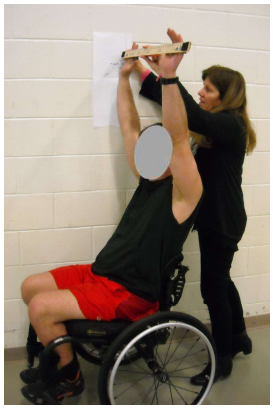
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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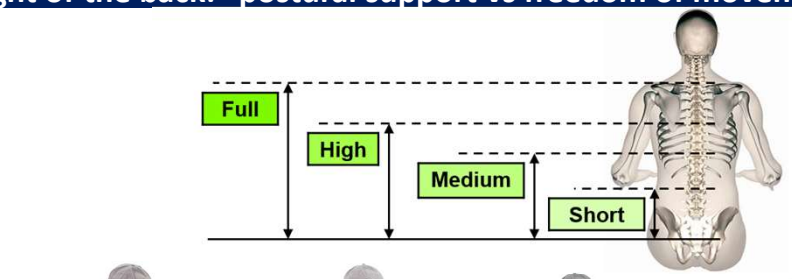
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

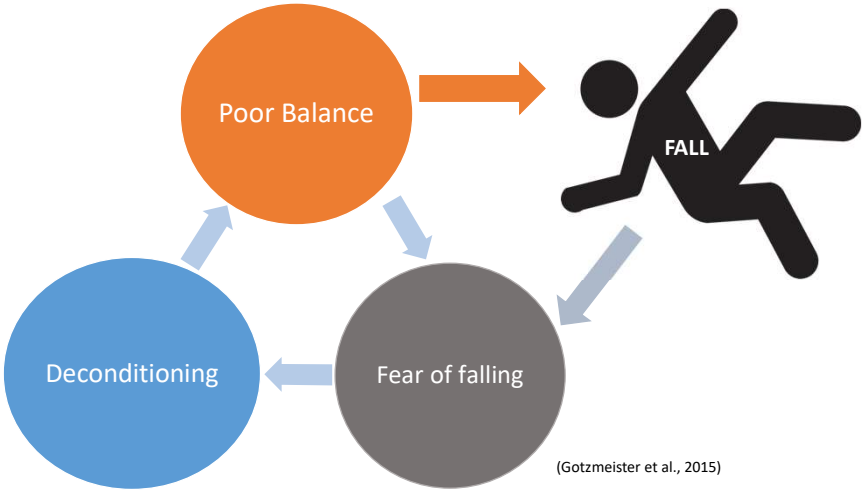
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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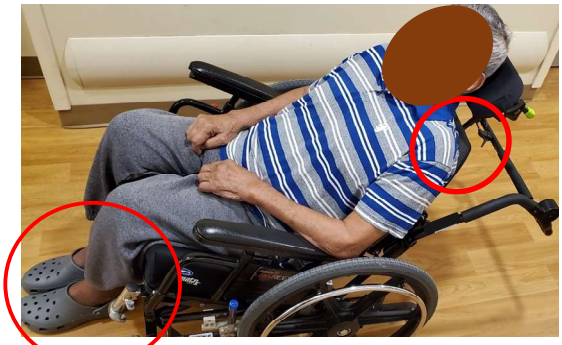
Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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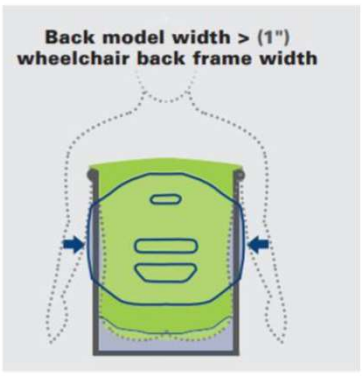
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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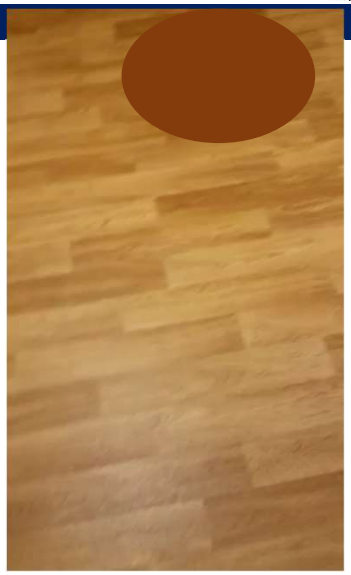
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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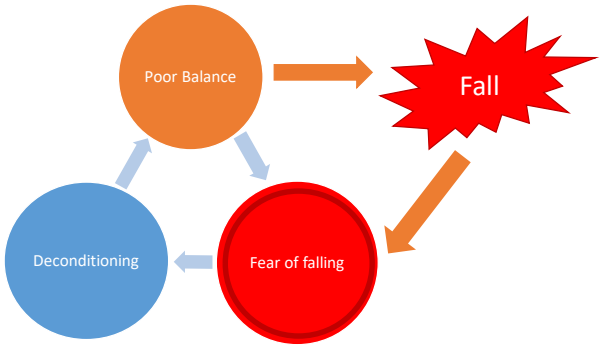
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

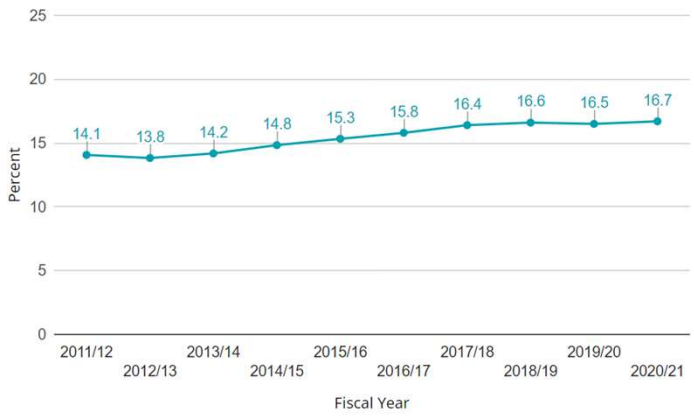
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

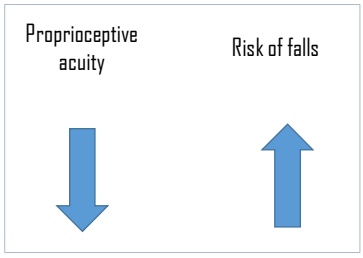
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

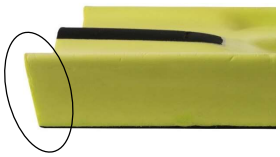
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

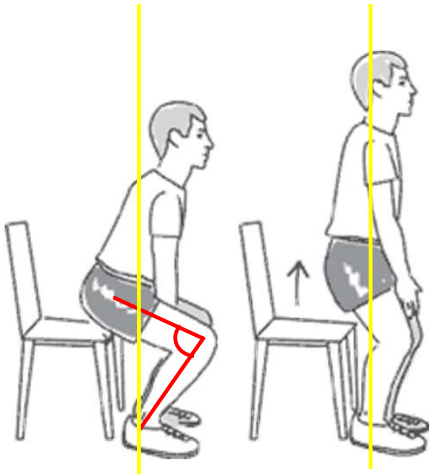
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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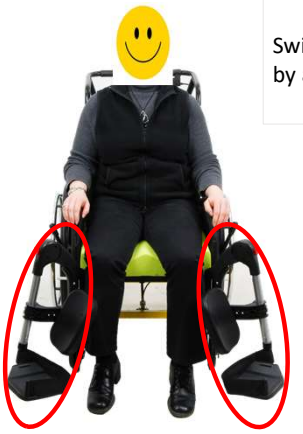
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

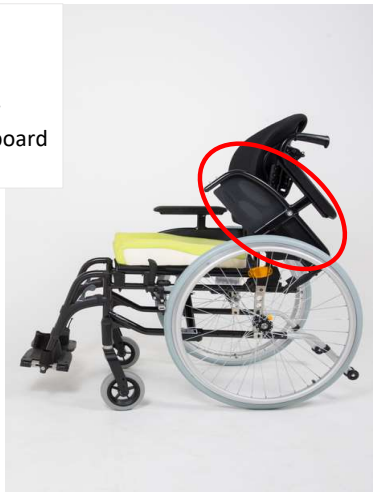
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



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Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

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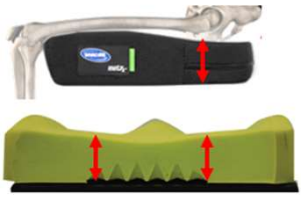
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

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Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

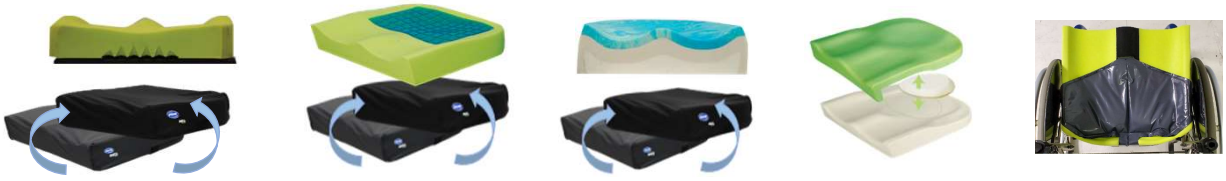
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

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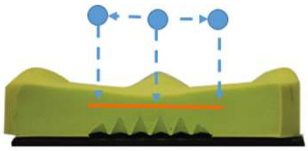
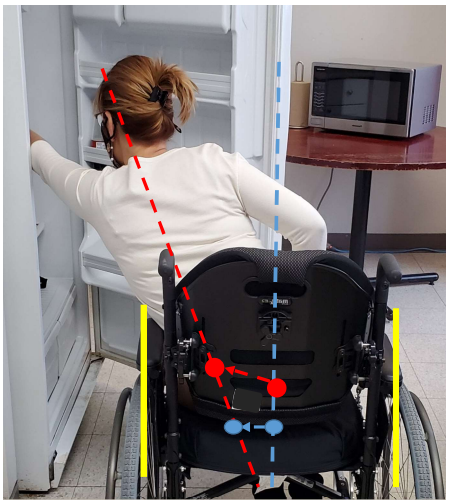
Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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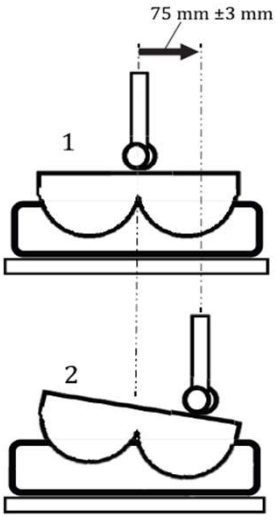
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

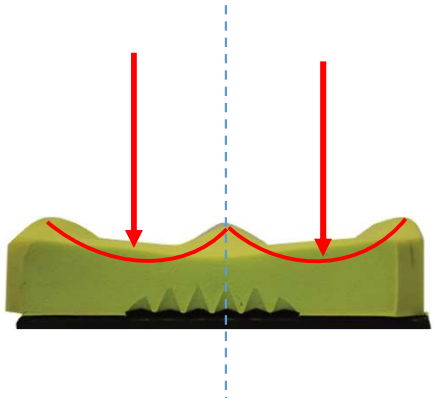
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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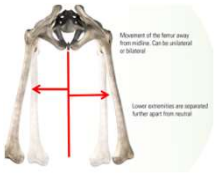
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

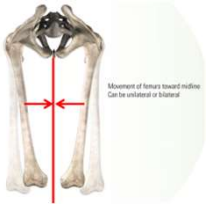


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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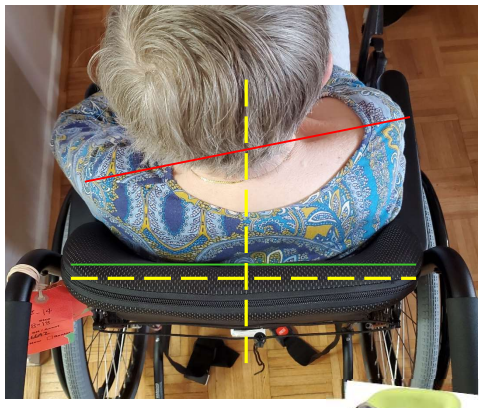
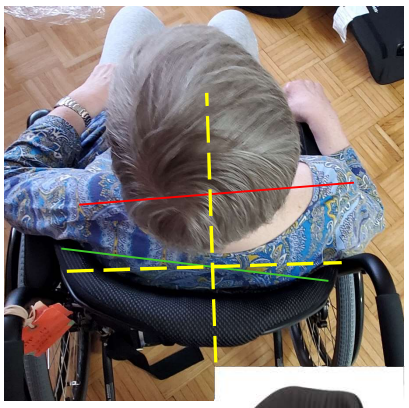
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

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Wheelchair-related risk factors: rigid backrest vs upholstery back

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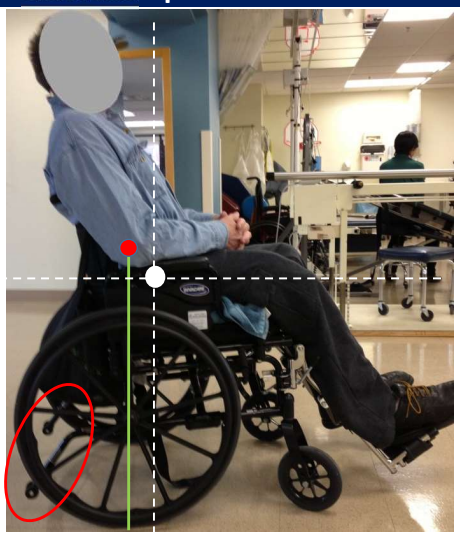
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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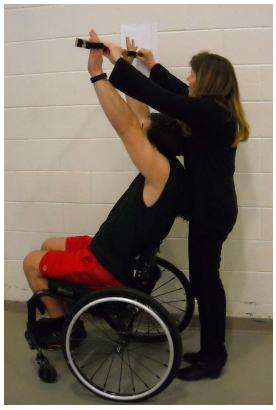
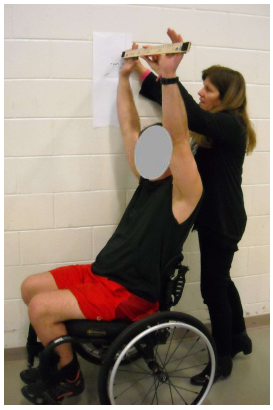
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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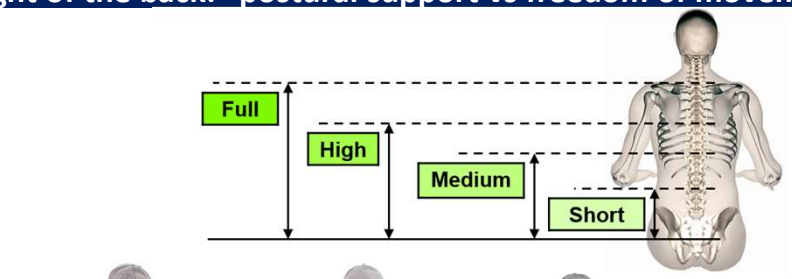
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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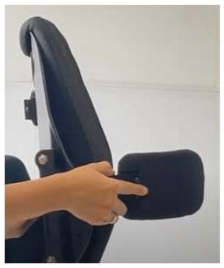
Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

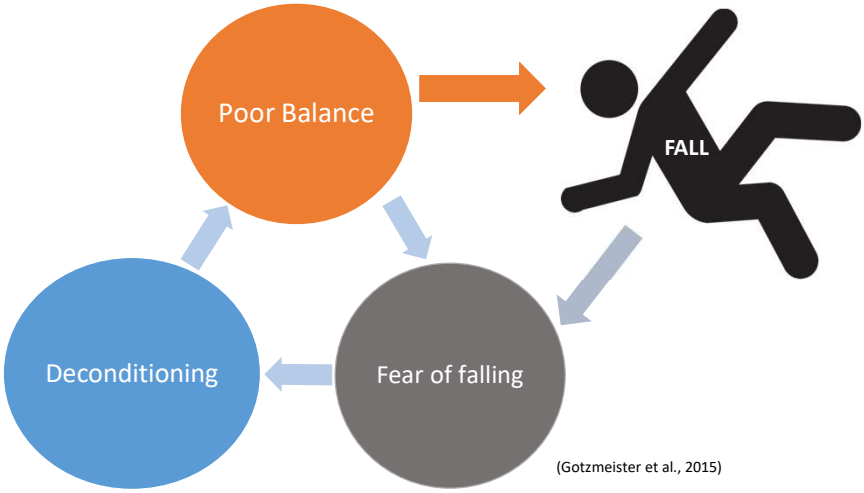
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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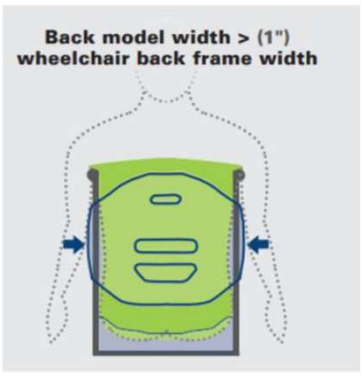
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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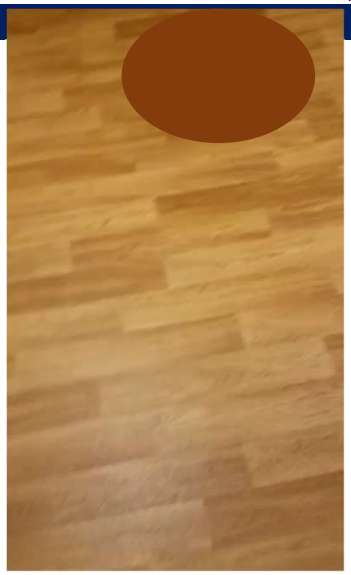
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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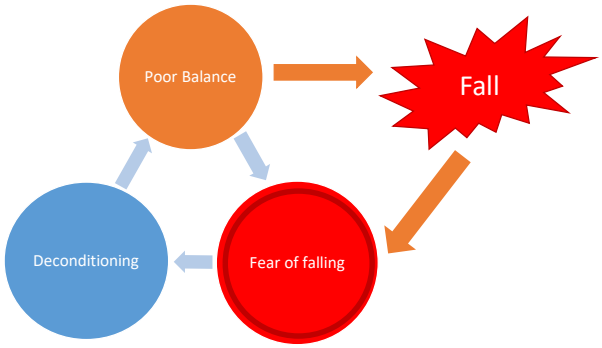
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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References:

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Fall Prevention & Wheelchair Seating

Anna Sokol, RN, MN, BScKin, BScN, WOCC(C)
Clinical Education Specialist
Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

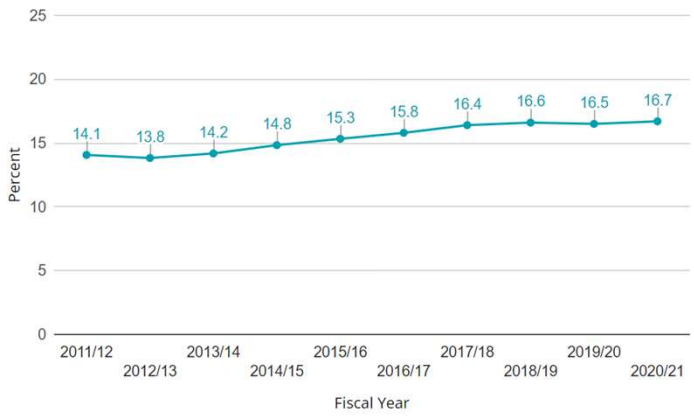
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

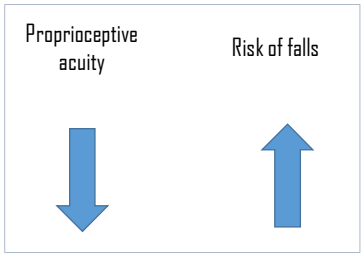
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

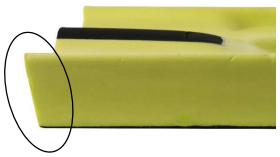
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

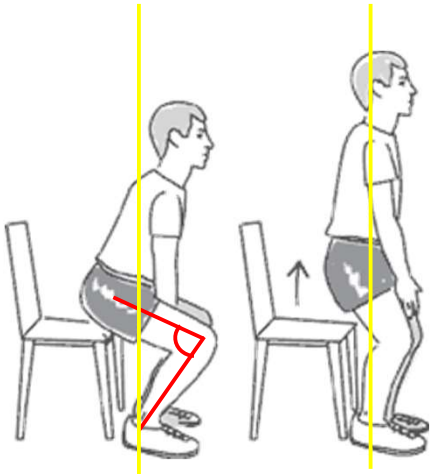
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

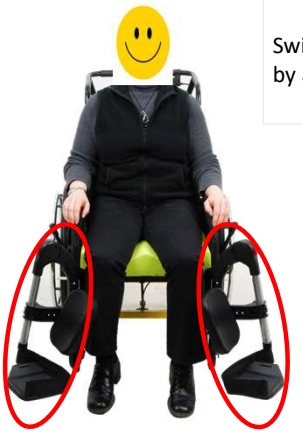
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

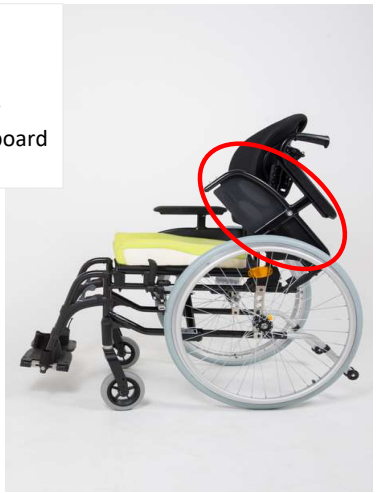
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

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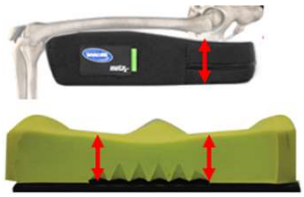
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

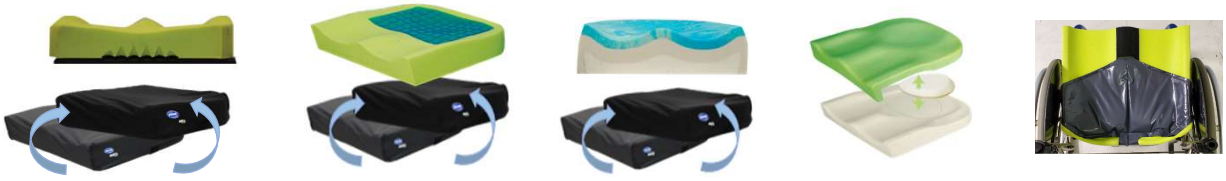
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

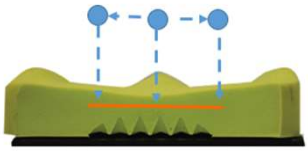
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

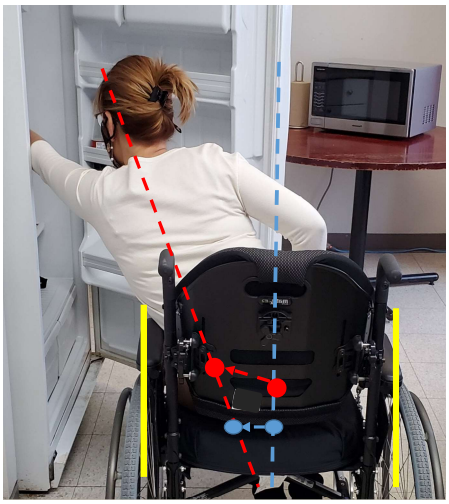
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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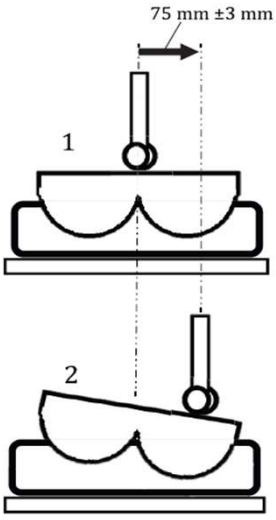
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

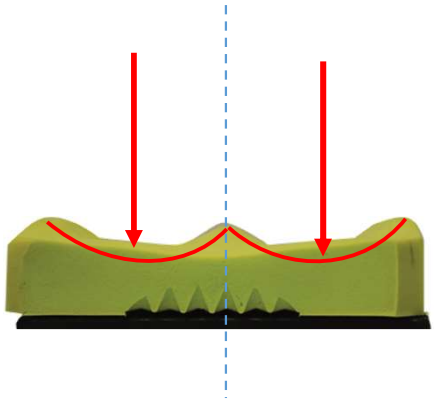
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

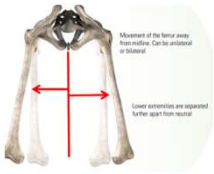
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

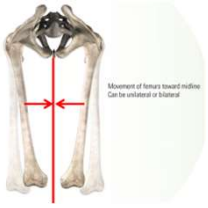


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

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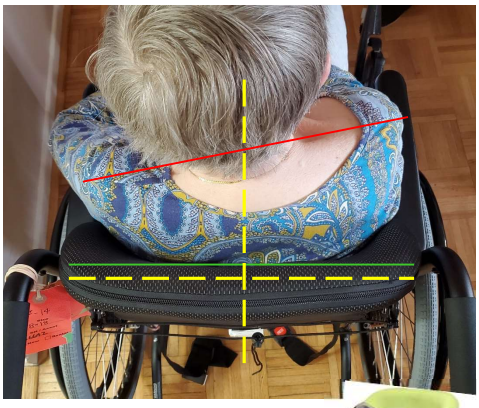
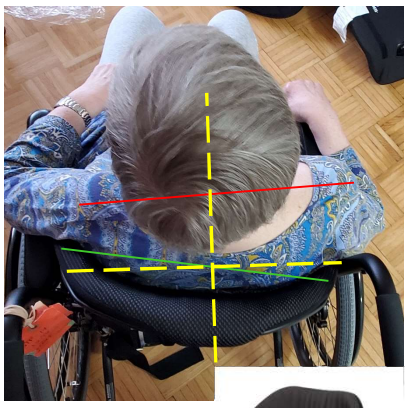
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

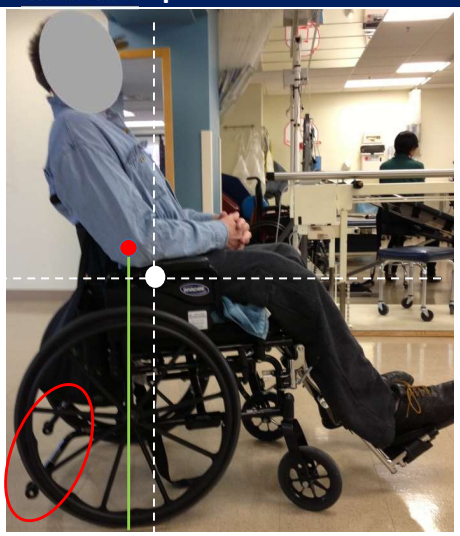
34

Wheelchair-related risk factors: rigid backrest vs upholstery back

38

Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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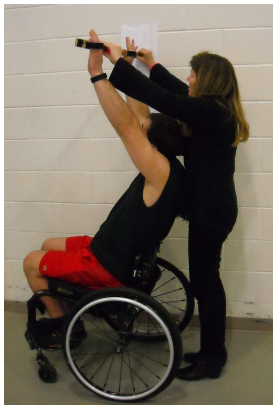
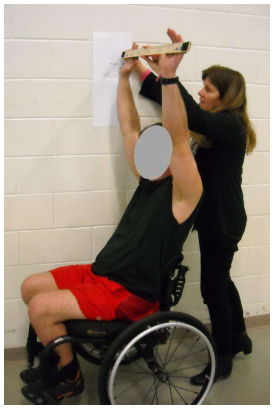
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

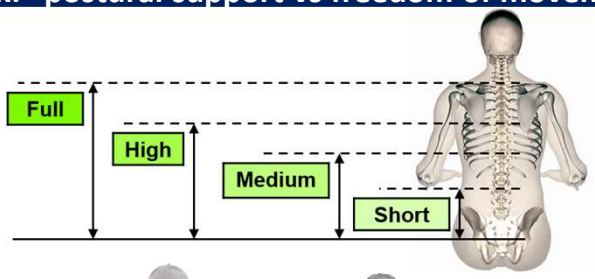
• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

41

Height of the back: postural support vs freedom of movement



42

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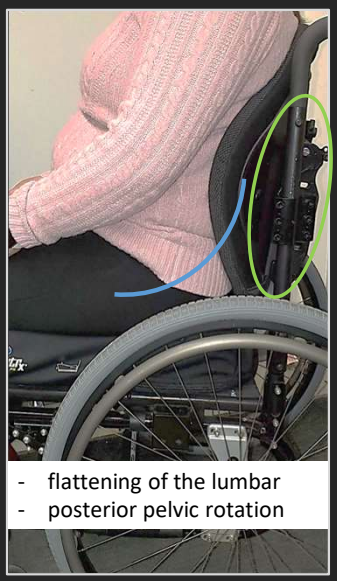
How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet



- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

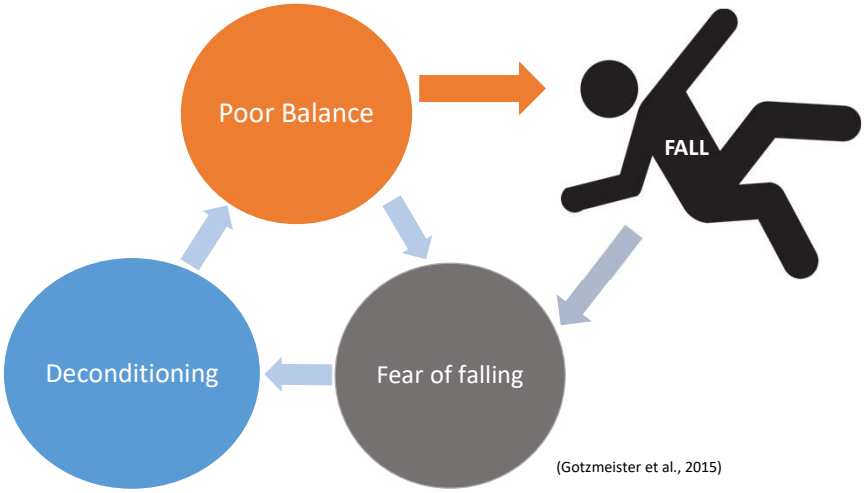
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

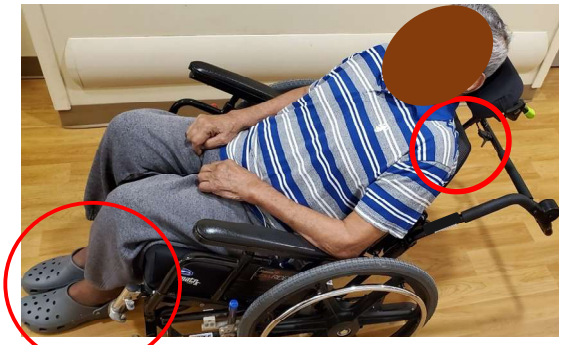
Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

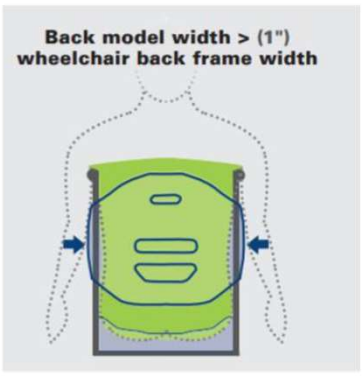
52

52

Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



53

Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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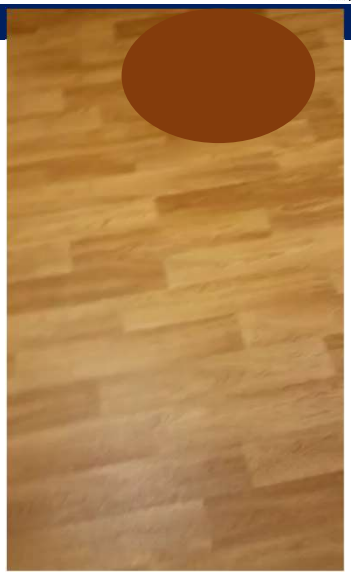
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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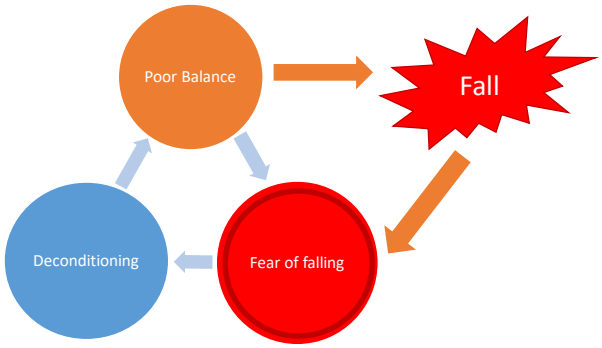
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

59

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)

3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

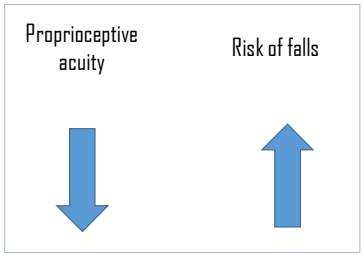
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

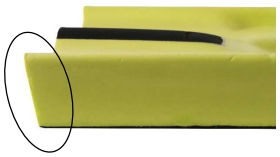
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

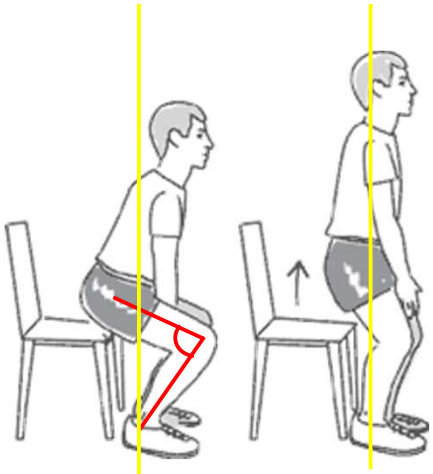
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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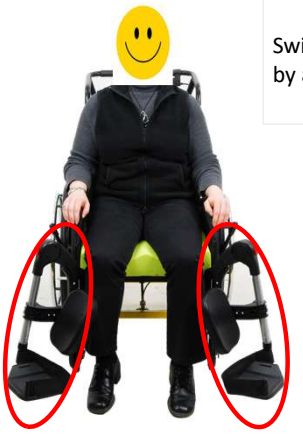
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

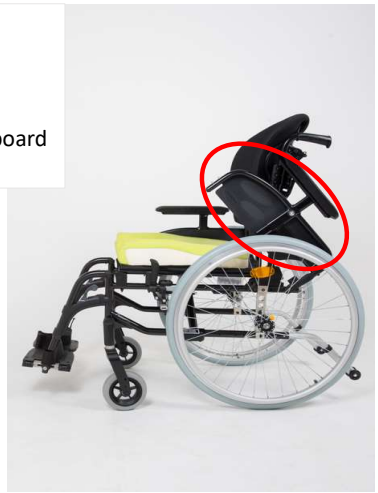
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely

- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

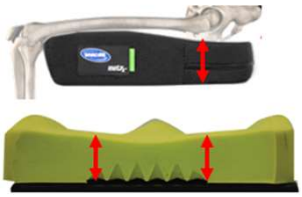
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

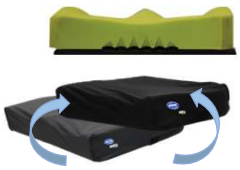
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion

Invacare® Matrx® PSP Cushion

Invacare® Matrx® Multi Cushion

Invacare® Matrx® Vi Cushion

Libra/Libra Adjust Cushion

Positioning

Skin Protection and Positioning

Skin Protection and Positioning

Skin Protection and Positioning

Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

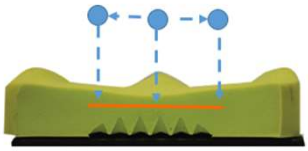
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

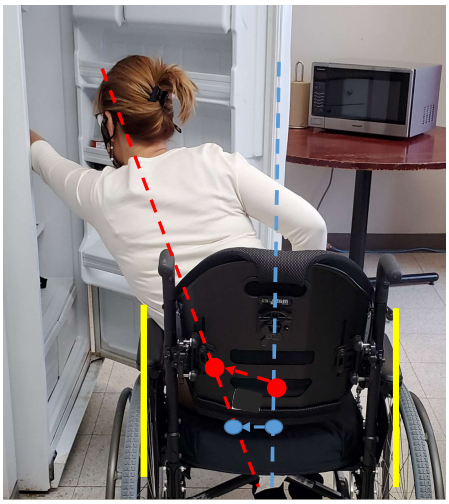
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

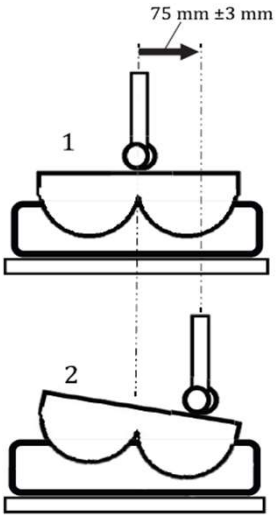
26

Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

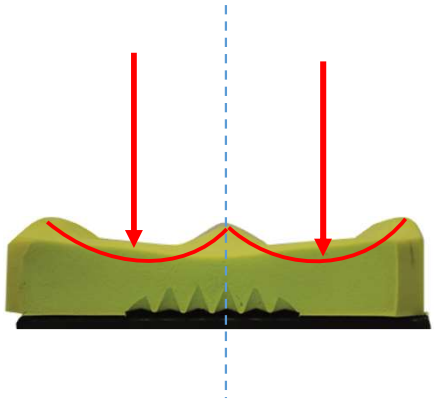
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

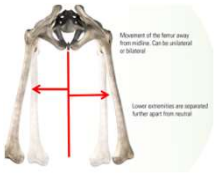
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

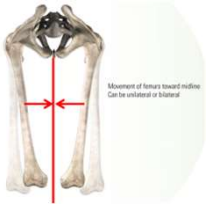


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

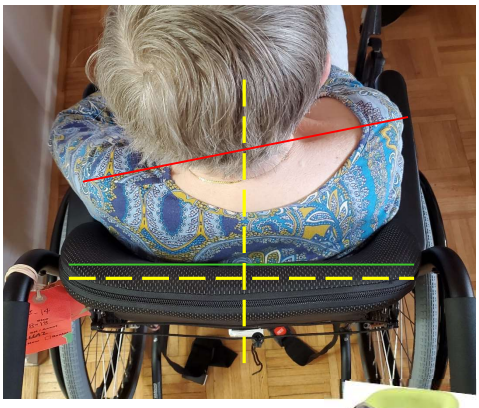
29

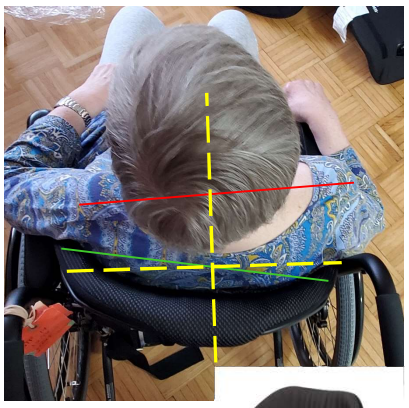
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

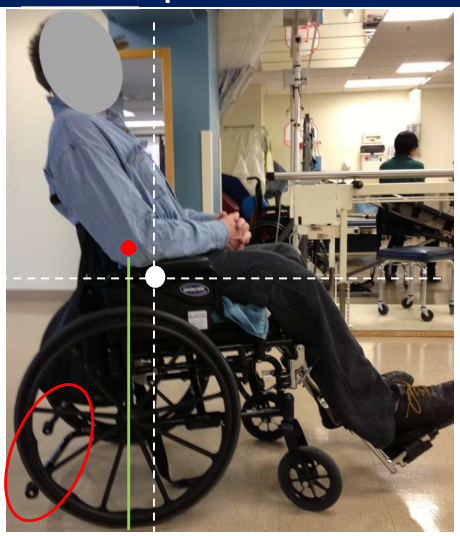
34

Wheelchair-related risk factors: rigid backrest vs upholstery back

38

Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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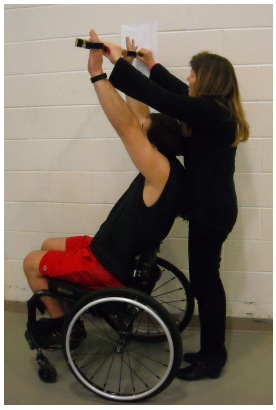
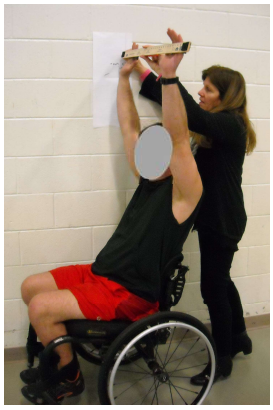
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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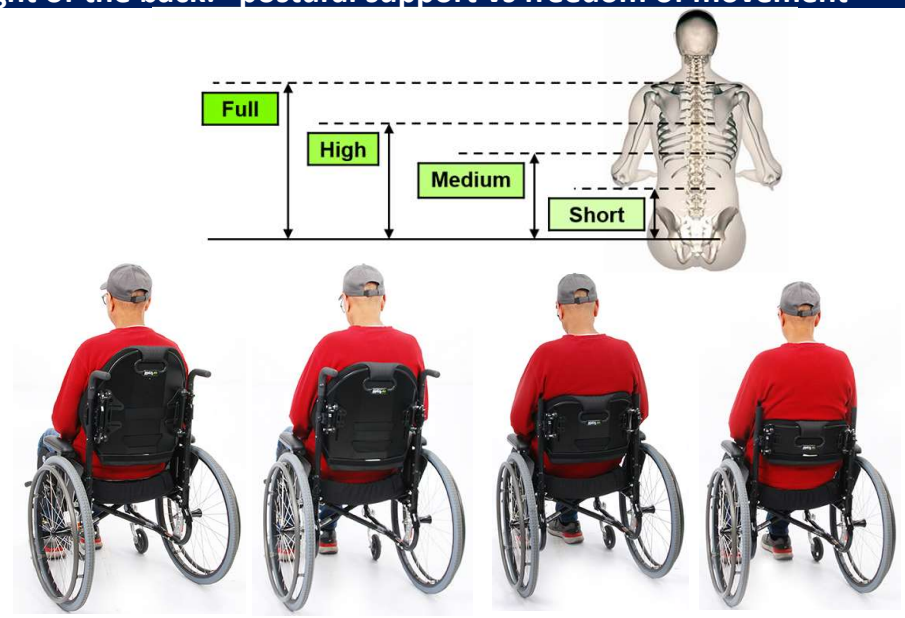
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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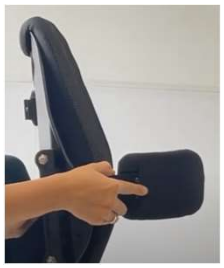
Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

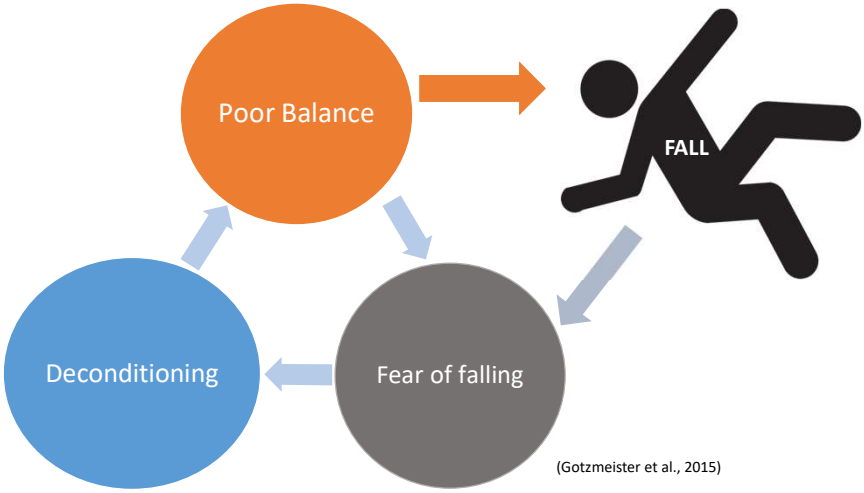
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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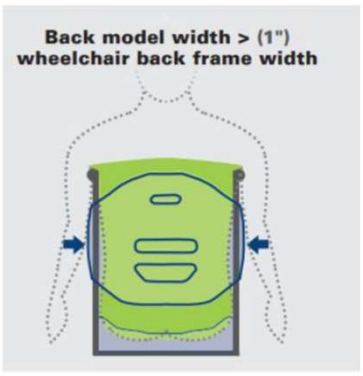
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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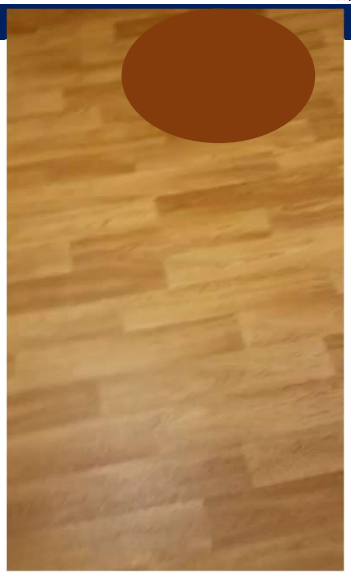
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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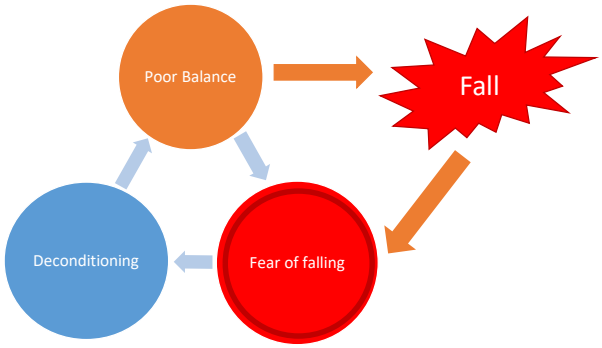
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

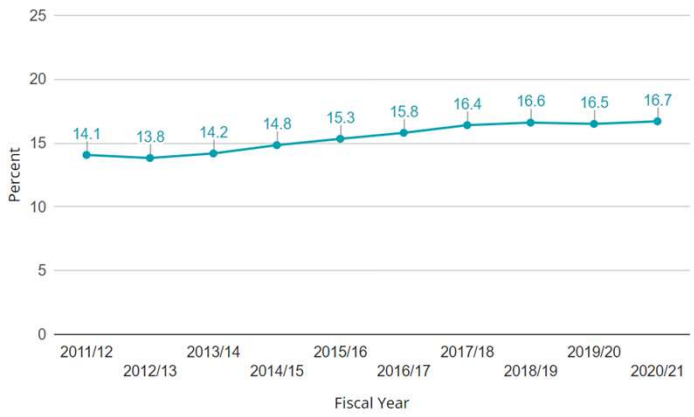
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

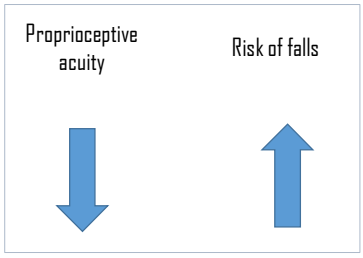
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

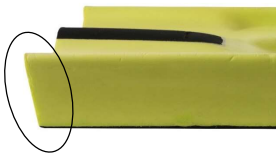
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

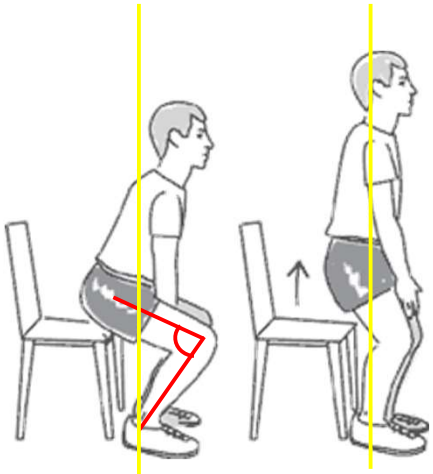
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

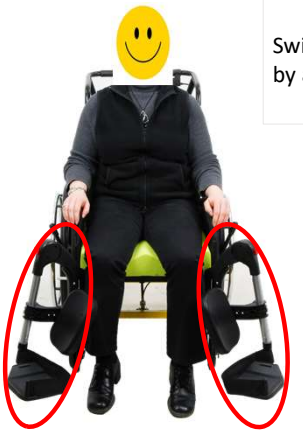
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

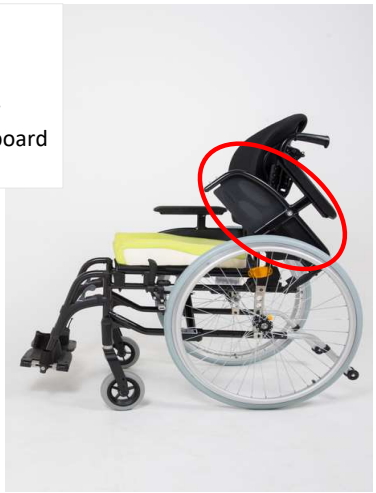
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

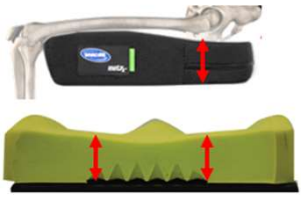
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

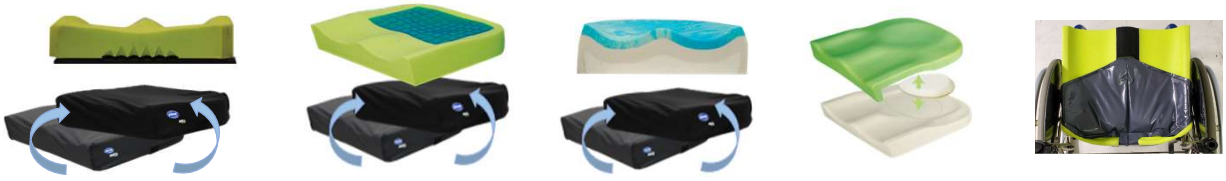
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

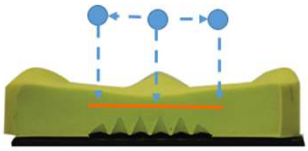
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

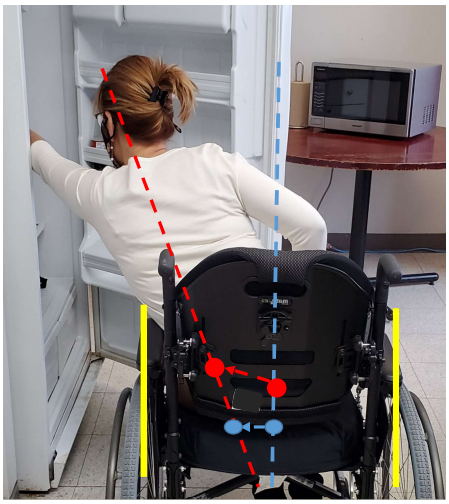
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

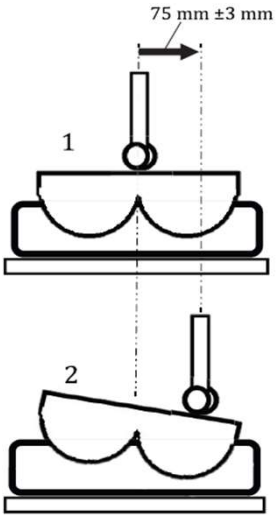
26

Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

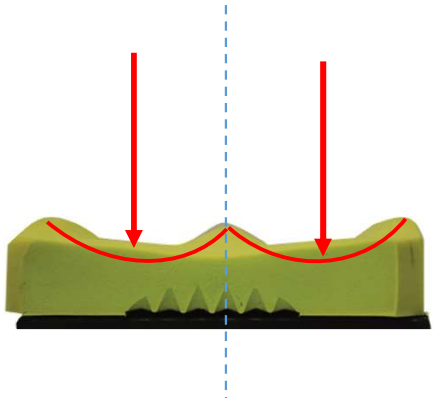
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

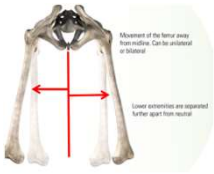
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

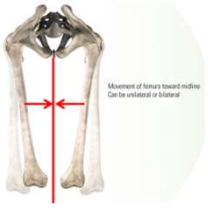


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

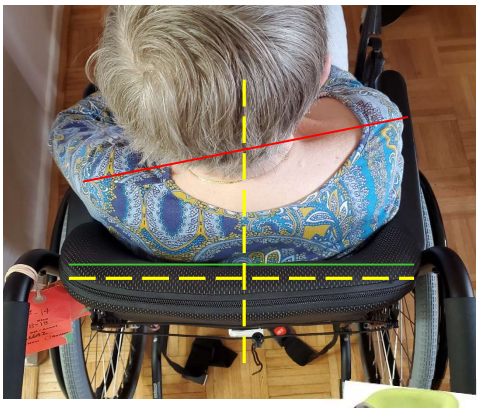
29

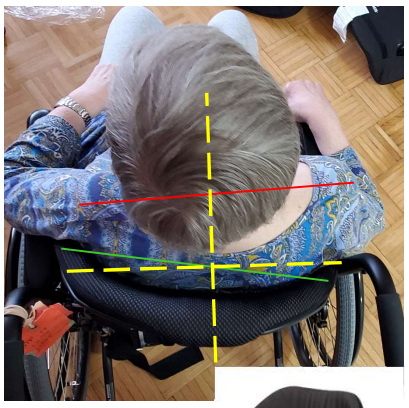
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

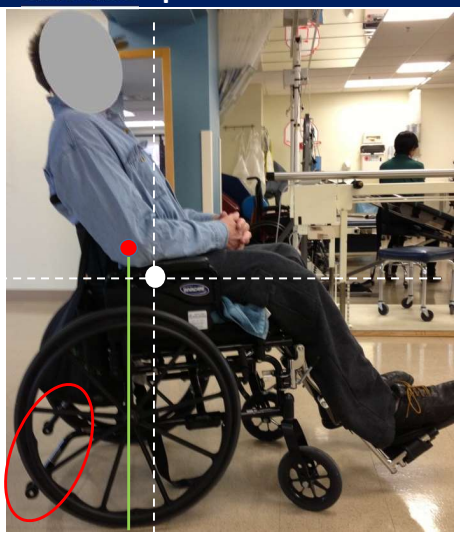
34

Wheelchair-related risk factors: rigid backrest vs upholstery back

38

Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

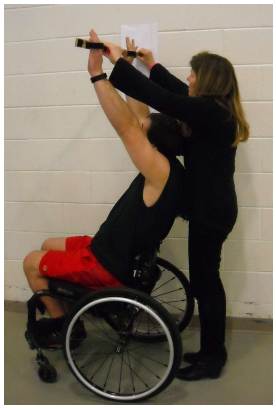
Solid posterior thoracic support with more height

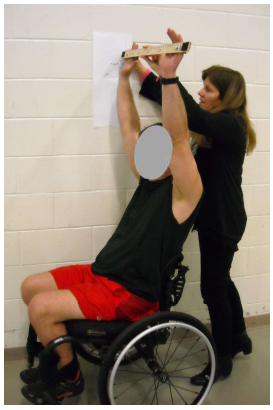
Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

39

RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

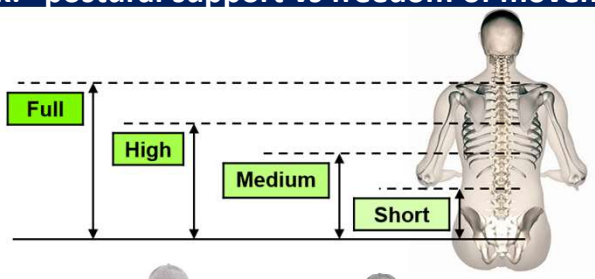
• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

41

Height of the back: postural support vs freedom of movement

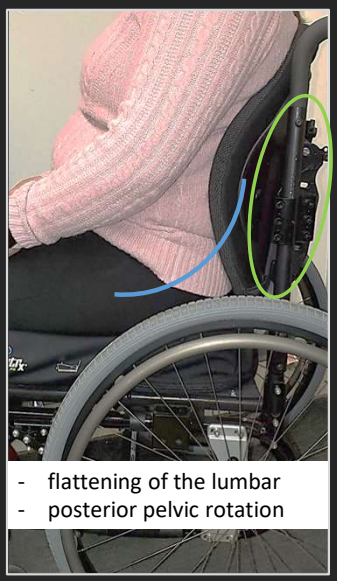


42

42

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet



- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

43

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

44

Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

46

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

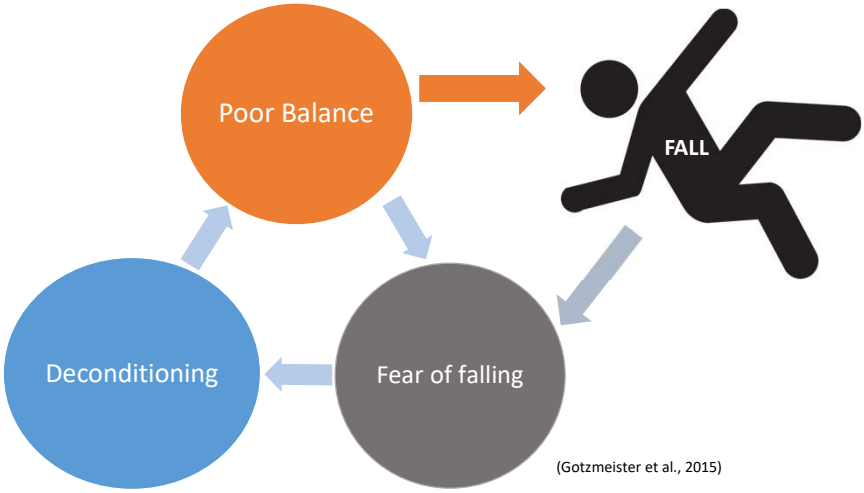
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

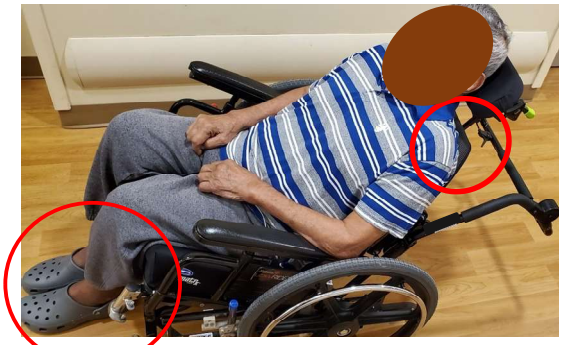
Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

52

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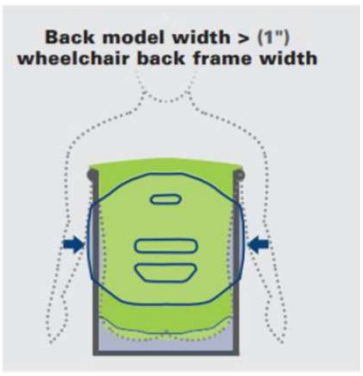
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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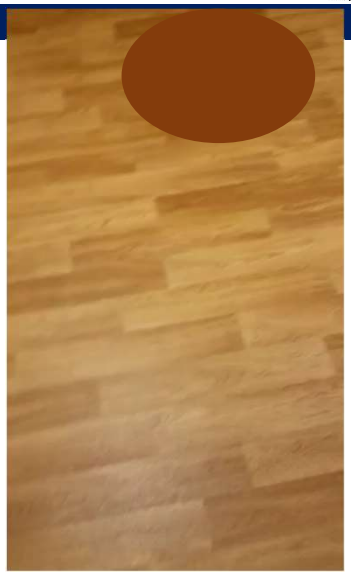
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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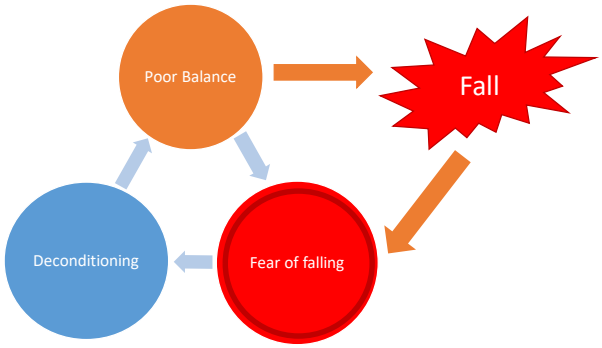
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

57

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)

3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

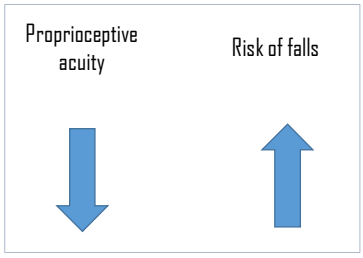
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

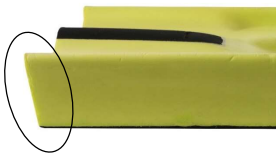
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

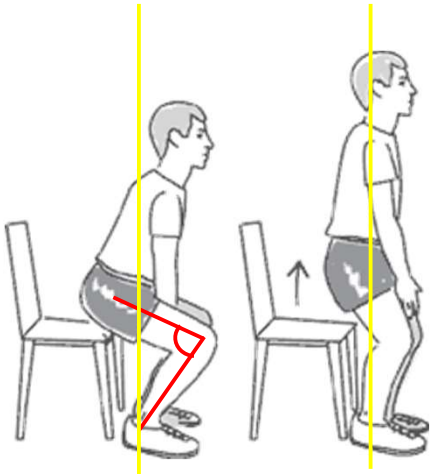
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

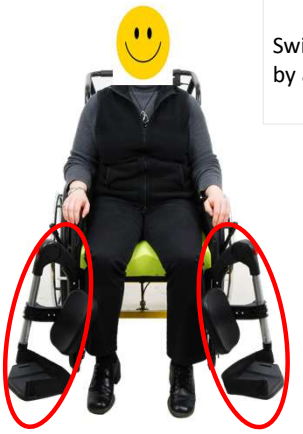
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

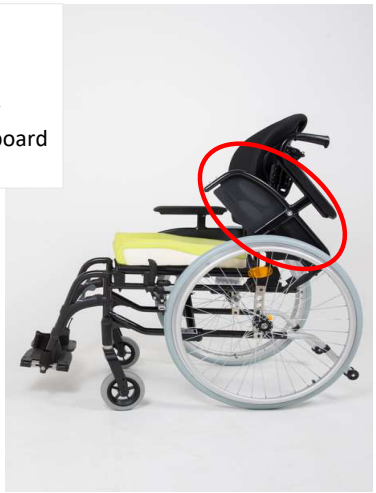
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

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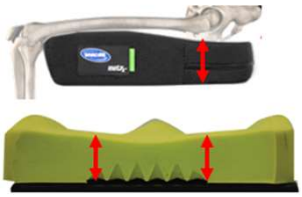
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

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Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

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MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

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Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

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Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

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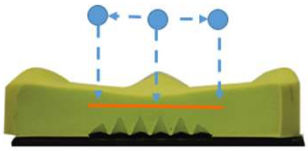
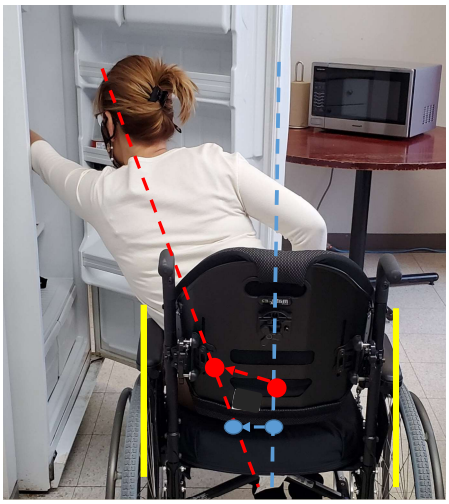
Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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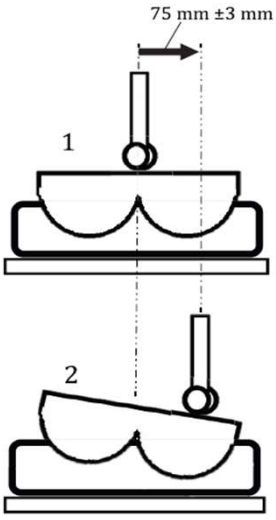
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

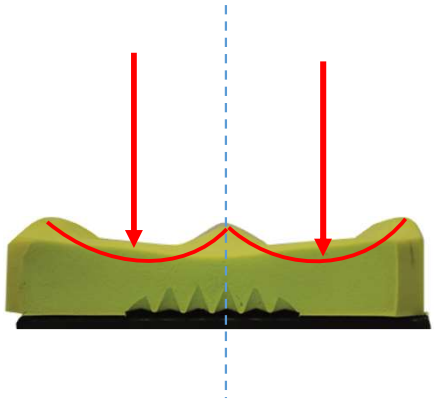
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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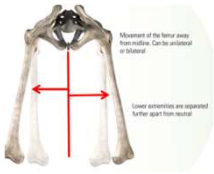
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

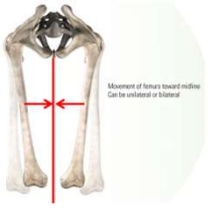


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

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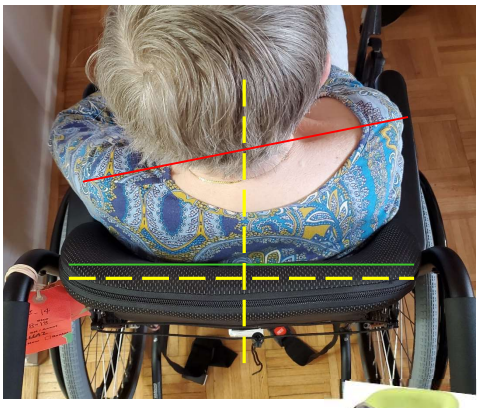
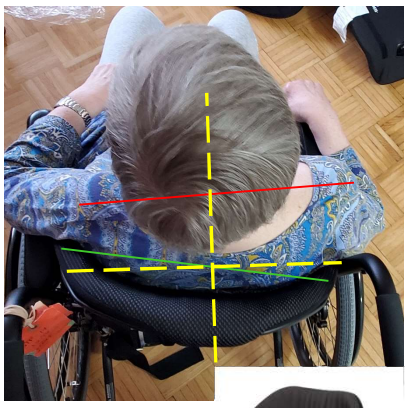
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

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Wheelchair-related risk factors: rigid backrest vs upholstery back

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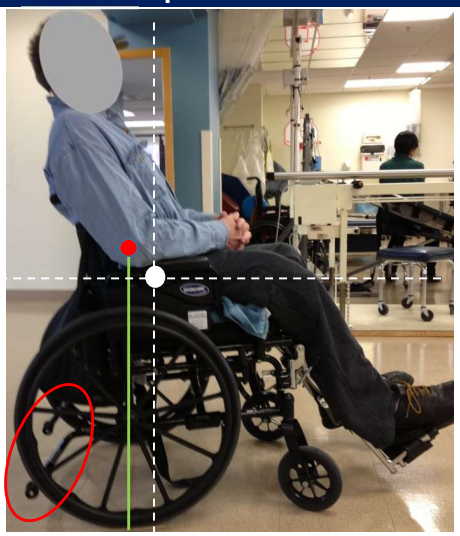
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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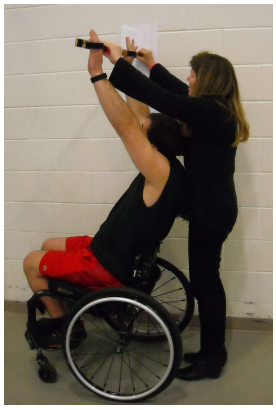
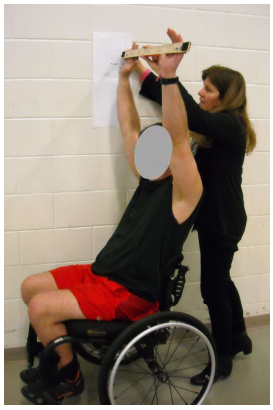
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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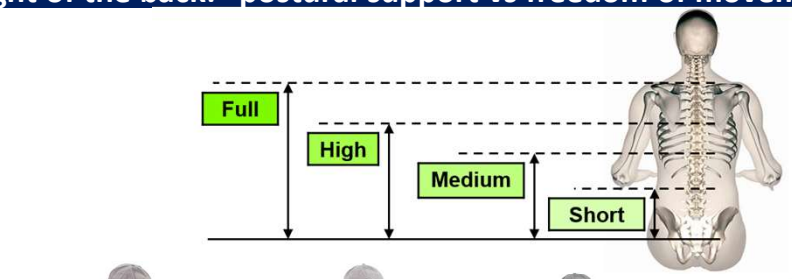
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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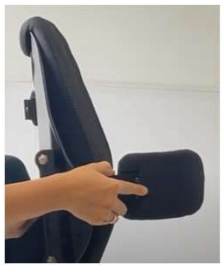
Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

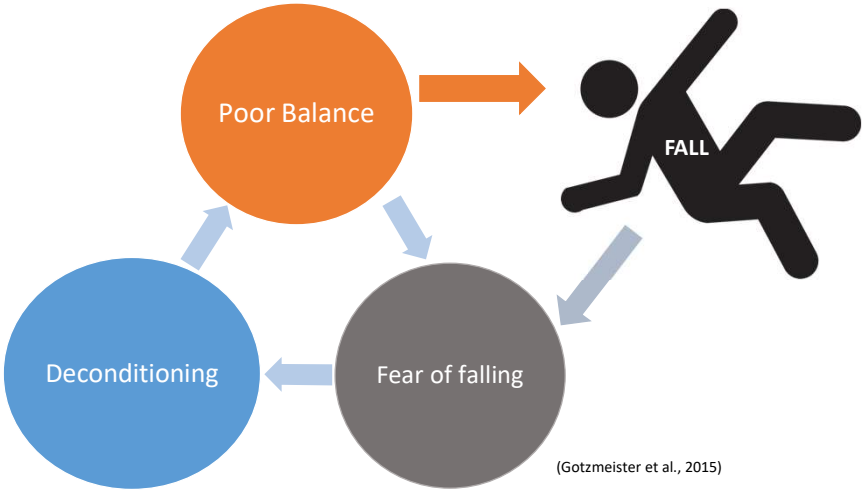
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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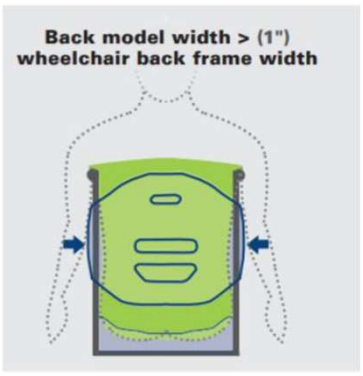
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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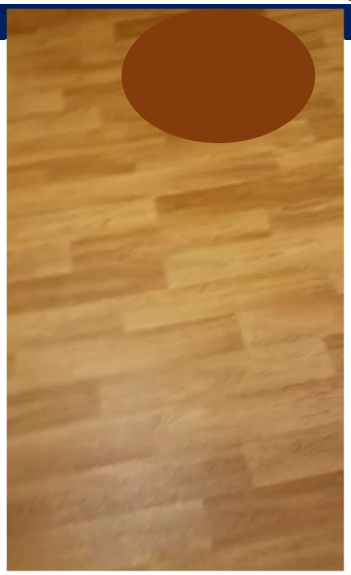
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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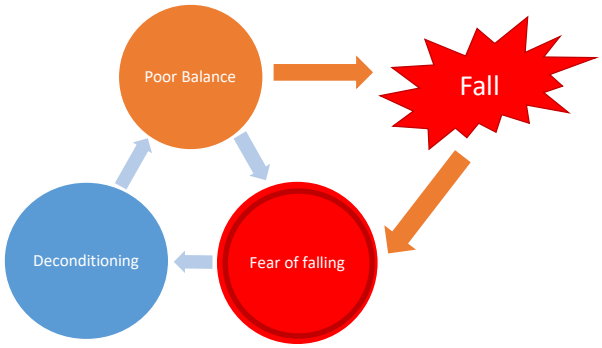
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

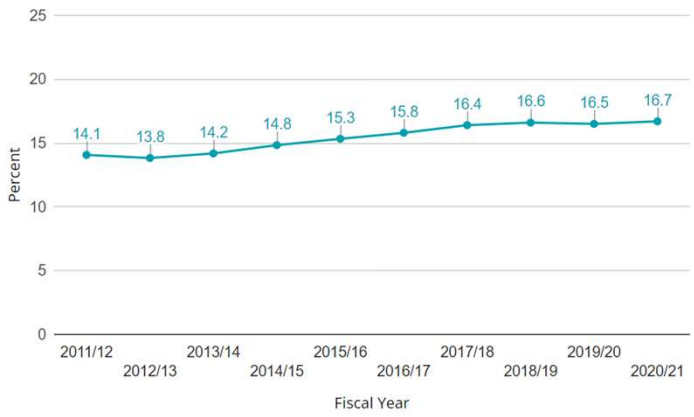
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

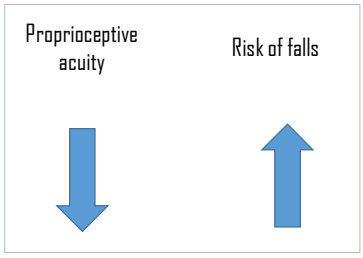
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

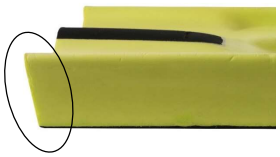
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

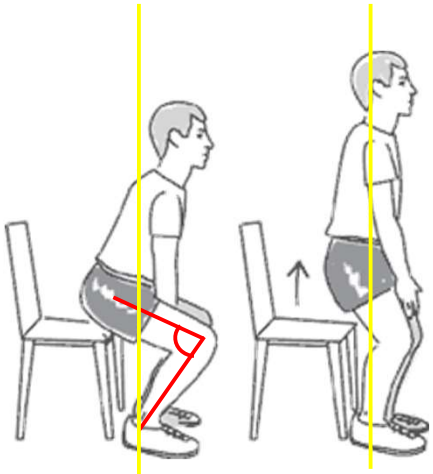
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

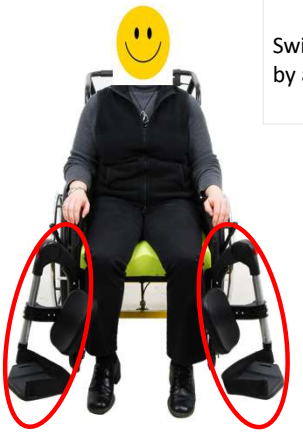
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

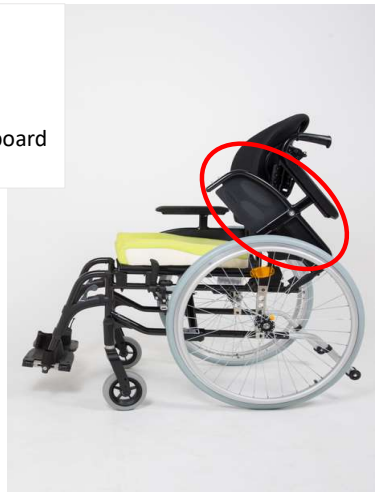
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely

- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

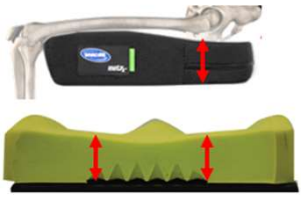
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

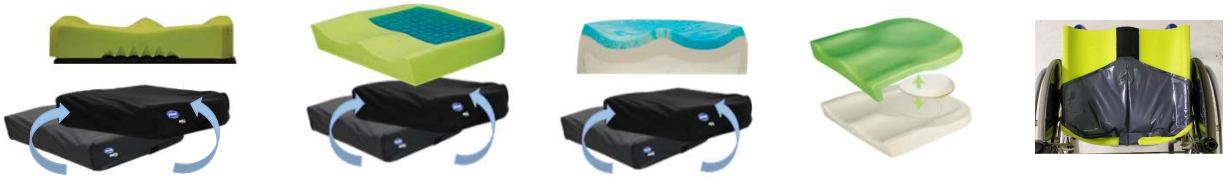
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

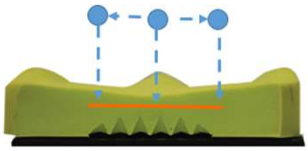
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

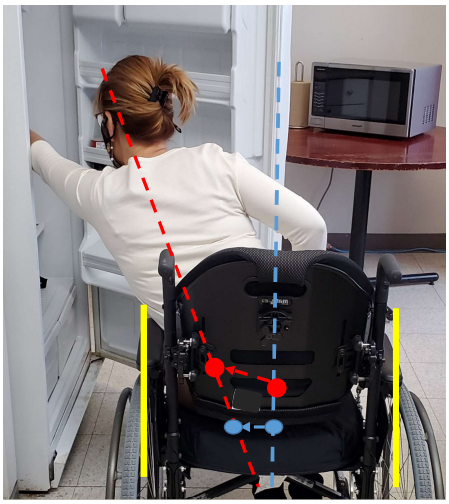
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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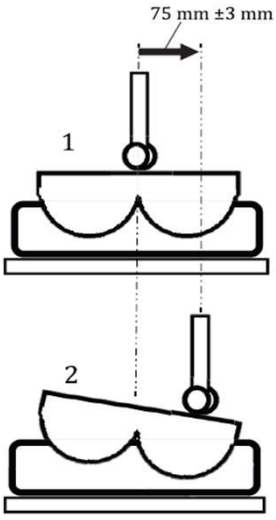
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

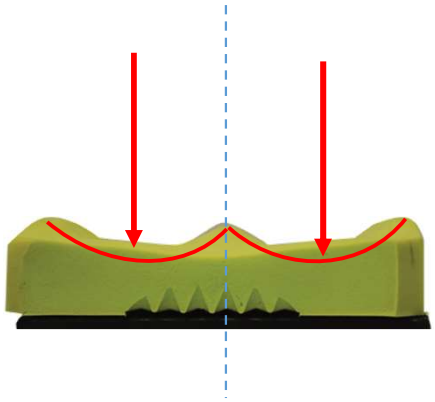
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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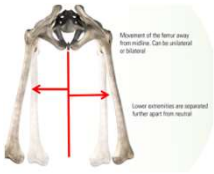
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

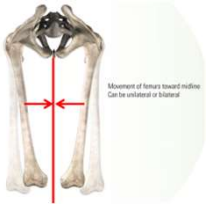


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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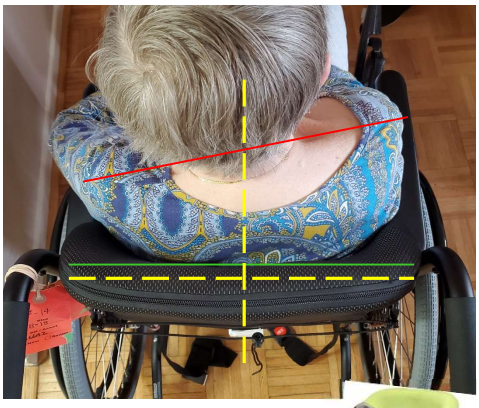
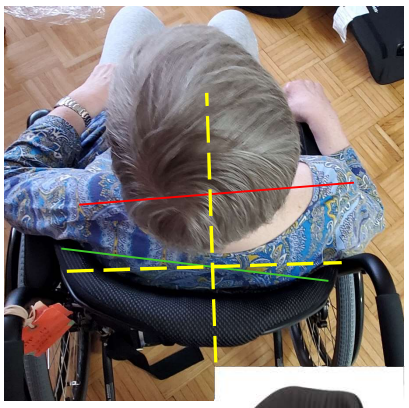
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

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Wheelchair-related risk factors: rigid backrest vs upholstery back

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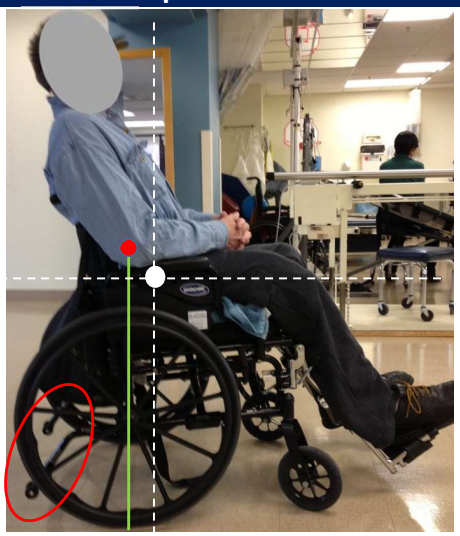
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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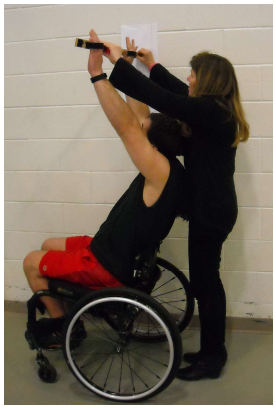
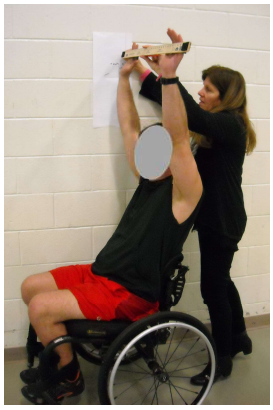
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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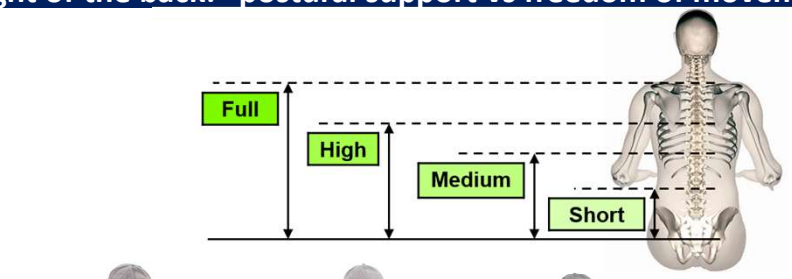
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

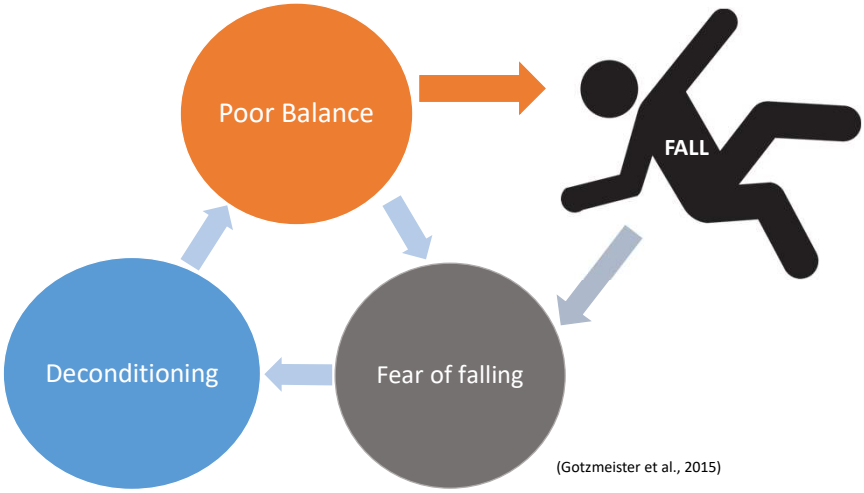
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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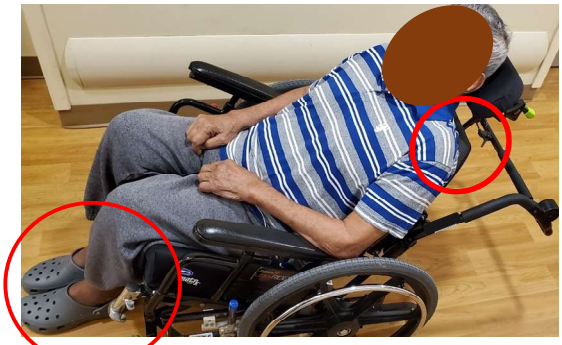
Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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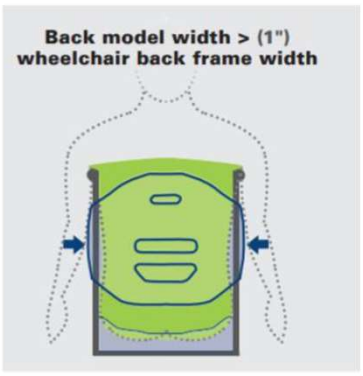
52

Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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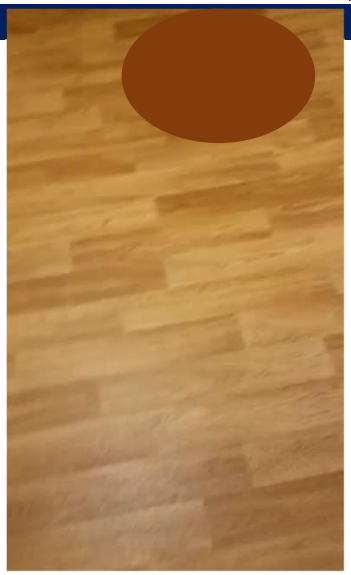
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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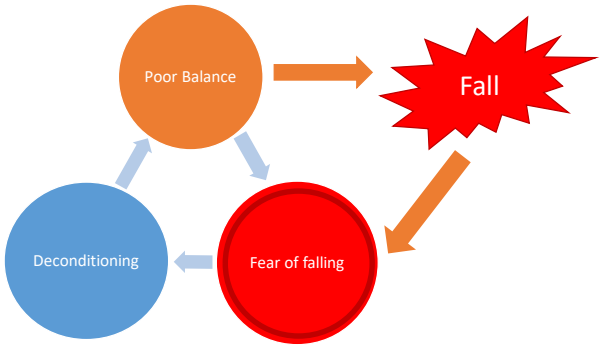
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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References:

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Fall Prevention & Wheelchair Seating

Anna Sokol, RN, MN, BScKin, BScN, WOCC(C)
Clinical Education Specialist
Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

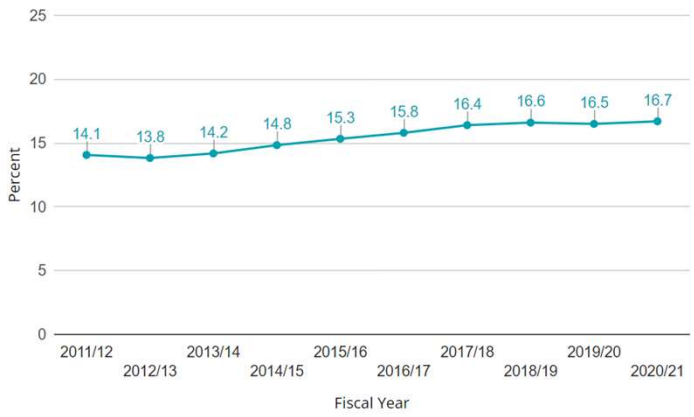
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

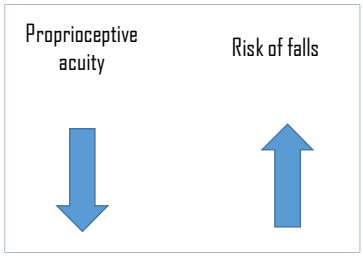
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

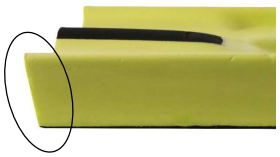
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

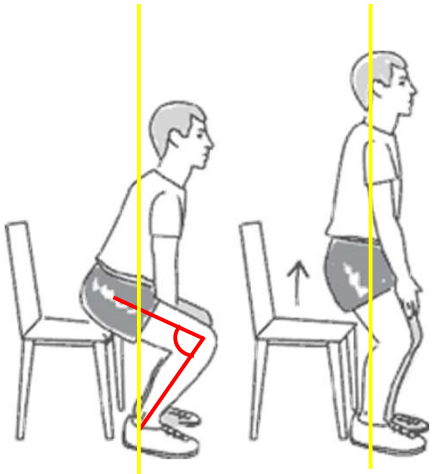
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

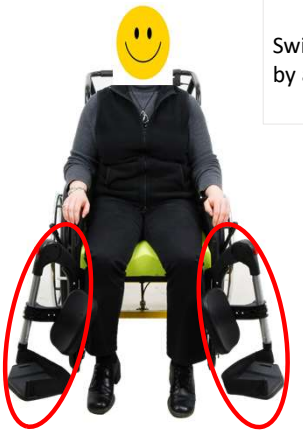
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

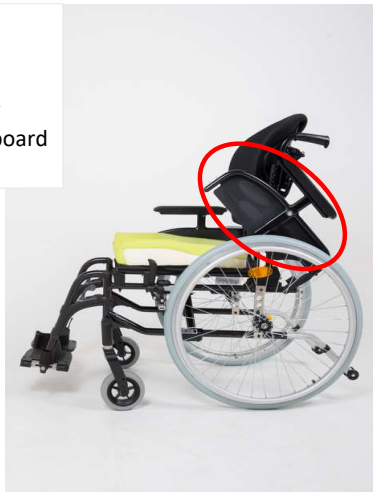
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

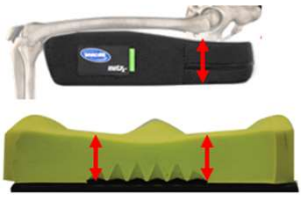
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

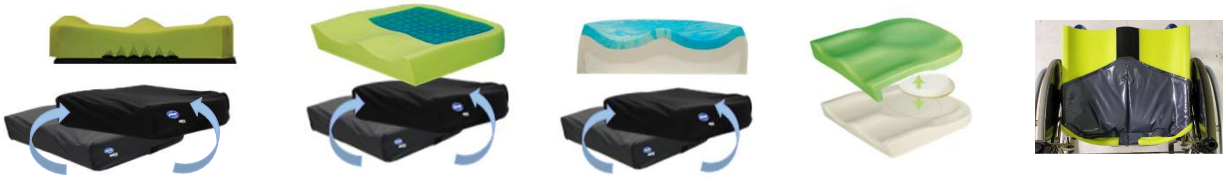
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

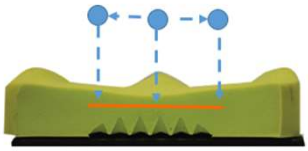
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

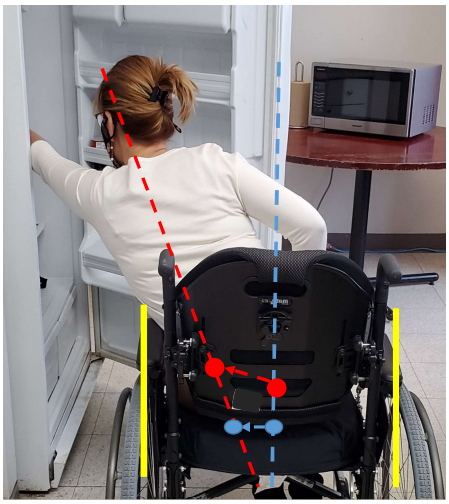
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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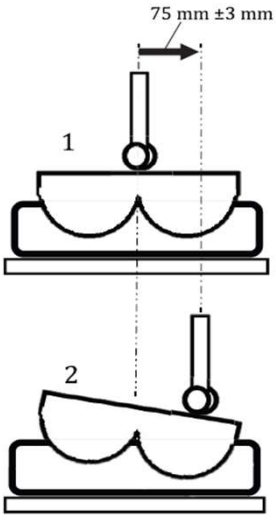
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

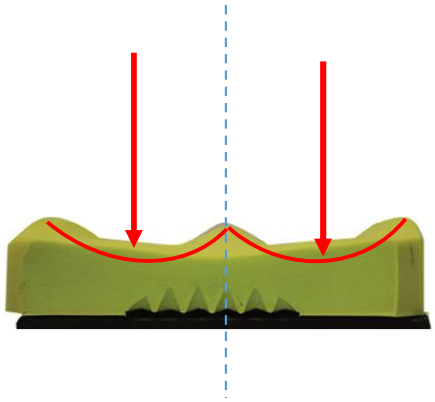
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

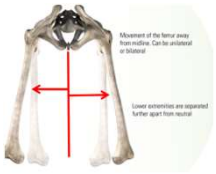
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

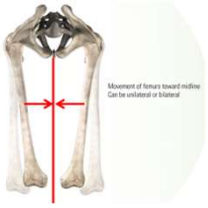


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

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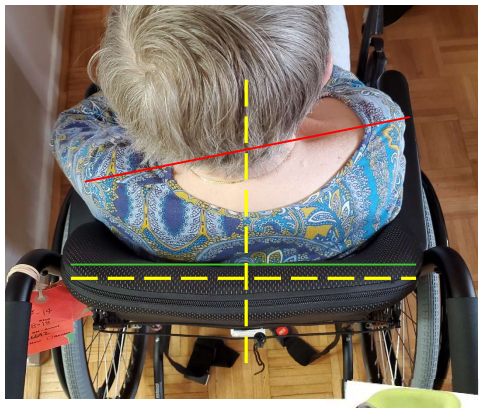
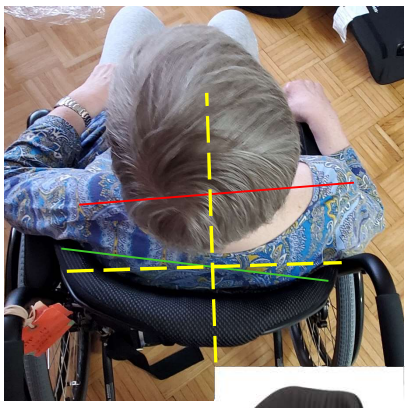
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

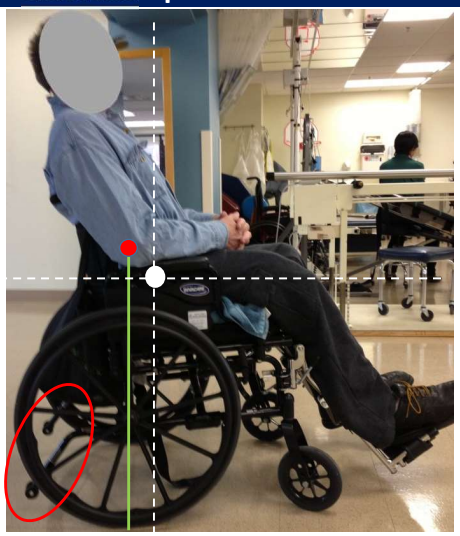
34

Wheelchair-related risk factors: rigid backrest vs upholstery back

38

Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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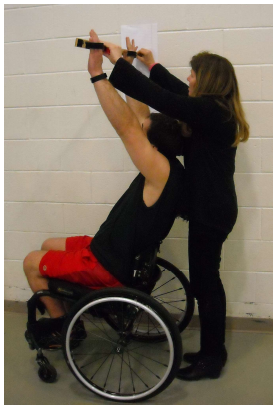
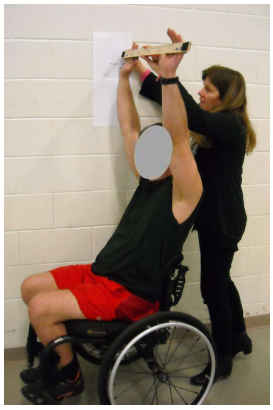
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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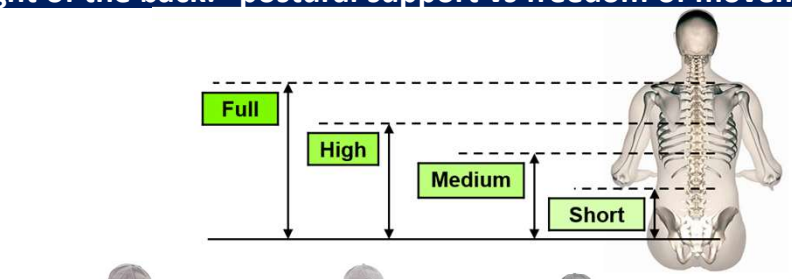
Height of the back: postural support vs freedom of movement



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42

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

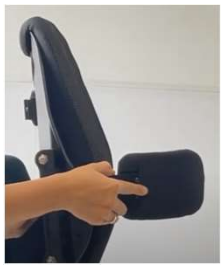
How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

44

Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

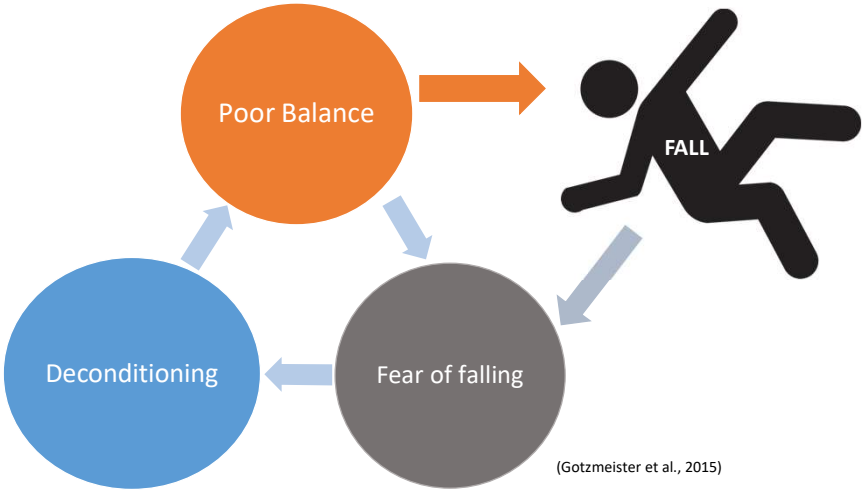
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

52

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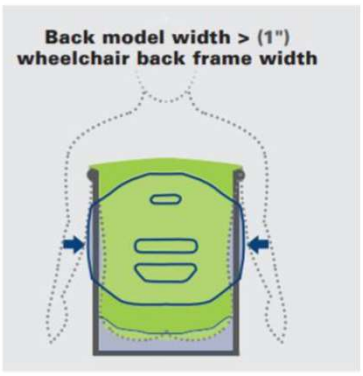
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



53

Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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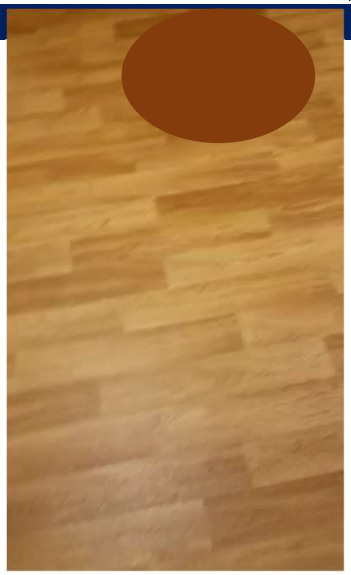
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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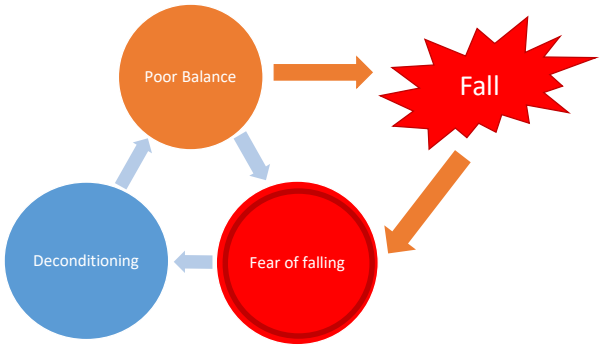
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

59

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

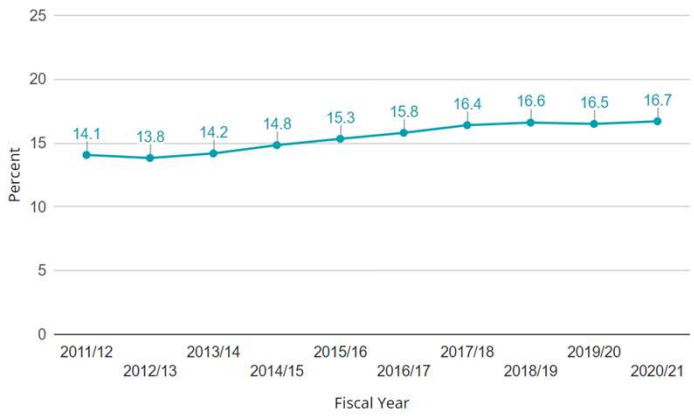
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

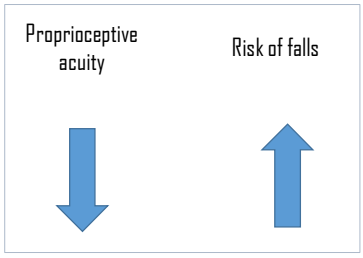
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

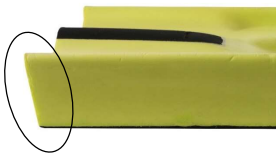
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

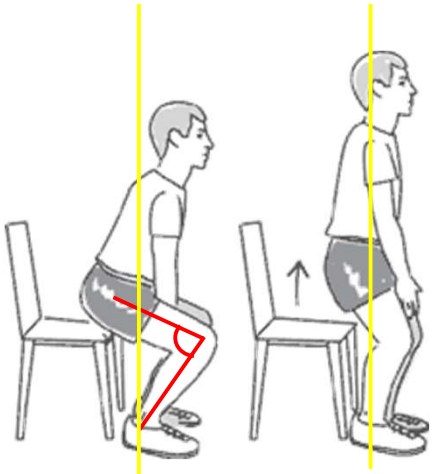
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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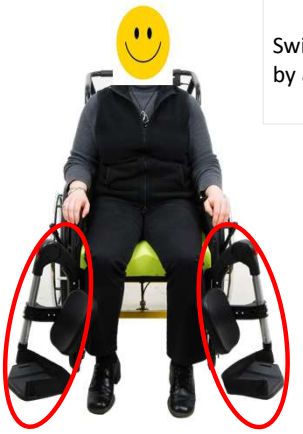
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

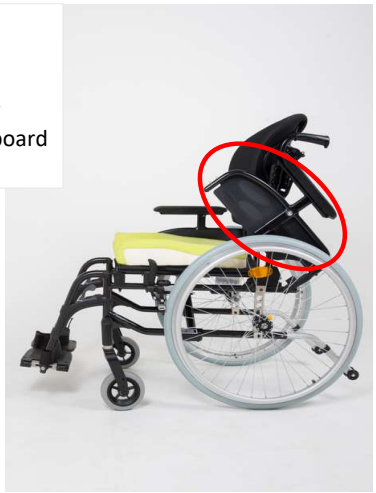
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

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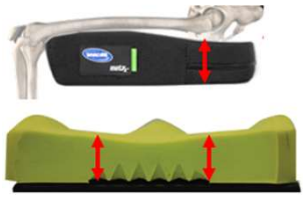
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

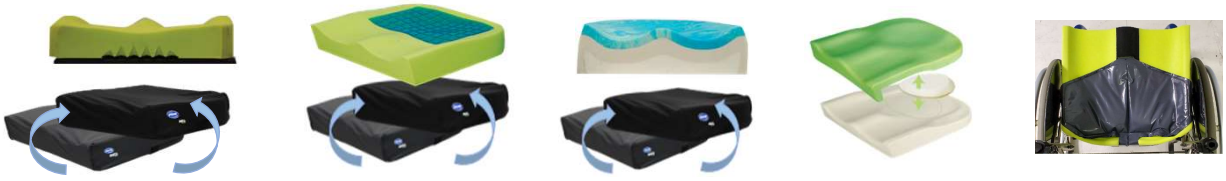
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

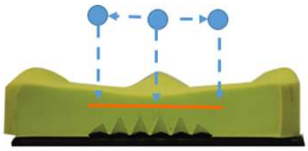
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

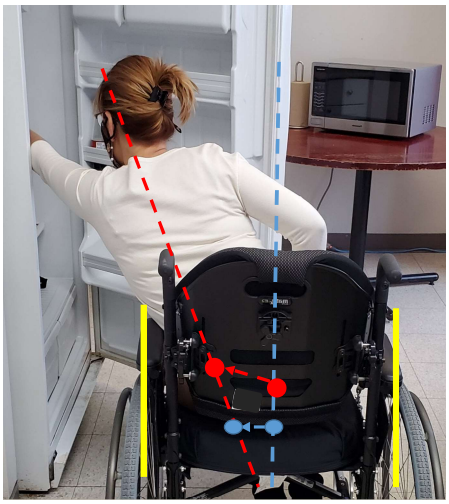
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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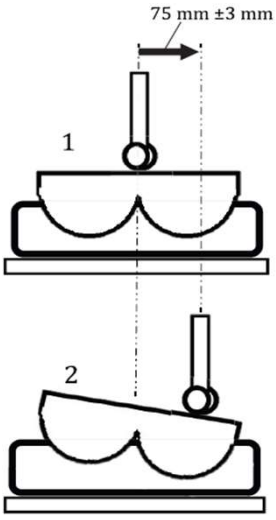
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

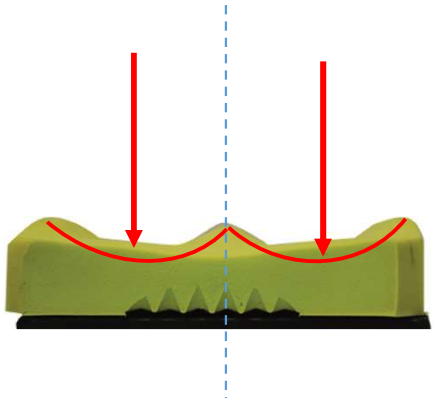
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

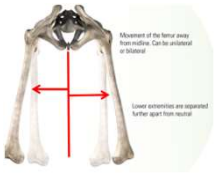
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

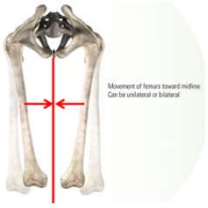


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

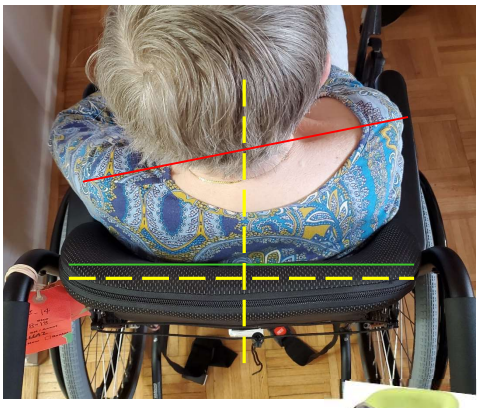
29

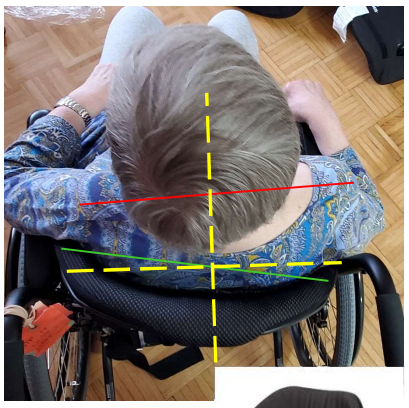
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

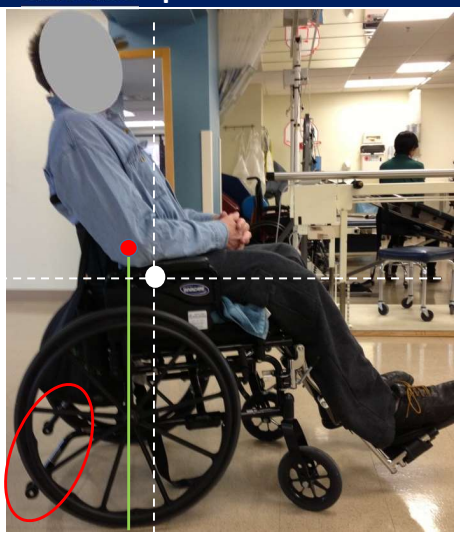
34

Wheelchair-related risk factors: rigid backrest vs upholstery back

38

Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

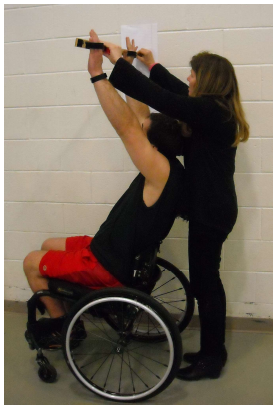
Solid posterior thoracic support with more height

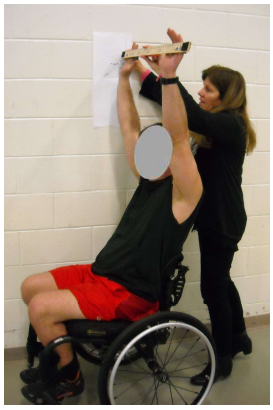
Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

39

RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

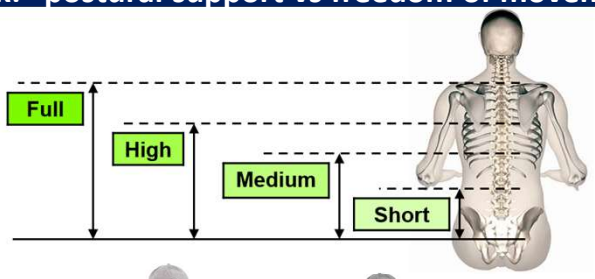
• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

41

Height of the back: postural support vs freedom of movement

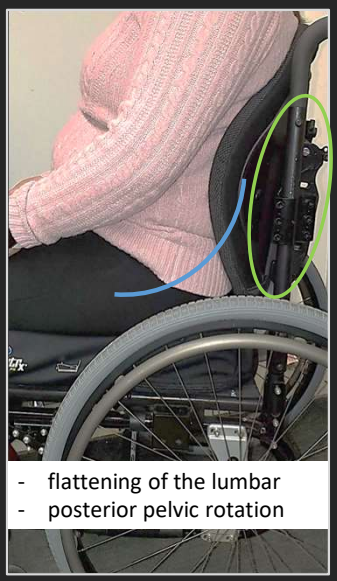


42

42

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet



- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

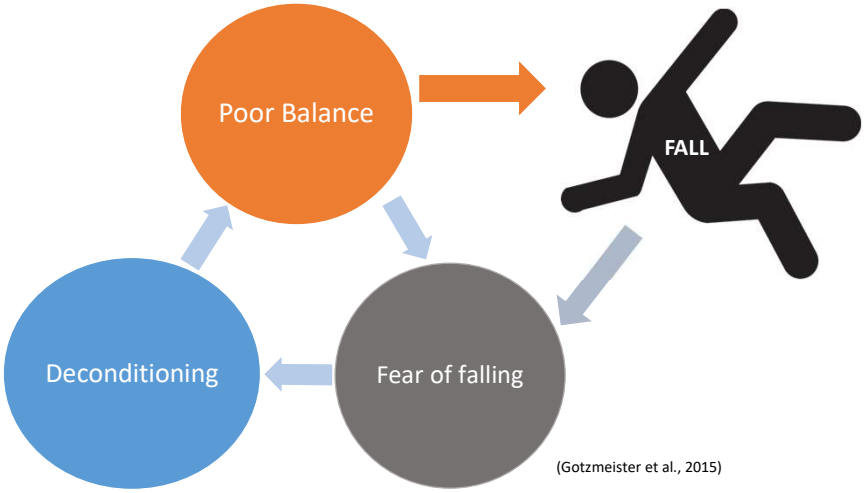
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

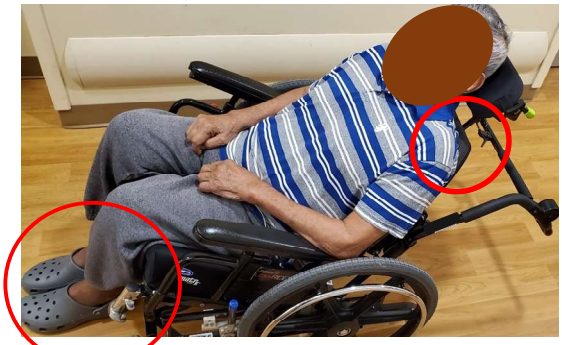
Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

52

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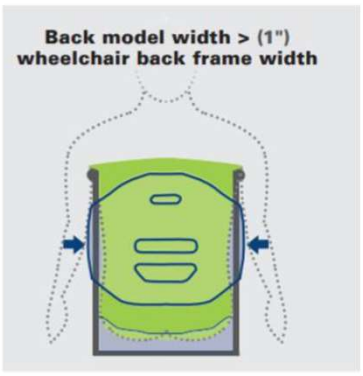
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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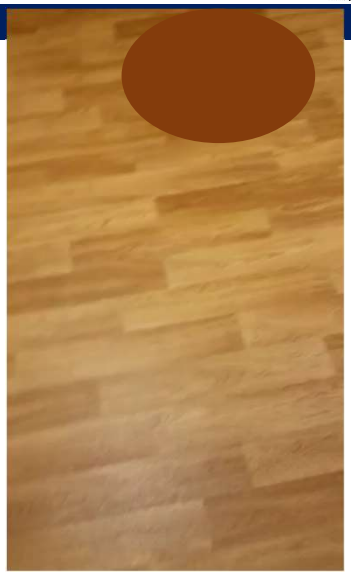
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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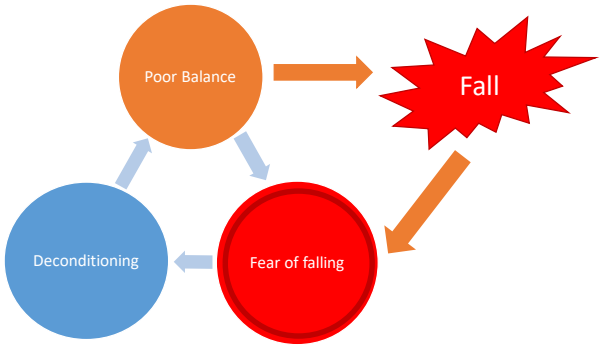
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)

3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

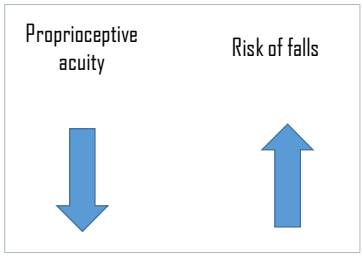
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

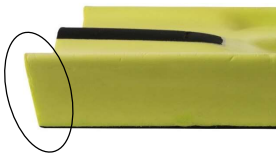
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

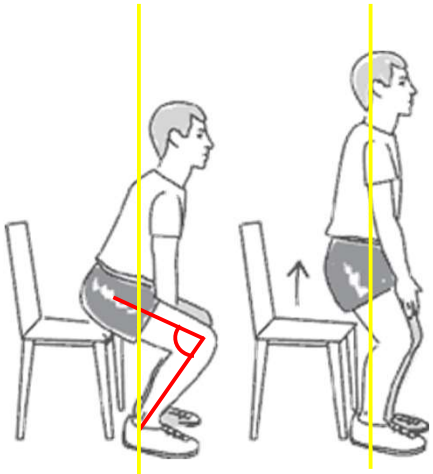
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

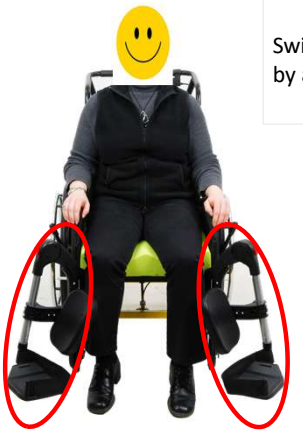
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

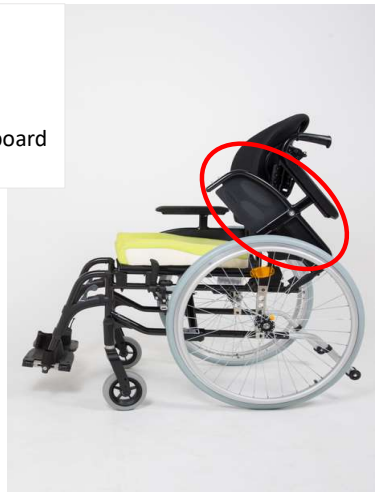
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely

- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

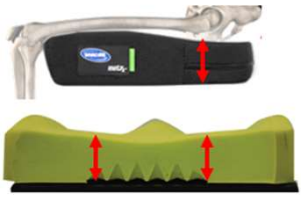
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

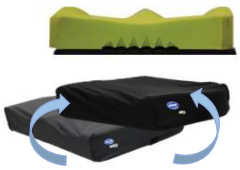
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion

Invacare® Matrx® PSP Cushion

Invacare® Matrx® Multi Cushion

Invacare® Matrx® Vi Cushion

Libra/Libra Adjust Cushion

Positioning

Skin Protection and Positioning

Skin Protection and Positioning

Skin Protection and Positioning

Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

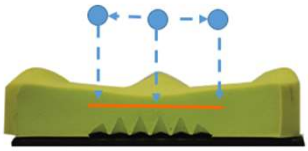
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

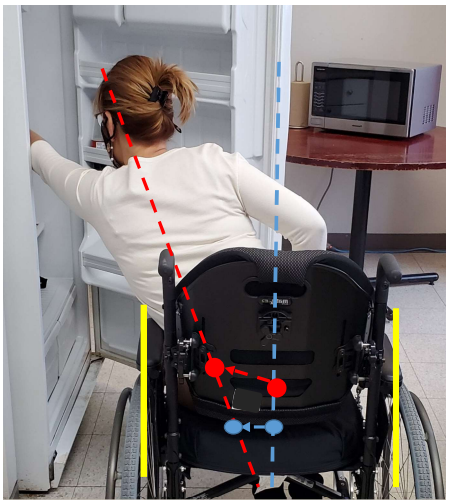
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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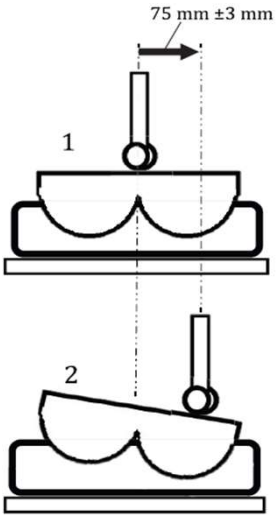
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

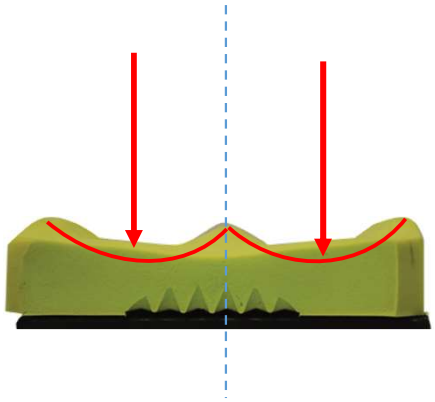
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

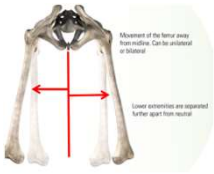
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

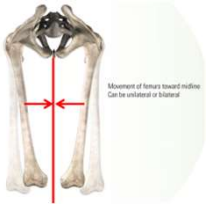


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

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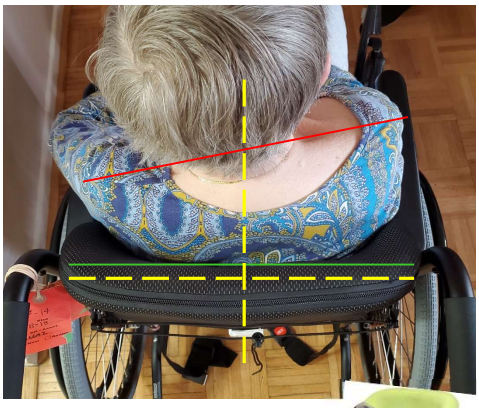
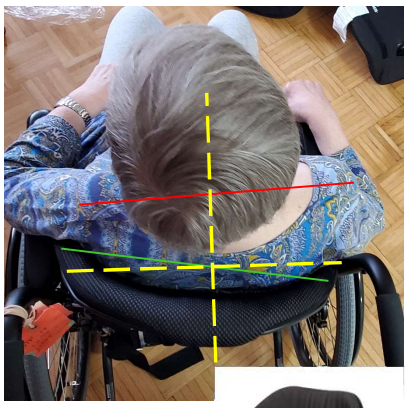
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

33

Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

34

Wheelchair-related risk factors: rigid backrest vs upholstery back

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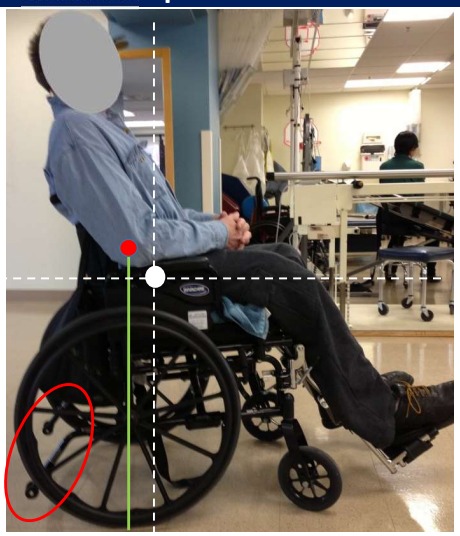
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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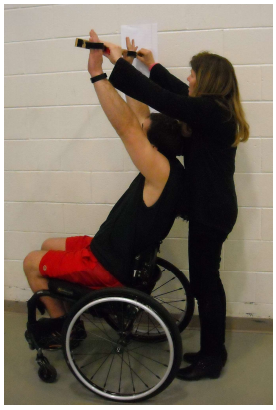
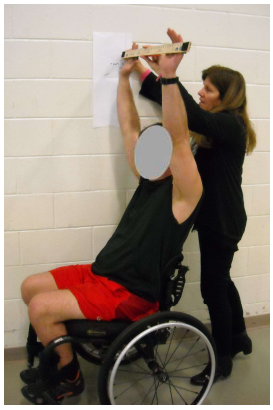
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

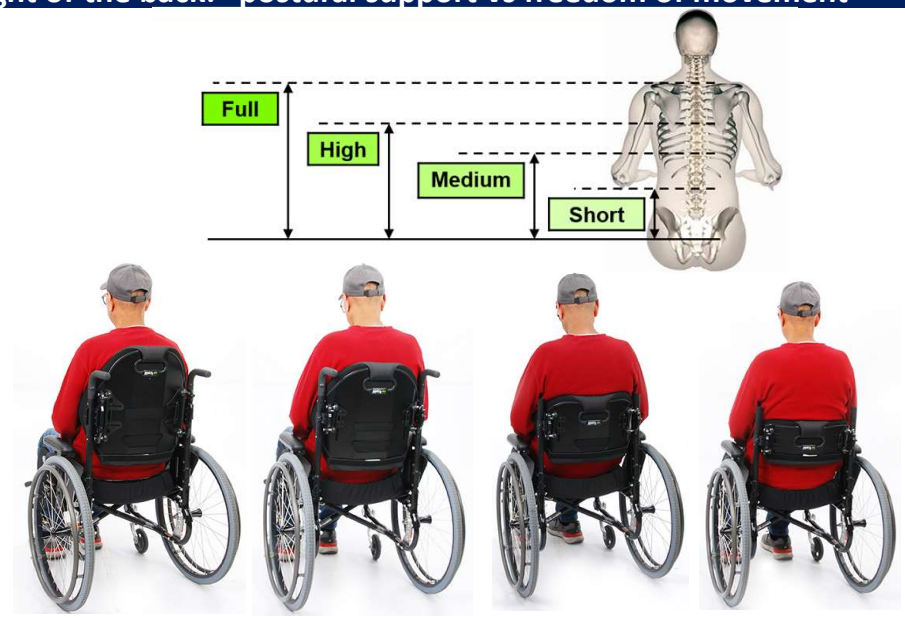
• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

41

Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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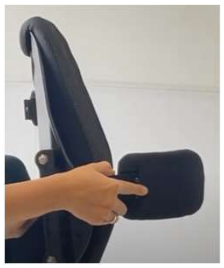
Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

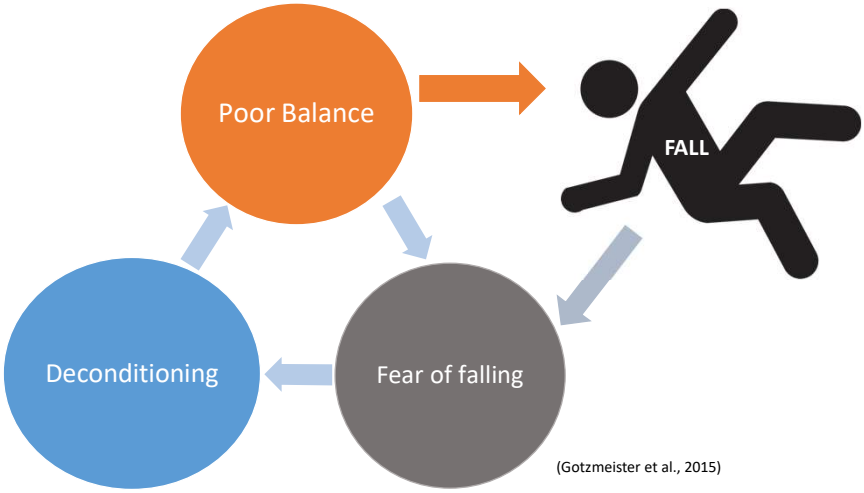
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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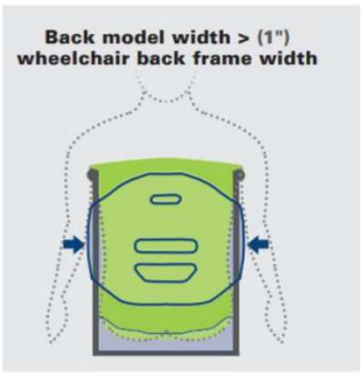
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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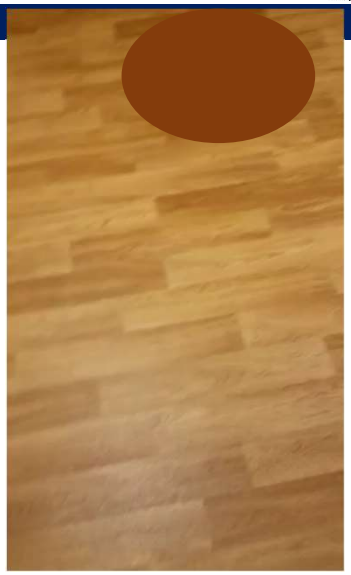
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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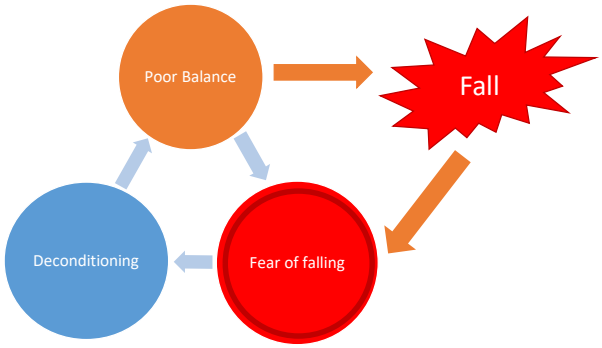
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

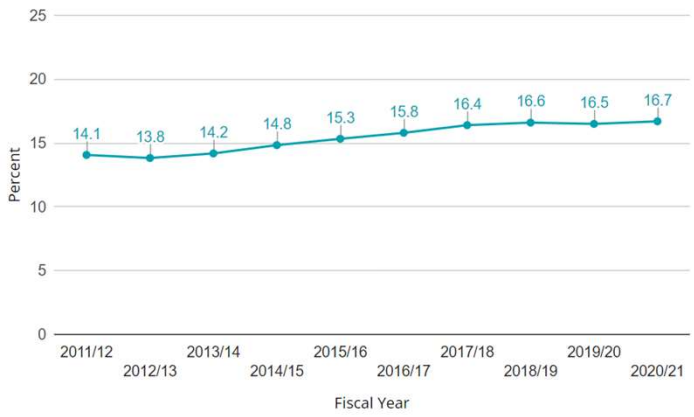
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

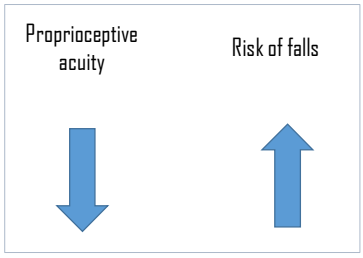
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

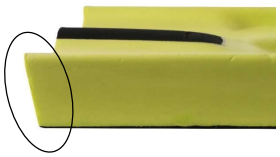
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

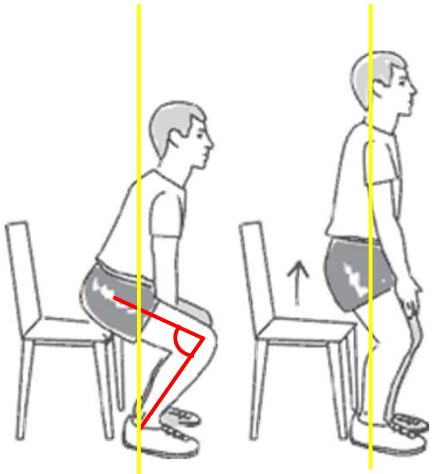
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

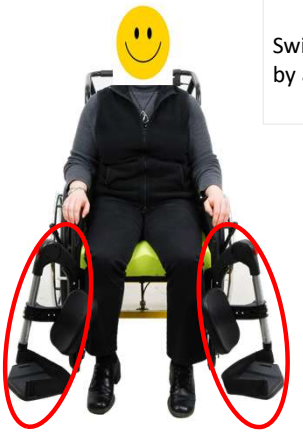
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

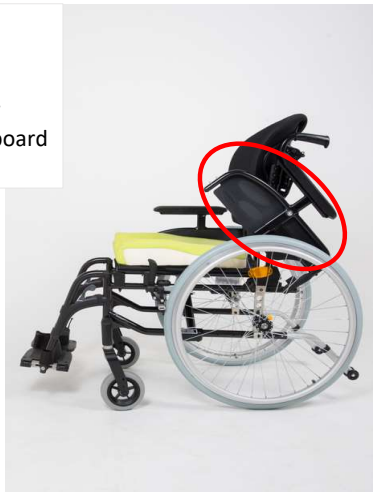
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

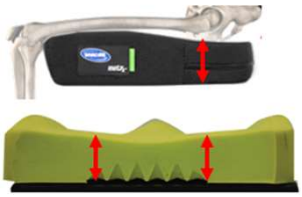
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

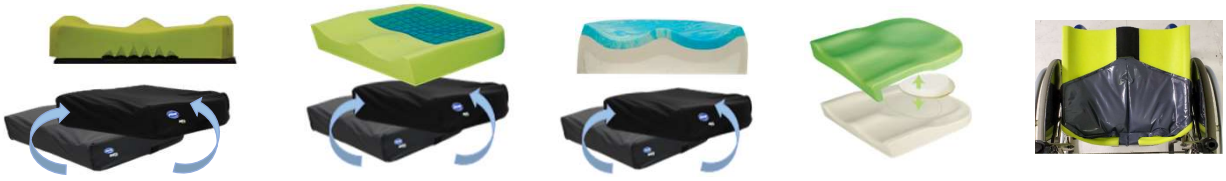
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

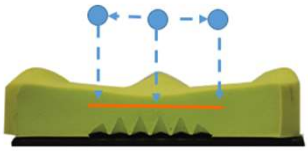
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

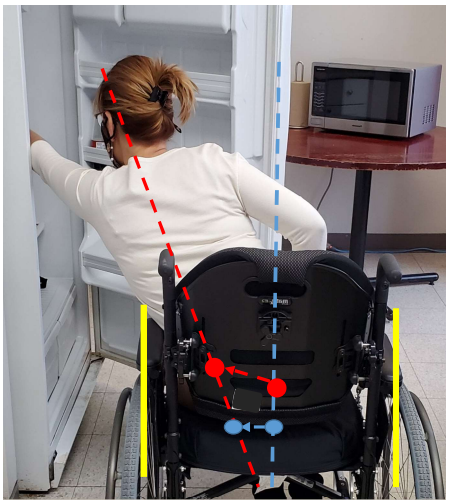
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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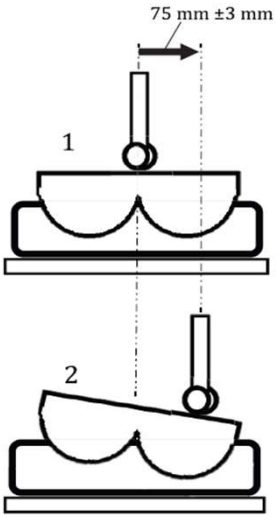
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

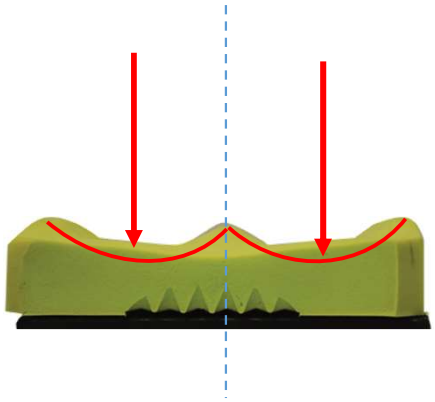
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

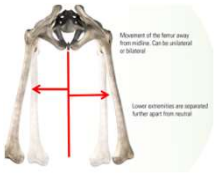
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

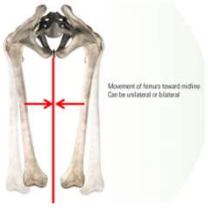


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

29

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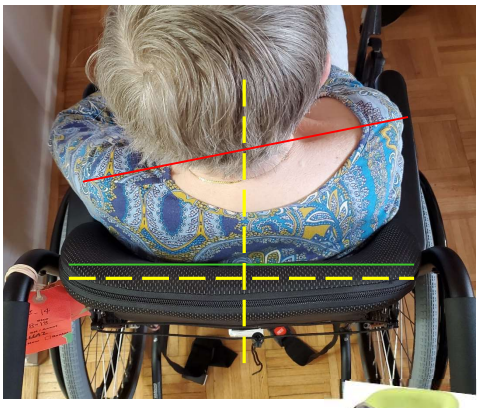
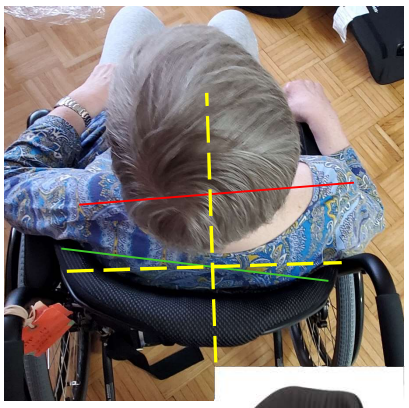
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

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Wheelchair-related risk factors: rigid backrest vs upholstery back

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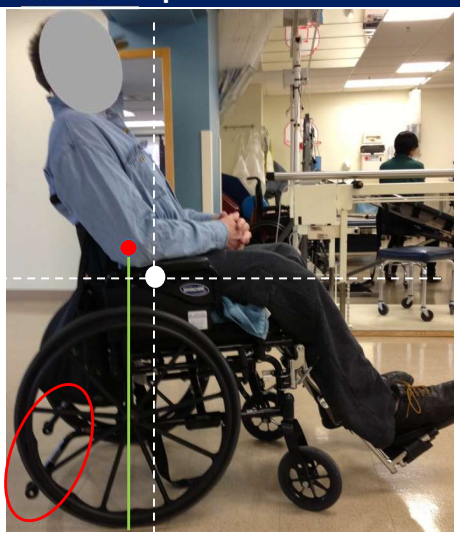
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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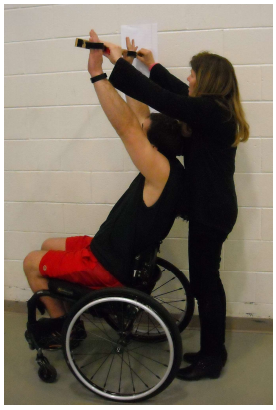
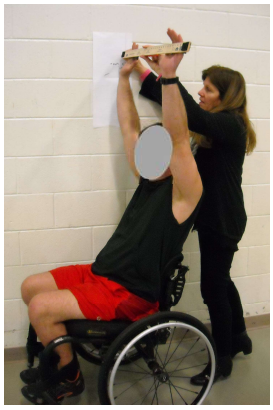
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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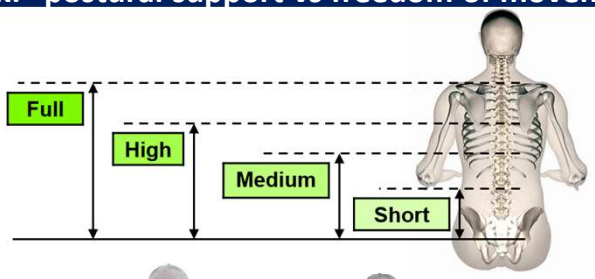
Height of the back: postural support vs freedom of movement



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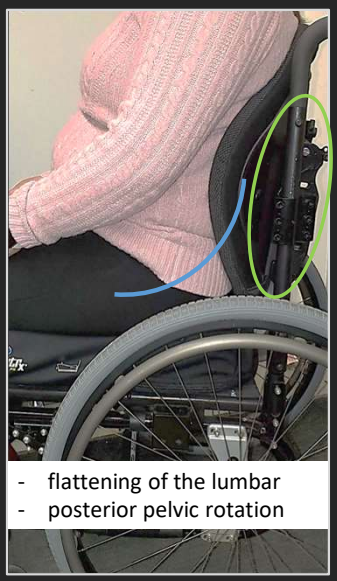
How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet



- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

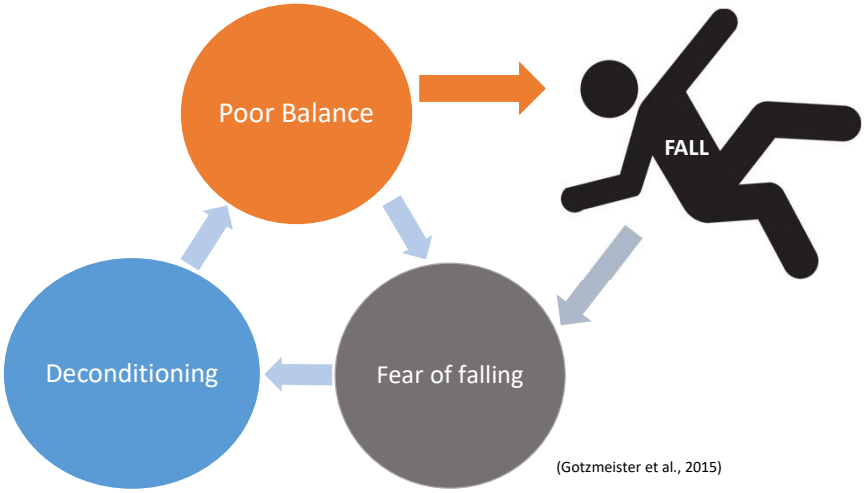
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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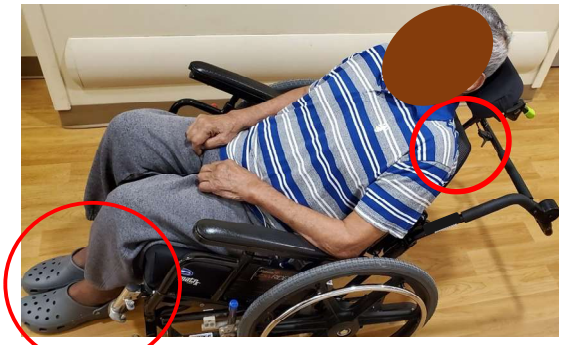
Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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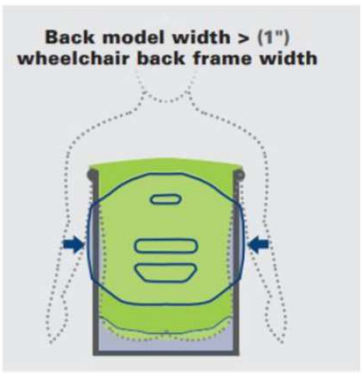
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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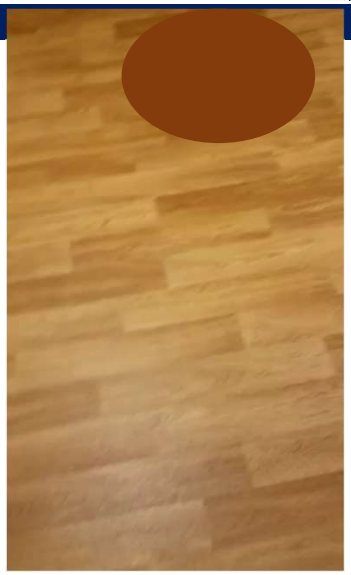
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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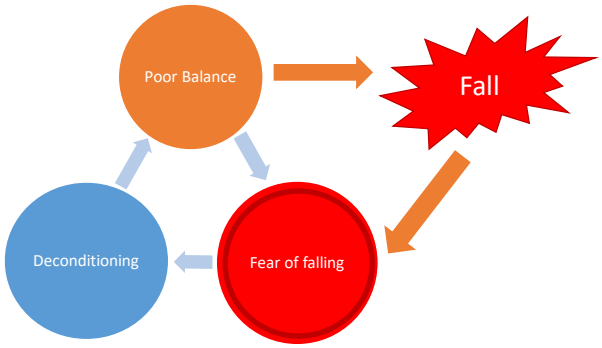
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

Anna Sokol, RN, MN, BScKin, BScN, WOCC(C)
Clinical Education Specialist
Motion Concepts

1

Learning objectives

By the end of this session, the participant will be able to:

- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)

3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

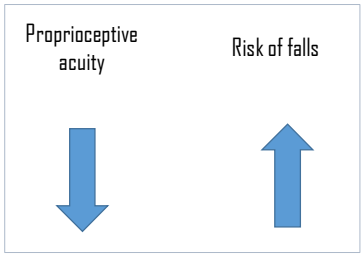
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

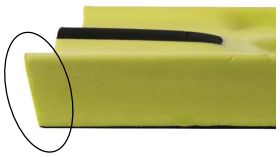
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

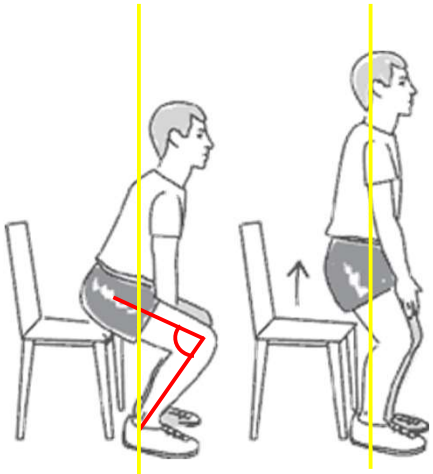
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

11

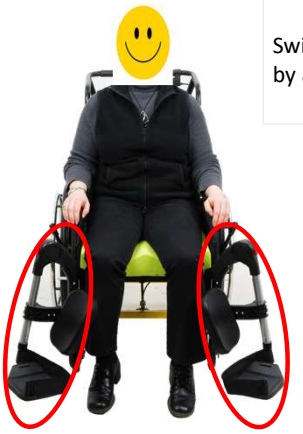
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

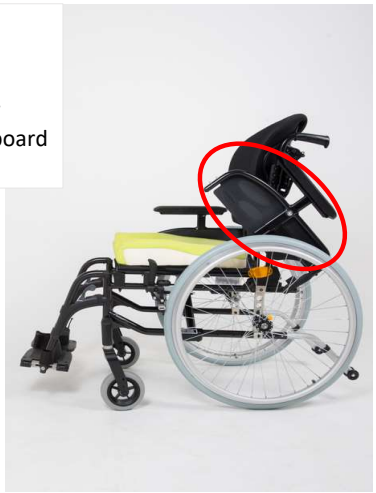
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

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Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

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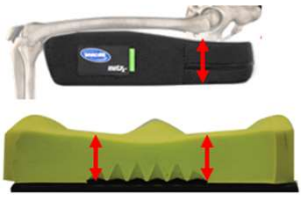
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

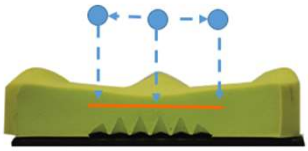
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

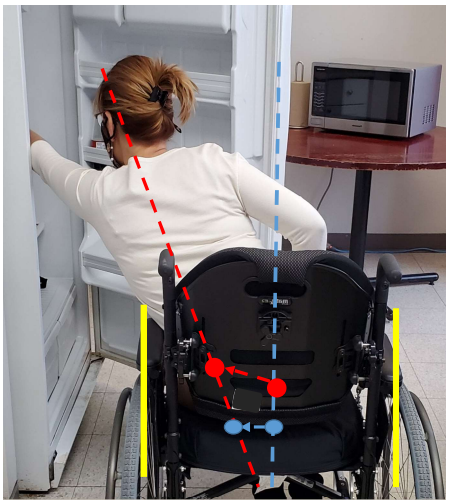
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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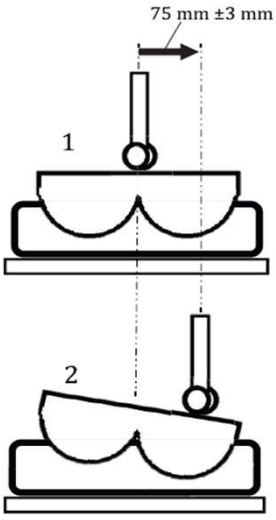
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

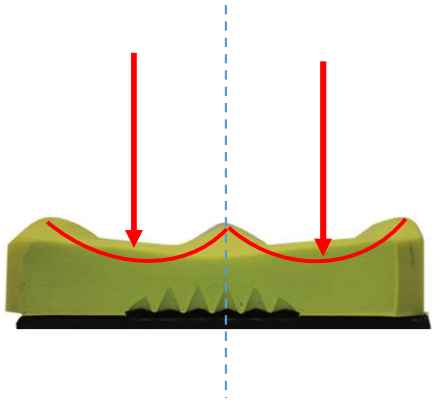
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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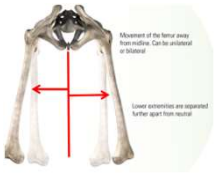
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

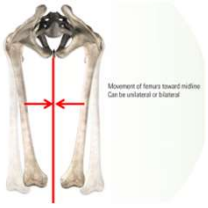


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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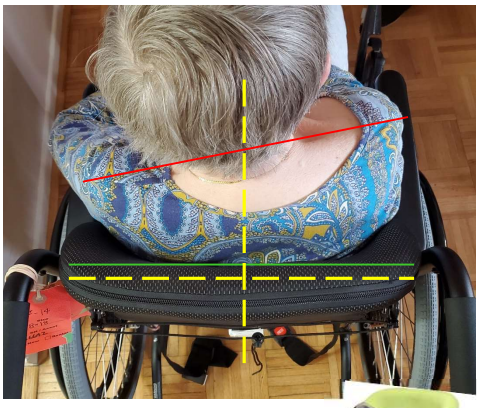
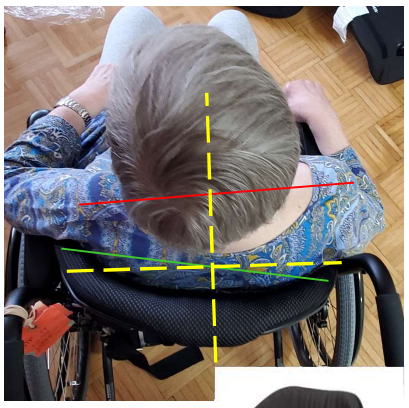
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

32

Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

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Wheelchair-related risk factors: rigid backrest vs upholstery back

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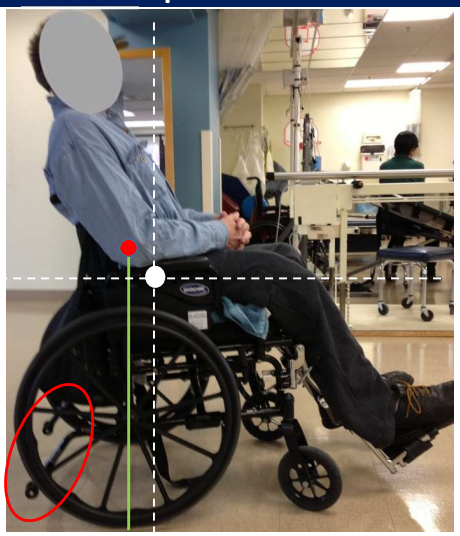
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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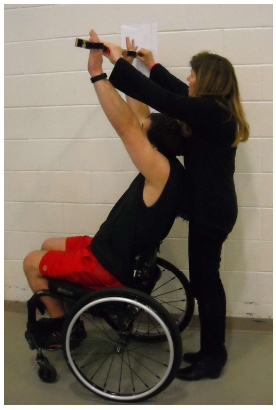
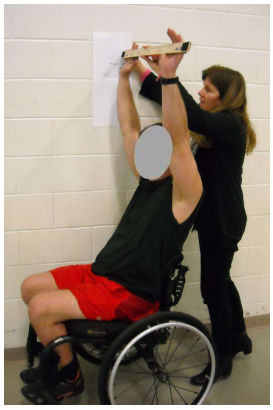
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

40

40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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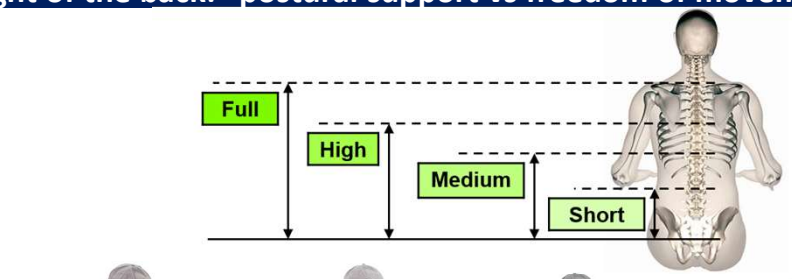
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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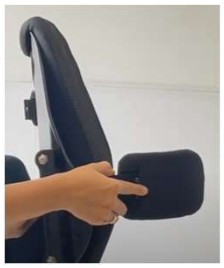
Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

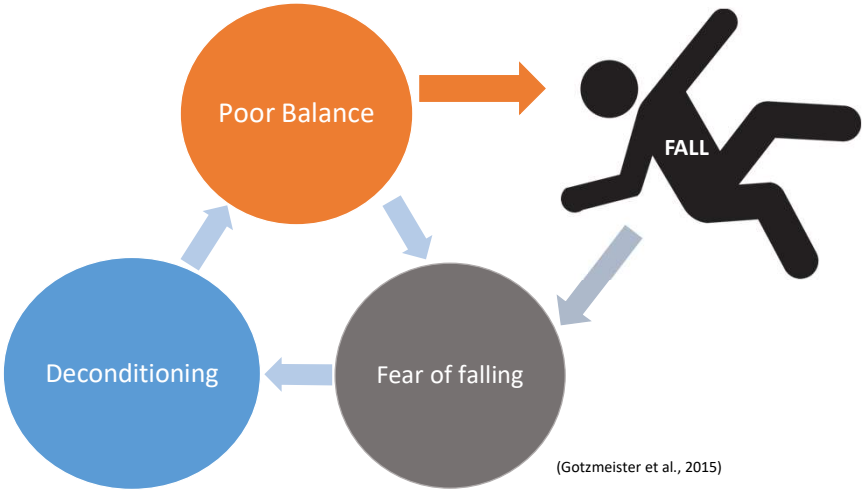
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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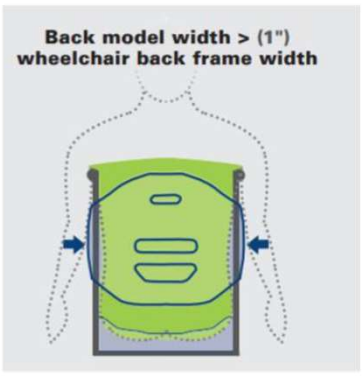
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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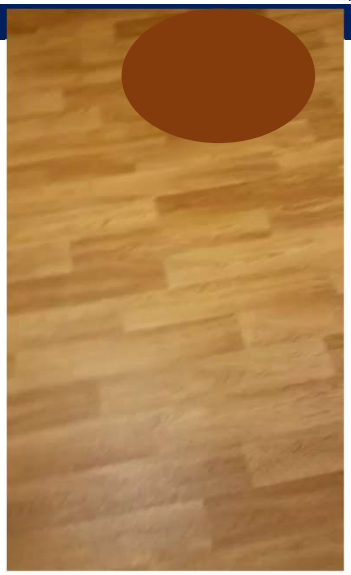
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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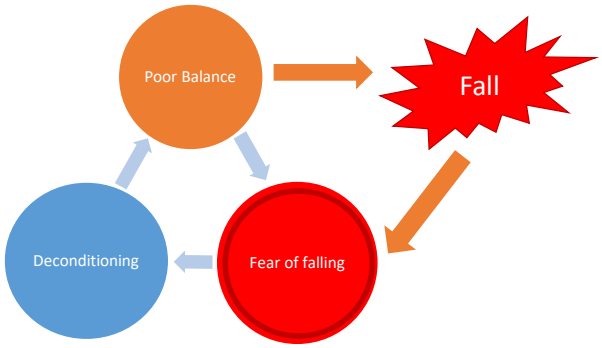
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

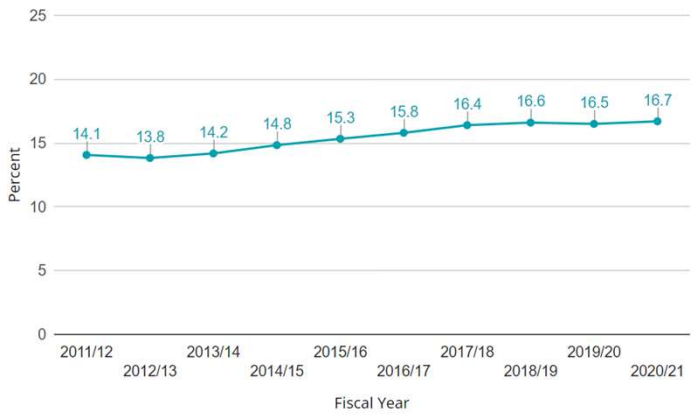
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

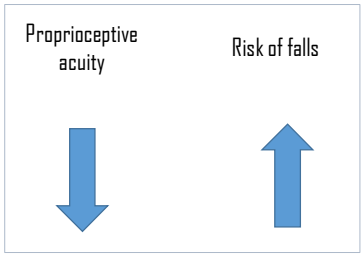
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

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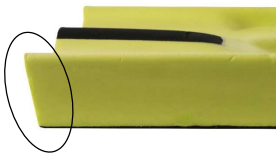
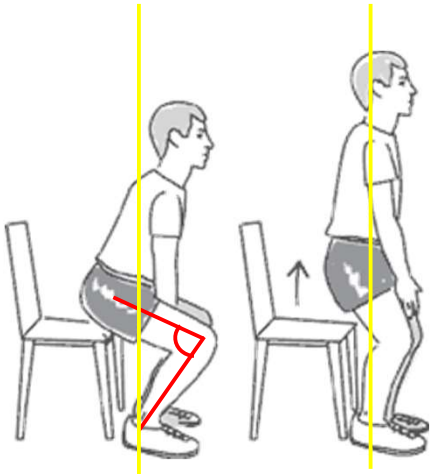
Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

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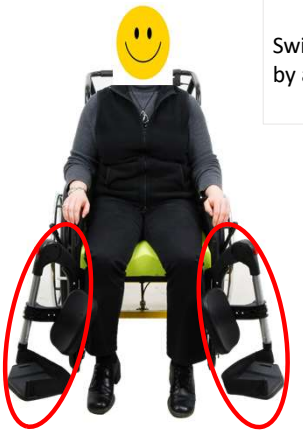
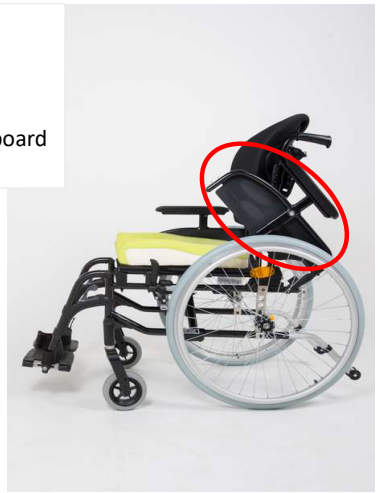
Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

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Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely

- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

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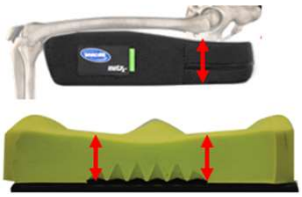
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

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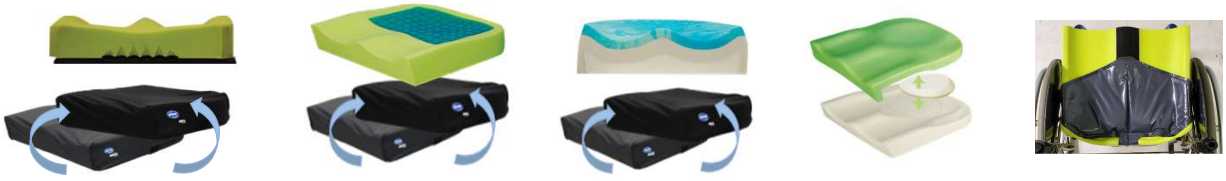
MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
				
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

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Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

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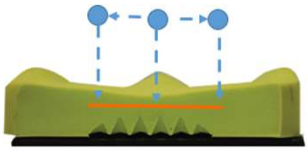
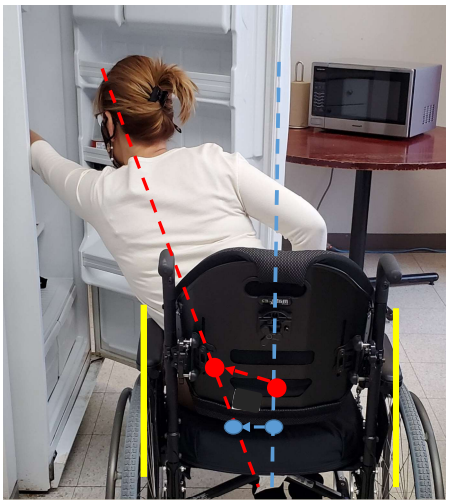
Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

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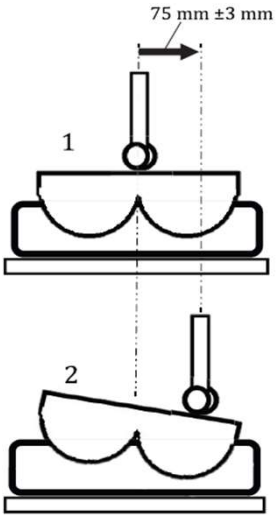
Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



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Wheelchair cushion design: Abductor and adductor contouring

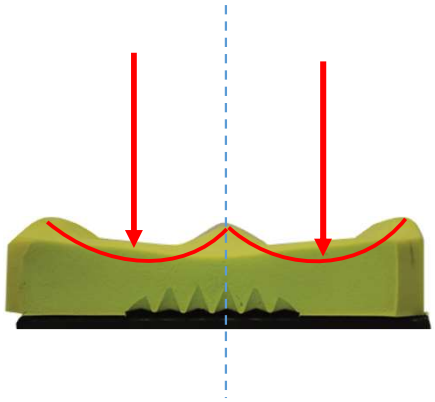
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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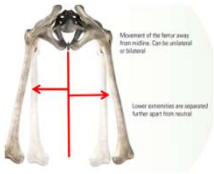
Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

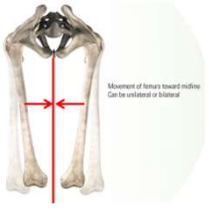


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

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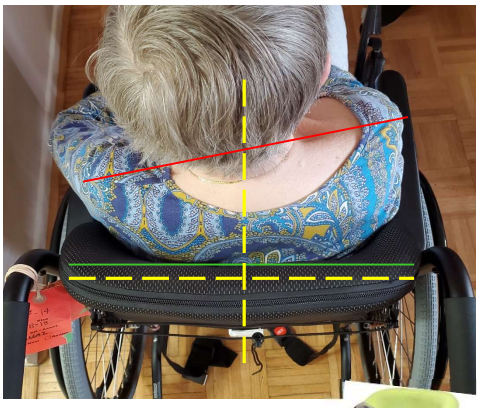
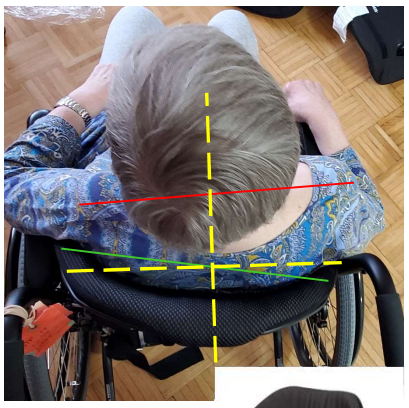
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

34

Wheelchair-related risk factors: rigid backrest vs upholstery back

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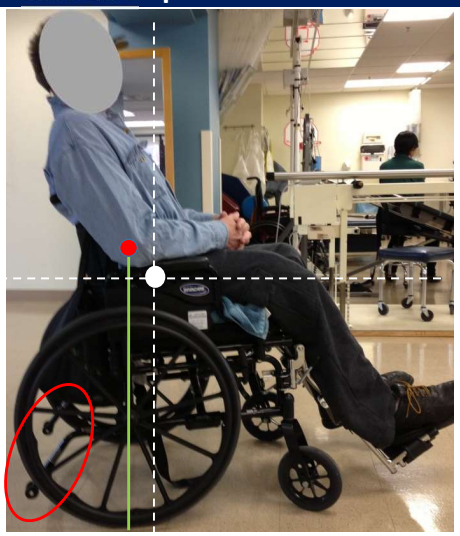
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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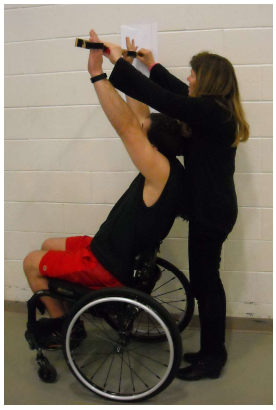
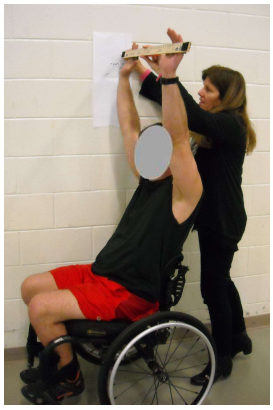
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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40

Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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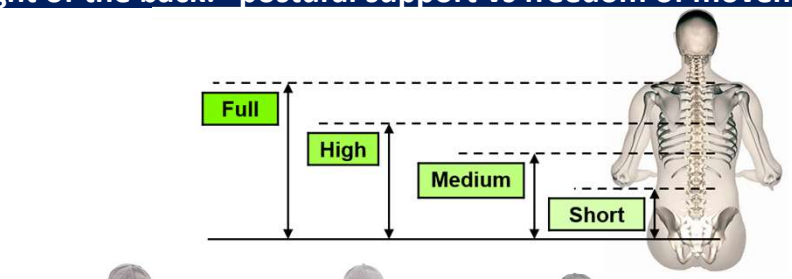
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

43

How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

44

Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

46

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

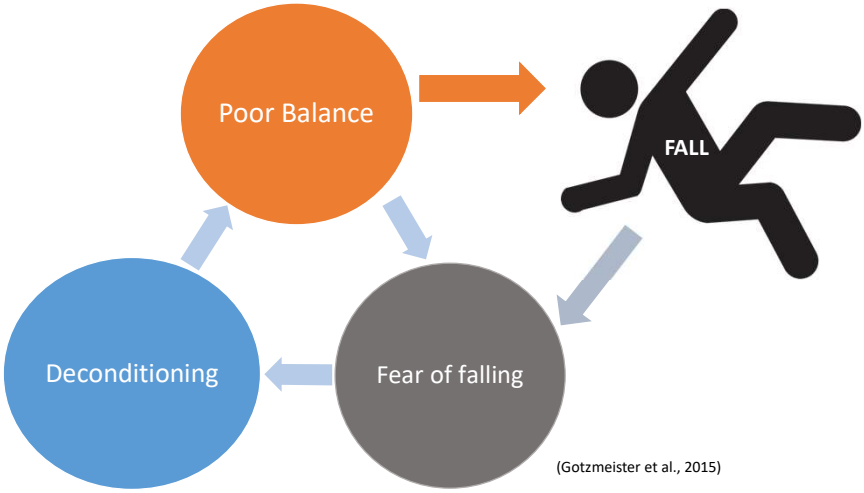
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

50

Case study: Mr. Singh

December 10 - 17

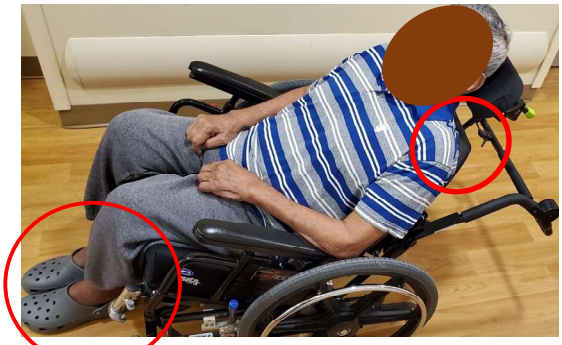
Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

51

Case study: Mr. Singh



High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

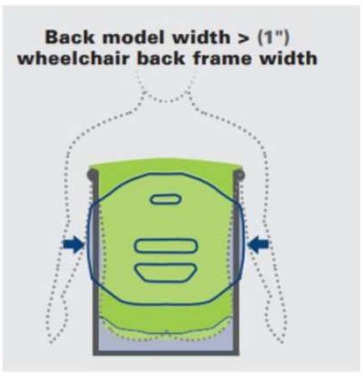
52

52

Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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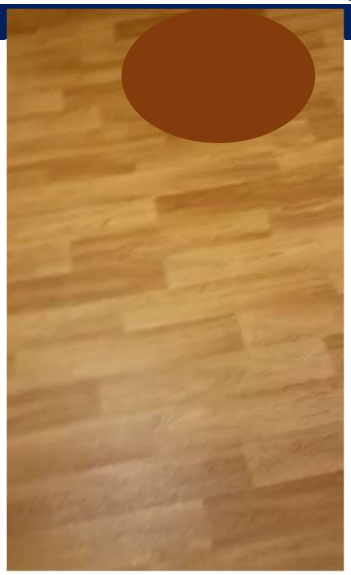
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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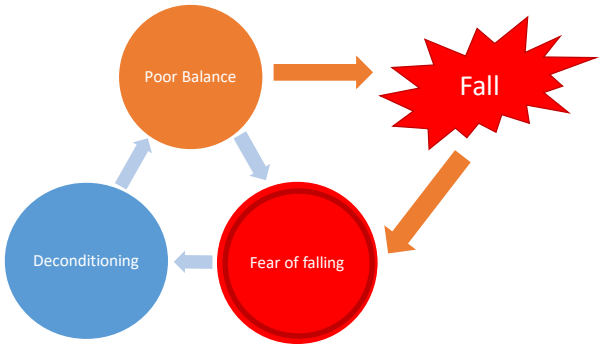
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

59

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Fall Prevention & Wheelchair Seating

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1

Learning objectives

By the end of this session, the participant will be able to:

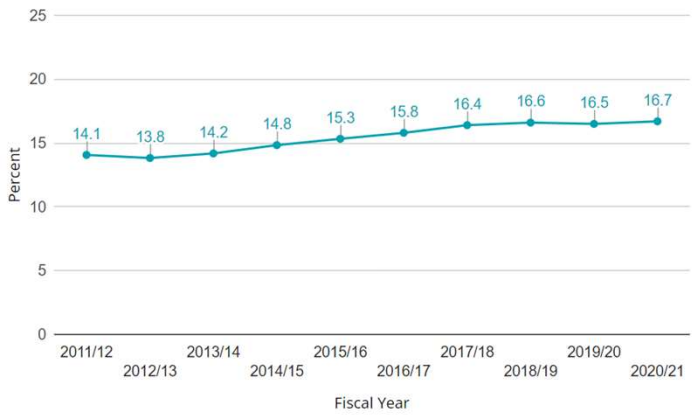
- List 3 most common wheelchair-related activities associated with falls.
- Name 3 aspects of wheelchair cushion design aimed to prevent sliding out and to minimize risk of falling.
- Explain how height of the back and depth of the cushion affect centre of gravity and wheelchair stability.
- Describe postural support and back hardware set up options that may help stabilize the person in his/her wheelchair
- Discuss the role of OT in addressing patient's seating safety and postural goals

2

Ontario LTCs: Falls statistics

Percentage of long-term care home residents who fell, in Ontario,2011/12 to 2020/21

HQO (2022)



3

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care

(Yang et al., 2017)

Activity at time of fall	Number of falls (%)	
	Men (N=231)	Women (N=298)
Walking	29.2	40.3
Standing	25.0	23.8
Sitting down or lowering	15.9	14.3
Seated or wheeling	15.5	11.5
Getting up or rising	14.4	10.2
Slip	0.9	0.9

5

British Columbia LTC falls study: How do people fall?

Falls captured on video in long-term care (N=529)

(Yang et al., 2017)

Falls while getting up

- 40% were associated with moving objects and loss of support
- most often due to
  incorrect shift of body weight or
  excessive sway of the trunk

Falls while seated

- most often due to loss of support associated with
  moving object (60%) or
  sliding out of a chair (40%)

Number of falls suffered:

Number of falls	**% of participants** (N=529)
1	46 %
2	20 %
3	10 %
4	6 %
5 or more	18 %

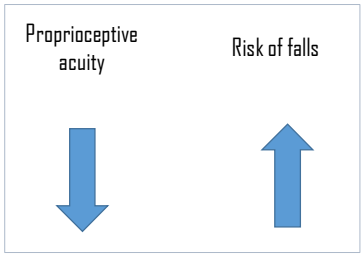
6

Proprioception and balance

Proprioception – position and gravity sense

Proprioception affects person's control of movement. Proprioception is created as a result of the brain processing information from:

- sensory nerves (joint position sensed by Vater-Paccini corpuscles in ligaments)
- sensation from skin (touch and stretch)
- motor nerves (degree of effort required to move the body part)
- input from visual cortex
- vestibular system



(Suetterlin & Sayer, 2014)

7

Proprioception: Why is incorrect shift of body weight so common in seniors?

Proprioception is ***worsened*** with:

- Aging (changes in muscles and nerves)
- Visual changes
- Surgical interventions in joints
- Arthritis or other pathological changes
- Injections into the joints
- Neuropathy
- Prolonged vibration
- Immediately after intensive exercise
- Spatial neglect or 'pusher syndrome' (changes in processing visual input after CVA/strokes)
- Low back pain (reliance on trunk proprioception with decline of proprioception in legs)
- Simultaneous demand for cognitive attention to dynamic postural control

Proprioception is ***improved*** with:

- Improvements in vision
- Regular balance training on unstable surface
- Short-term vibration
- Sensation of touching a surface/object
- 3-point or 4-point surface contact (e.g. back of the legs + both hands on armrests)
- Balanced posture of the trunk

(Haibach, Slobounov, & Newell, 2009; Karnath & Broetz, 2003; Nishio et al., 2019; Toosizadeh, Ehsani, Miramonte, & Mohler, 2018; Vermette et al., 2019)

8

Sitting down or lowering

Getting up or rising

Seat-to-stand

Stand-to-seat

9

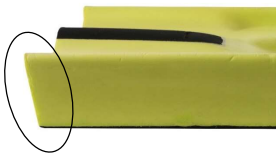
Wheelchair-related fall prevention: Seat-to-stand transfers

Seat-to-stand transfer is safer, when:

- Legs are positioned midline in preparation for transfer
- As many points of contact with surfaces as possible are utilized for stability – to facilitate peripheral sensory input (both arms, both legs if possible)
- Armrests are stable positioned to serve as base of support and can withstand person's weight
- Leg rests may be moved to eliminate potential obstacle (e.g., swing-away design)
- In preparation for transfer, the legs are tucked under the seat to bring centre of gravity forward

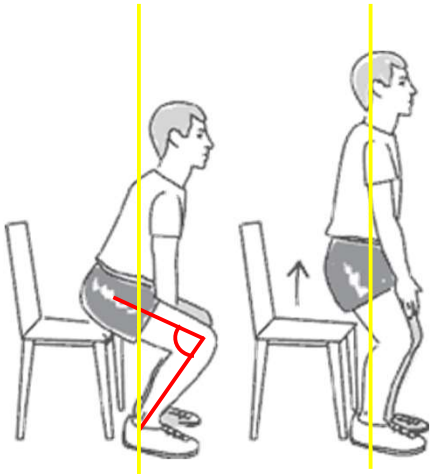
10

Wheelchair cushion design: Waterfall front edge



Waterfall front edge

- Allows to tuck the feet under for safe transfer of weight during seat-to-stand task
- For visually impaired, this preparation for transfer improves balance and stability and may prevent fall



For visually impaired, **sit-to-stand task** is more risky due to:

- altered perception of location in space (proprioception)
- impaired sense of balance
- excessive anterior-posterior movement (forward and back)
- excessive movement in the vertical axis (upward)

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

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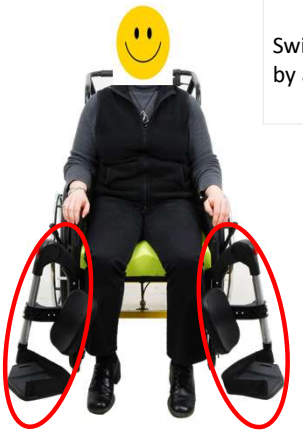
Wheelchair-related fall prevention: Stand-to-seat transfers

Stand-to-seat transfer is safer, when:

- Front surface of the cushion is designed to maximize contact and proprioception (e.g., with waterfall edge design, sensation of touching a seat at the popliteal area is more prominent and gives person a 'message' that wheelchair is reached)
- Swing-away leg rests allow to come closer to the chair
- Floor-to-seat height is appropriate
- 3- or 4-point surface contact for stability helps to balance centre of gravity (e.g. legs on the floor + both hands on a walker)
- The chair is locked and is not moving

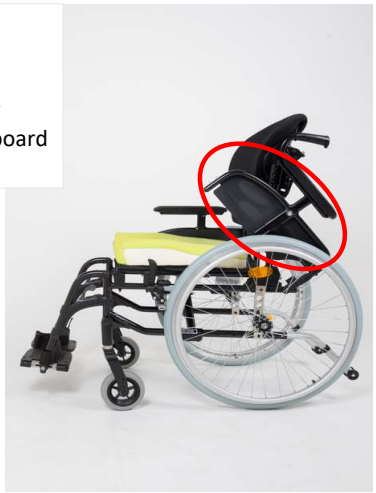
12

Wheelchair-related fall prevention: Removing obstacles



Swing-away leg rests
allow to move away tripping hazard

Swing-away arm rests make side transfer safer
by allowing better positioning of the transfer board



13

Falling while being seated or wheeled: sliding out of the wheelchair

Posture – related?
Wheelchair – related?
Wheelchair seating - related?

Or all the above?

1. Assess patient (mat assessment)
2. Assess the wheelchair

- Start from the seat, then look at the back, then the rest of the wheelchair system
- Change one thing a time and assess postural changes

14

Wheelchair seat and cushion heights

Seat-to-floor height too high
or seat cushion too deep:

- Hard to reach the floor, and the person slides forward deliberately
- If cushion cover is slippery, falls due to sliding out are more likely
- Increased degree of shear and risk of skin injury
- Increased pressure to the heels
- Check if the footrests are possibly missing (Is person foot-propelling?)

15

Proper size and centre of gravity

Wheelchair too small

- Seat cushion too short
- Seat-to-floor height too low
- Centre of gravity is too far forward
- High risk of falls due to tipping forward

16

16

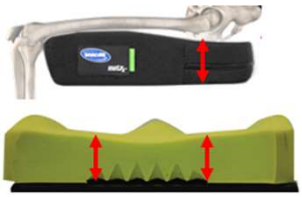
Wheelchair seat and cushion heights

Is wheelchair height appropriate for a person?

Is it low enough for sit-to-stand transfers?

Is it high enough for a person's weight to be distributed evenly?

Is it low enough for legs to reach the floor and for foot-propelling?



Height of a seat pan

Seat height with cushion

17

17

Wheelchair cushion design for fall prevention

Rear cushion radius
- Promotes sacral support and optimal pelvic positioning
- Prevents posterior pelvic tilt and flattening of the lower back

Pelvic Seat Well
- Facilitates immersion and anterior/posterior pelvic stability
- Promotes spinal extension for improved upper body and upper extremity function

Pre-ischial contour
- Prevents sliding and forward migration of pelvis
- Prevents posterior pelvic tilt and flattening of the lower back

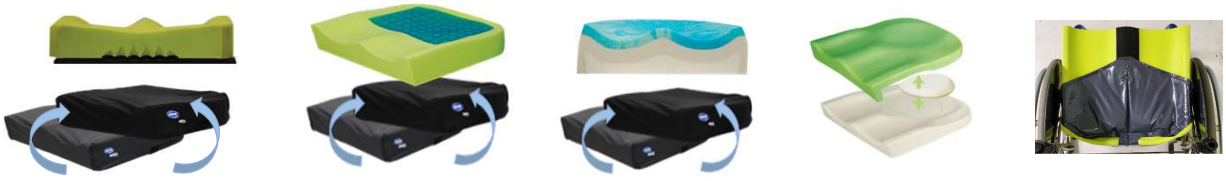
Adductor and Abductor Contouring
- Designed for midline positioning to facilitate pelvis stability
- Prevents knees from moving medially or laterally

Preventing sliding out of a chair

Low profile
- Helps with static and dynamic stability
- Helps to keeps centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

20

MATRX CUSHIONS CONTINUUM OF SKIN PROTECTION



Invacare® Matrx® PS Cushion	Invacare® Matrx® PSP Cushion	Invacare® Matrx® Multi Cushion	Invacare® Matrx® Vi Cushion	Libra/Libra Adjust Cushion
Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Skin Protection and Positioning	Adjustable Skin Protection and Positioning

Degrees of Skin Protection

21

Wheelchair cushion design: Anterior part of the cushion

Preventing sliding out of a chair

Anterior (front) wedge

When adjustment of the height of the seat is not possible,
anterior wedge placed under the front of the cushion
may provide just enough height to prevent sliding out of the chair

Unilateral placement of the anterior wedge may provide more balance for patients with amputations or clients propelling with only one leg

22

Wheelchair locks and seat belts

Apply locks!!!
- when not propelling
- when not being transported

Educate patients
Educate all caregivers
Use effective reminders and cues

Are locks within easy reach?

Is seat belt on during activity/movement?

23

Wheelchair-related fall prevention: anti-tippers, casters, axles, and armrests

Educate patients
Educate all caregivers
Use effective reminders and cues

Use anti-tippers
Check position of axles
Apply seat belt during transfers
Use contoured low profile cushion
Don't forget to put armrests back after side transfer
Adjust wheelchair casters to improve stability during transfers

In the Nova Scotia study (Kirby et al., 1994),
out of 331 manual chair propellers who fell:
— 46.3% fell forward,
— 29.5% backward
— 24.2% sideways

24

Wheelchair-related risk factors: Centre of gravity

For patients in manual chairs,
centre of gravity
should never fall
outside the boundaries
of the base of support

In the absence of a negative camber of the wheels (neutral upright position), this tennis player would fall

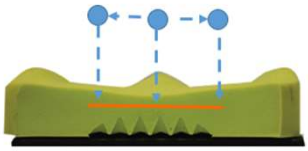
Negative camber widens the base of support to ensure centre of gravity stays within the boundaries

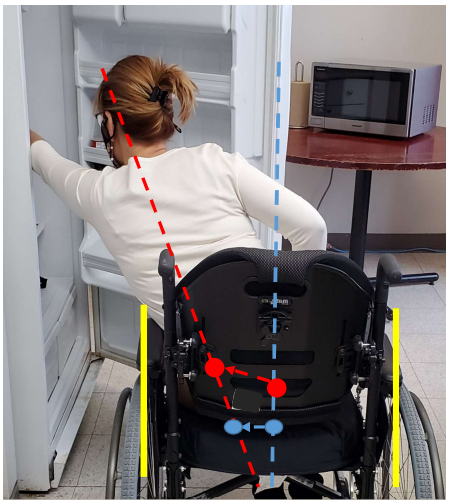
25

Wheelchair-related risk factors: Centre of gravity

Dynamic stability:
Seat cushion is said to be stable when it allows the center of pressure to cover a larger distance with higher speed during voluntary reaching tasks without falling out of the chair

(Aissaoui et al., 2001)





Red dotted line represents the axis of body position
Red dot – centre of gravity that shifts to the left and upright when person leans to the side and extends the arm
Blue dotted line represents the axis of body positioning when the person is sitting upright in the wheelchair
Blue dot – centre of pressure that shifts to the left when person leans to the left side
Yellow line – boundaries of the base of support (frame of the chair)

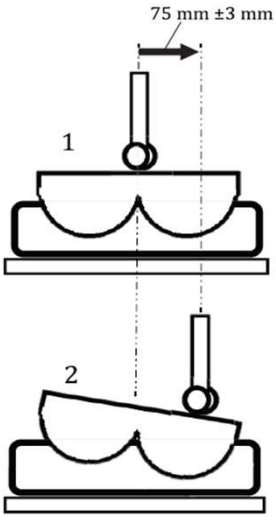
26

Wheelchair-related risk factors: Cushion stability

INTERNATIONAL STANDARD **ISO 16840-13**

Wheelchair seating —

Part 13:
Determination of the lateral stability property of a seat cushion



27

Wheelchair cushion design: Abductor and adductor contouring

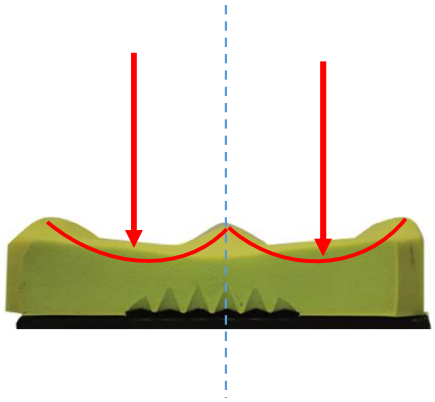
For elderly females **sit-to-stand task** with adducted hips presents

- risk of instability
- the highest challenge for balance control
- high risk of falls

Risks are related to challenges of coordinating simultaneous ankle, lower leg, and hip movement

(Jang, Kim, & Yoo, 2014)

Importance of Midline Leg Positioning



For visually impaired, **sit-to-stand task** is affected by

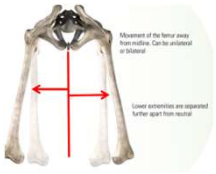
- altered perception of position in space
- altered centre of mass transfer
- altered use of dominant and non-dominant legs and feet

(Aylar, Dionosio, & Jafarnezhadgero, 2019)

28

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

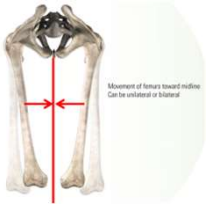


Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive abduction

Adduction



Abductor

improve midline leg positioning for patients with excessive adduction

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Nancy: addressing pain, postural collapse and falls for patient with extreme rotation

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

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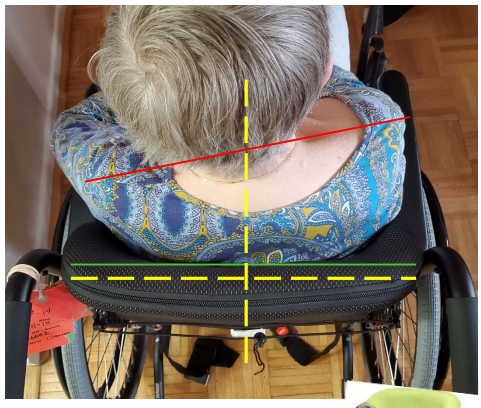
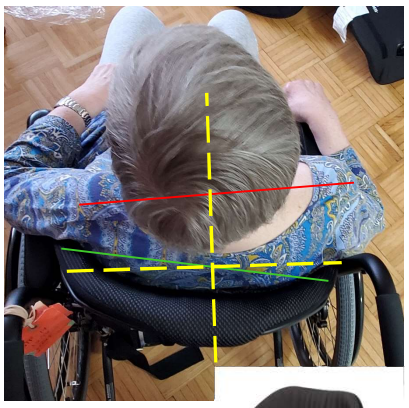
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation





Matrx PB Back

Matrx Elite E2 Back

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Nancy: comfortable deep cushion

Top layer
SuperSoft BreZZy Viscofoam
Middle layer
Anatomically molded Viscofoam
Bottom layer
Anatomically contoured HR Foam

Invacare® Matrx® Multi Cushion

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Nancy: fitted contoured E2 back in shorter height + anterior postural support

September 15, 2022 – Second trial – E2 1814 (shorter back) and Posture Flex

Reduced rotation of the back mount by ≈10 degrees (from 20° earlier)

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Wheelchair-related risk factors: rigid backrest vs upholstery back

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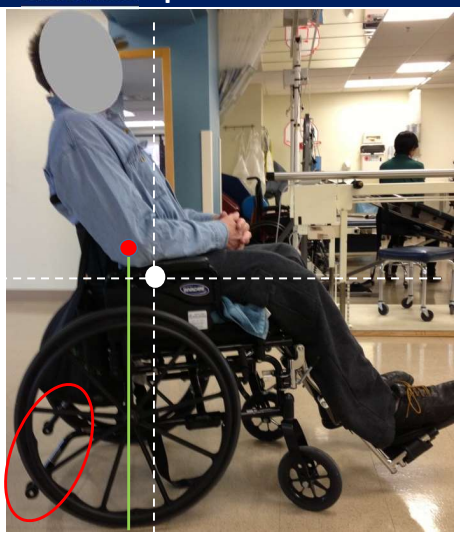
Wheelchair-related fall prevention: Centre of gravity corrected by rigid back support

Chair tipping over to the back placed stress on anti-tippers



Sling upholstery with lower thoracic support

Solid posterior thoracic support with more height

Balanced chair
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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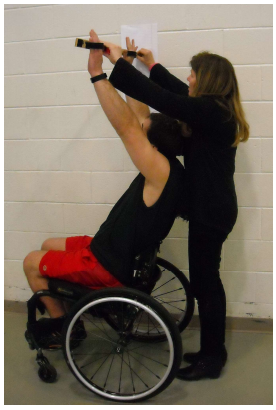
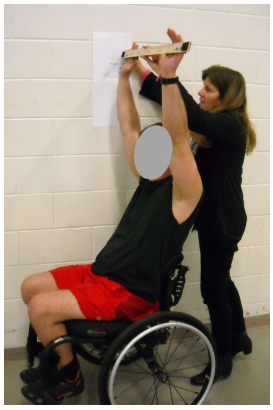
RESEARCH ARTICLE BY Shirley Ryan AbilityLab CRAIG

Wheelchair backs that support the spinal curves: Assessing postural and functional changes





- Patients with motor complete SCI (spinal cord injury) in T4-C6 level using contoured Matrx backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:

- 9° better (less posterior) pelvic angle ($\bar{x}$=96.92°)
- 2° better (more upright) spinal angle
- sitting 2cm taller
- lower pain levels (0.78 points lower intensity)
- reaching 5cm further in vertical forward reach task
- propelling manual chair 26 cm further with 1 stroke push
- going faster by 1.75 sec on a 23 m propelling test
- 7 sec faster on ascending and 1 sec faster on descending ramp[2]

- 1Center for Rehabilitation Outcomes Research, Shirley Ryan AbilityLab, Feinberg School of Medicine, Northwestern University, Chicago, Illinois, USA, 2Craig Hospital, Denver, Colorado, USA

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Matrx® E2 Back Models and Sizes: Infinite Height Options

WIDTH

HEIGHT	14"	15"	16"	17"	18"	19"	20"
FITS W/C	13"-16"	14"-17"	15"-18"	16"-19"	17"-20"	18"-21"	19"-22"
6"	•	•	•	•	•	•	•
8"	•	•	•	•	•	•	•
10"	•	•	•	•	•	•	•
12"	•	•	•	•	•	•	•
14"	•	•	•	•	•	•	•
16"	•	•	•	•	•	•	•
18"	•	•	•	•	•	•	•
20"	•	•	•	•	•	•	•

• **MiniSet** Hardware • **EasySet** Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

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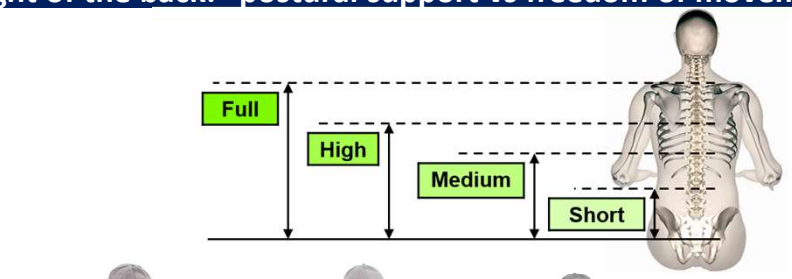
Height of the back: postural support vs freedom of movement



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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

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How to fix issue of sliding forward in a chair – Matrx® EasySet with Extended Range Hardware

E2S 1816 mounted onto
18''- wide chair

E2S 1712 mounted onto
18''- wide chair

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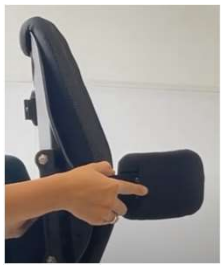
Lateral and postural supports



E2 - 3" Contour

E2 Deep - 6" Contour

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Case study: Mr. Singh

Addressing fear of falling

- Mr. Singh is 92 years old
- 5 unexplained falls within 6 months
- Refusal to mobilize due to fear of falling
- Admitted to the hospital with failure to thrive
- Treated for multiple blood clots in lower limbs, PE, and diabetes.

- After 2 months, d/c to LTC with extreme muscle wasting, frailty, urinary incontinence
- Referred to the ADP-prescriber for a wheelchair (2 week wait)

Case study: Mr. Singh

November 21:

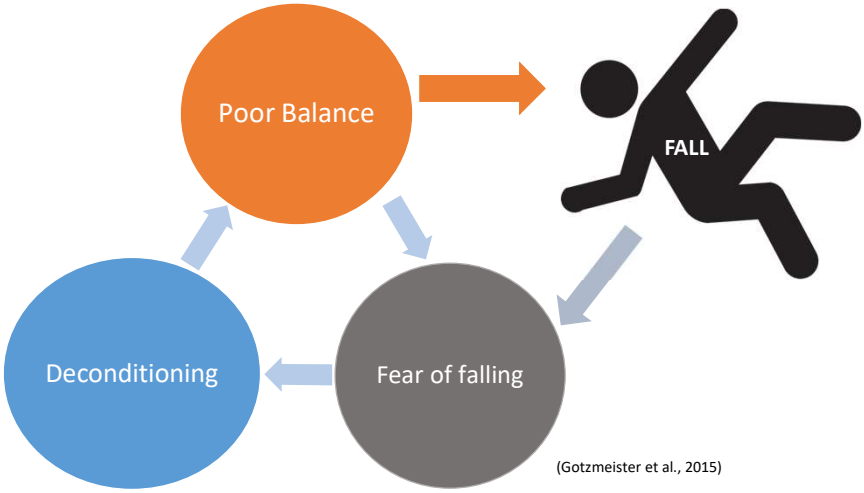
LTC home provided a loaner lightweight manual chair with

- rigid contoured back
- air cushion
- no seat cushion rigidizer
- Mr. Singh was sliding forward due to seat-to-floor too high

After 1 week of trying, physiotherapy team requested a consult:

- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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Case study: Mr. Singh

December 10 - 17

Progress 2 weeks after changing the seating system:

- Twice 10 min per day cycling
- Twice 10 min per day of foot-propelling the wheelchair
- Getting up and making steps with support of 2 assistants

Contoured low-profile foam and polymer skin protection and positioning cushion

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Case study: Mr. Singh

High rigid mildly contoured back 1818 +
Angle/depth/height adjustable headrest

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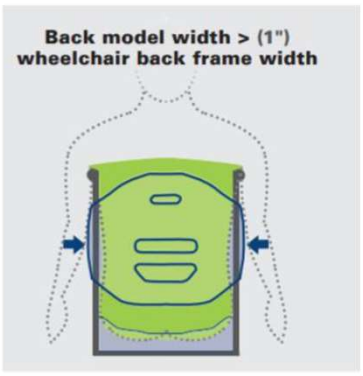
Case study: Mr. Singh

January 14 Final adjustments

- 19” wide back installed onto the 18” wide wheelchair



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Case study: Mr. Singh

Seating products that worked:

- Proper size (18”) w/c frame
- Stable skin protection & positioning cushion (1818)
- Gently contoured back 1” wider than chair frame (1918)
- Head support with adjustable mounting hardware

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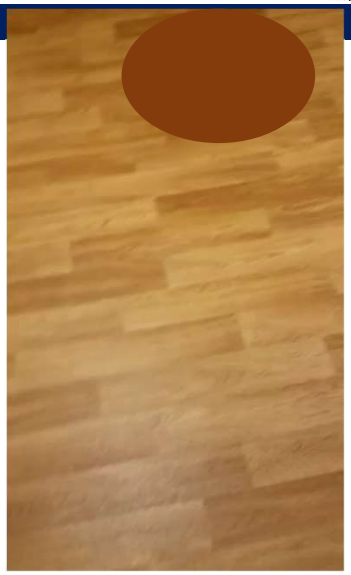
Case study: Mr. Singh

December 30 (5 weeks later):

- Started to hand-propel and foot-propel
- 20 min of cycling at the gym daily
- 20 min of supervised walking with a rollator
- 1-person assist for transfers
- First smile and first full-sentences conversation

Comments by PT:

“…Mr. Singh shows marked improvements. This is not a typical trajectory for our patients”.



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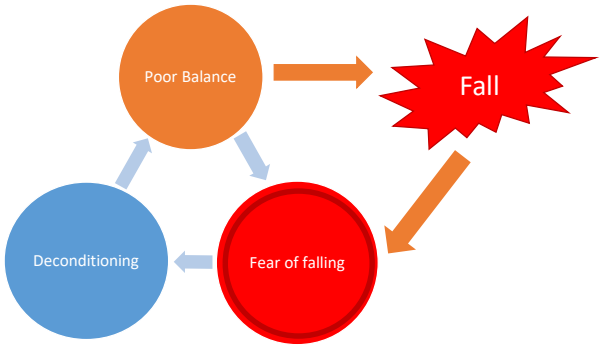
Role of balance in prevention of falls



(Yang et al., 2017; Gotzmeister , Zecevic , Klinger , & Salmoni, 2015)

Other factors contributing to falls:

- Ill-fitted mobility equipment
- Delayed and poor identification of risk factors
- Late involvement of OTs and PTs
- Information gaps in transition from acute care to community
- Medication errors
- Individual health factors: cognitive decline, vision loss
- Decreased physical activity and physical deconditioning
- Risky choices related to striving for independence
- Failure to apply safety belts and locks during wheelchair transfers

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SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity

It's important to find the perfect balance point

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THANK YOU!

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