





Fall Prevention & Wheelchair Seating

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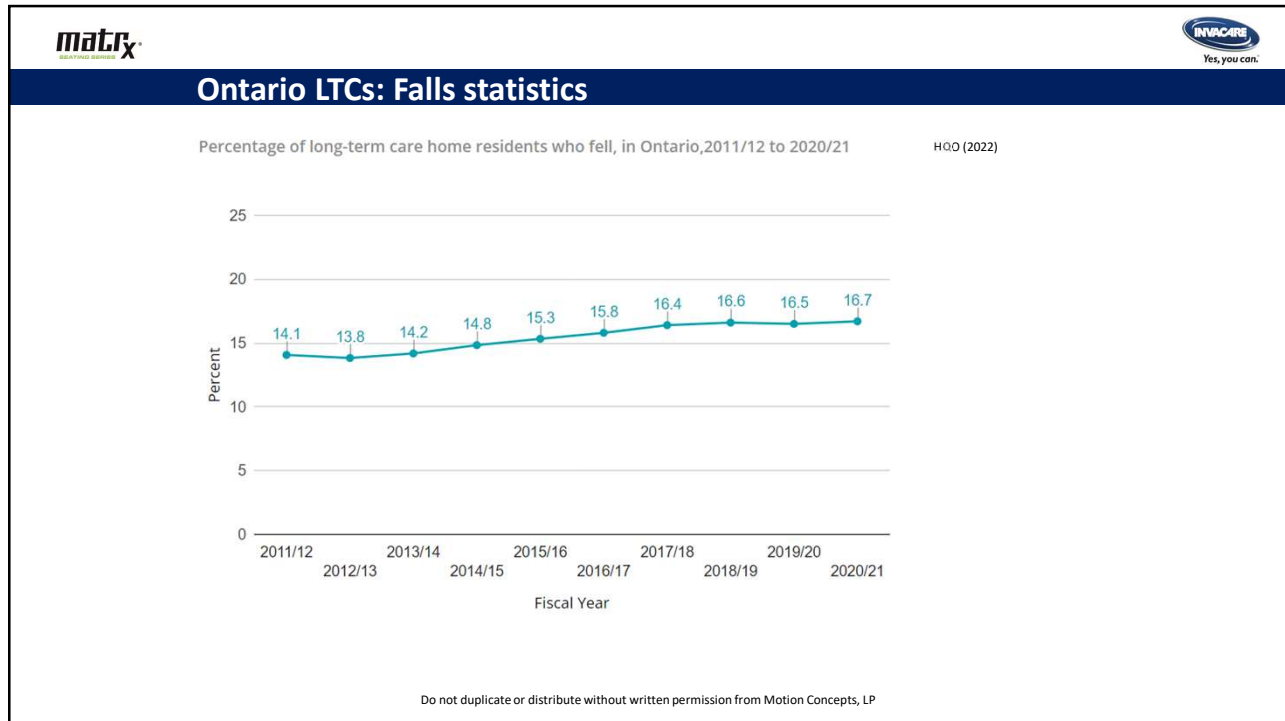



Learning objectives

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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British Columbia LTC falls study: How do people fall? (Yang et al., 2017)

Falls captured on video in long-term care

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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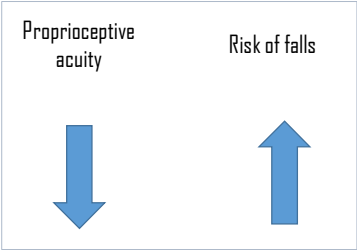



Proprioception and balance

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

(Halbach, 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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Yes, you can.

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

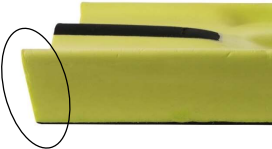


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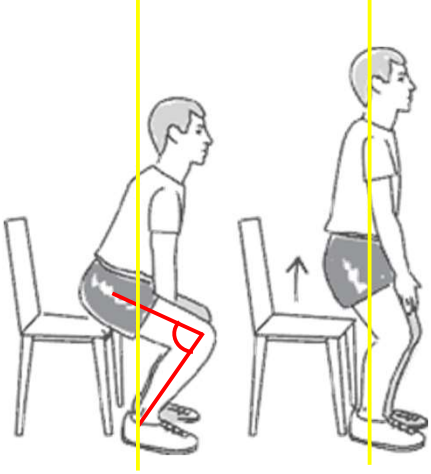
matrix SEATING SOLUTIONS **INVACARE**
Yes, you can.

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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INVACARE
Yes, you can.

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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Yes, you can.

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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Yes, you can.

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 keep centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection


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Yes, you can.

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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Yes, you can.

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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Yes, you can.

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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix BEYOND BARRIERS **INVACARE**
Yes, you can.

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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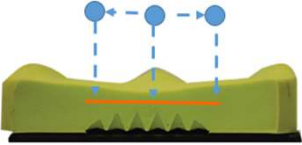
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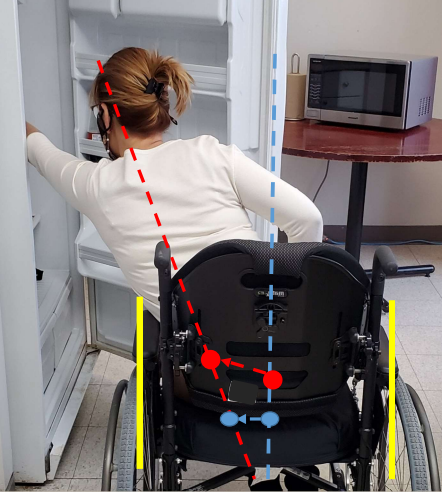



Wheelchair-related risk factors: Centre of gravity

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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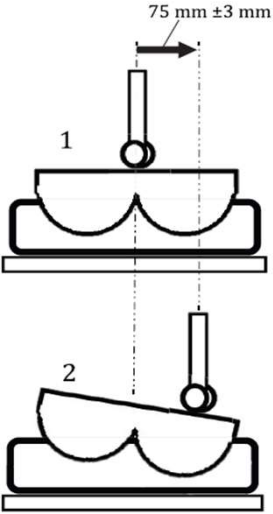



Wheelchair-related risk factors: Cushion stability





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

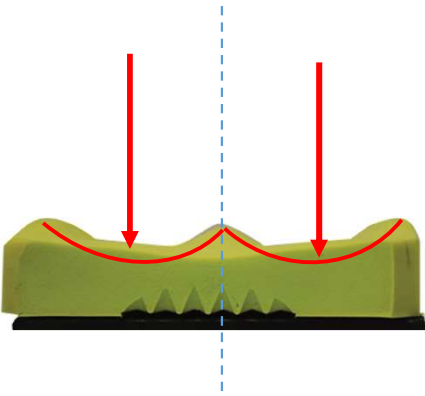
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

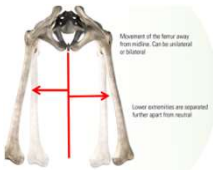
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

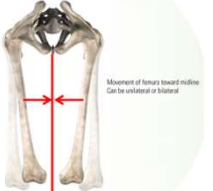


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

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Yes, you can.

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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Yes, you can.

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



Matrix PB Back

Matrix Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion



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




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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



Upholstery backrest



Support of a rigid backrest

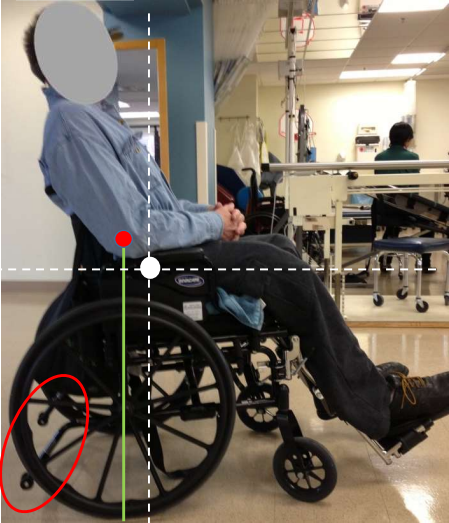
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Yes, you can.

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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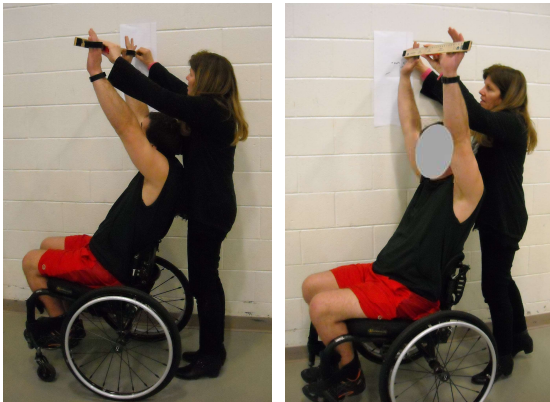
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



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matrx **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines representing different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

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matrx **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- 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 – Matrix® EasySet with Extended Range Hardware



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Lateral and postural supports



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matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> Fall((FALL))
      FearOfFalling((Fear of falling)) --> Deconditioning
      PoorBalance --> FearOfFalling
  
```

(Gotzmeister et al., 2015)

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matrix **INVACARE**
Yes, you can!

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

2.75"


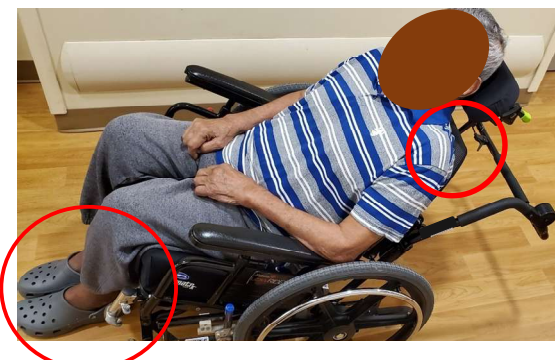
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matrix Rx **INVACARE**
Yes, you can.

Case study: Mr. Singh

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

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Yes, you can.

Case study: Mr. Singh

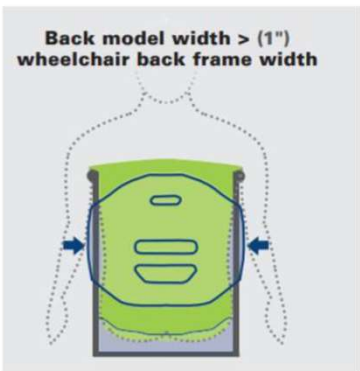
January 14 Final adjustments

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





**Back model width > (1")
wheelchair back frame width**



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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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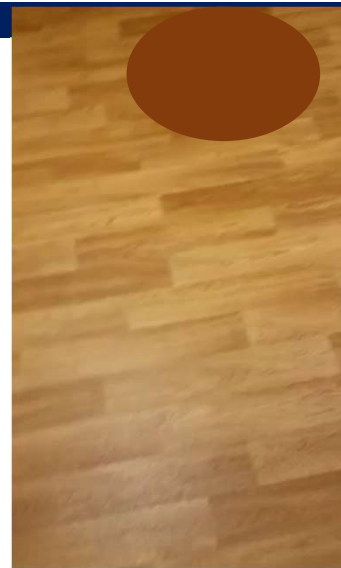
Case study: Mr. Singh

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:

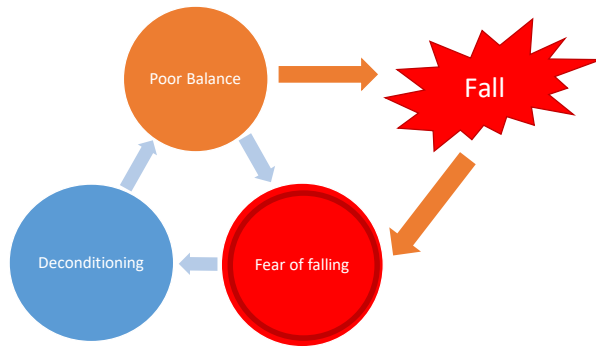
"...Mr. Singh shows marked improvements. This is not a typical trajectory for our patients".



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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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matrix
SEATING SERIES

Motion
Concepts

Fall Prevention & Wheelchair Seating

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

1

matrix
SEATING SERIES

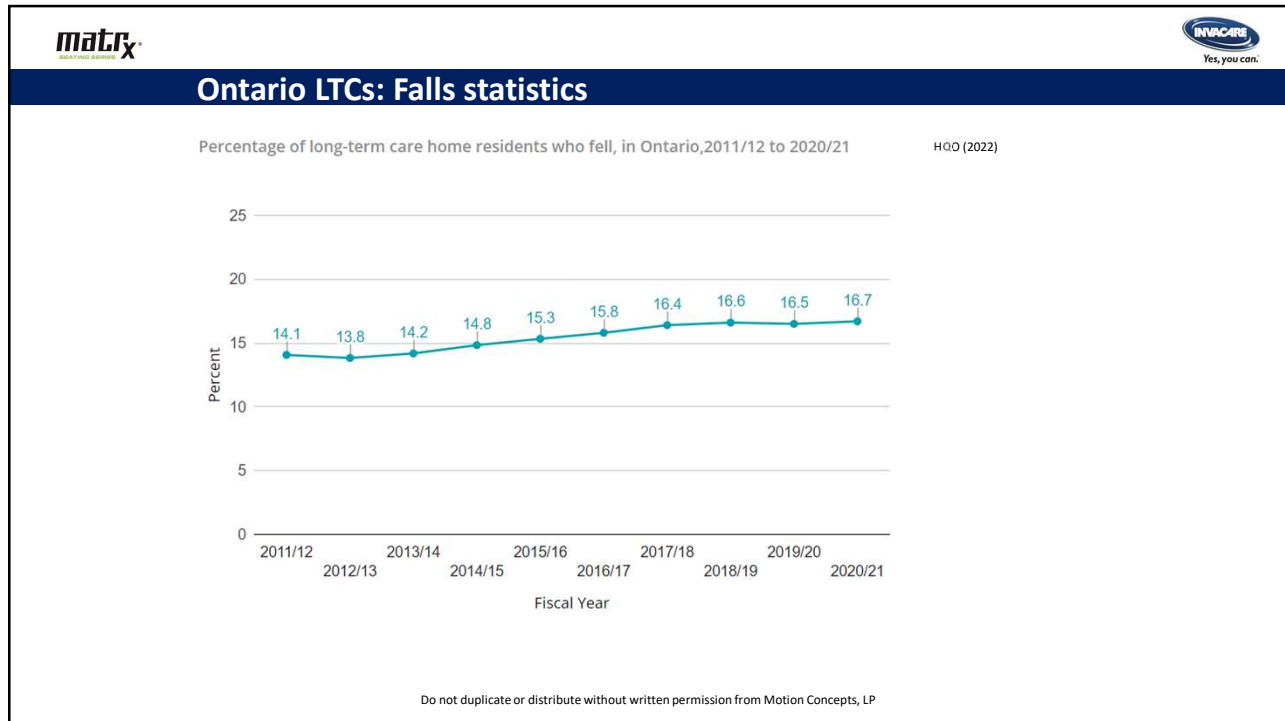
INVACARE
Yes, you can.

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



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

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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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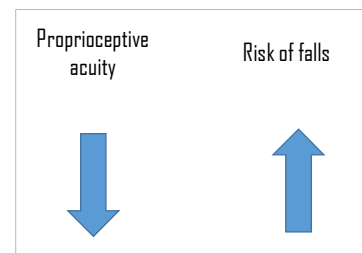
6

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

(Halbach, 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




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9

matrix SEATING FOR ALL


INVACARE
Yes, you can.

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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matrix SEATING FOR ALL

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge

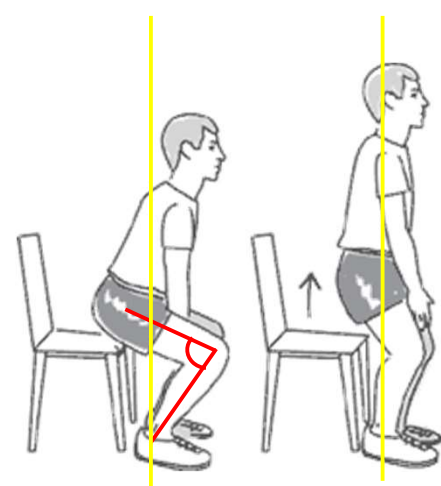


Waterfall front edge

- 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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INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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 keep centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair locks and seat belts


Apply locks!!!

- when not propelling
- when not being transported


Educate patients
Educate all caregivers
Use effective reminders and cues



Is seat belt on during activity/movement?



Are locks within easy reach?



Is seat belt on during activity/movement?

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matrix BEYOND BARRIERS **INVACARE**
Yes, you can.

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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix BEYOND BARRIERS **INVACARE**
Yes, you can.

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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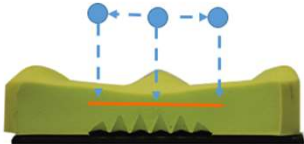
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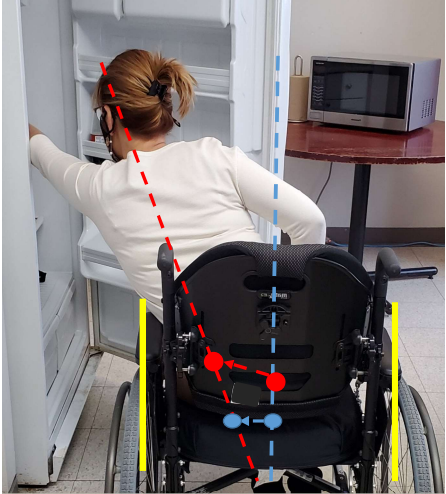



Wheelchair-related risk factors: Centre of gravity

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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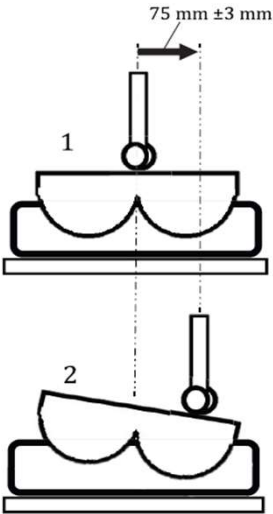



Wheelchair-related risk factors: Cushion stability



INTERNATIONAL STANDARD ISO 16840-13

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



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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Abductor and adductor contouring

Importance of Midline Leg Positioning

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)

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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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction

Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx SMARTER SEATING **INVACARE**
Yes, you can.

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

matrx SMARTER SEATING **INVACARE**
Yes, you can.

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



Matrx PB Back

Matrx Elite E2 Back

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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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34

matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

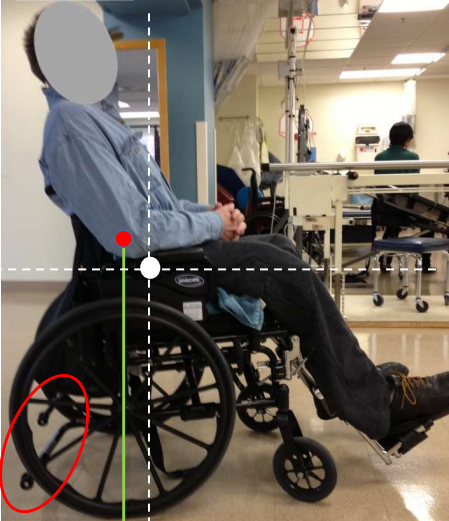
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matrix **INVACARE**
Yes, you can.

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

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 Matrix 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 ramp²

- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options

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

E2 - 3" Contour

E2 Deep - 6" Contour

• MiniSet Hardware • EasySet Hardware

41

matrx **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

42

42

matrx **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

E2 - 3" Contour


E2 Deep - 6" Contour

matrix 700 FLEX

46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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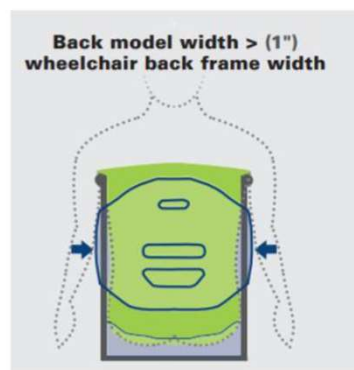
52

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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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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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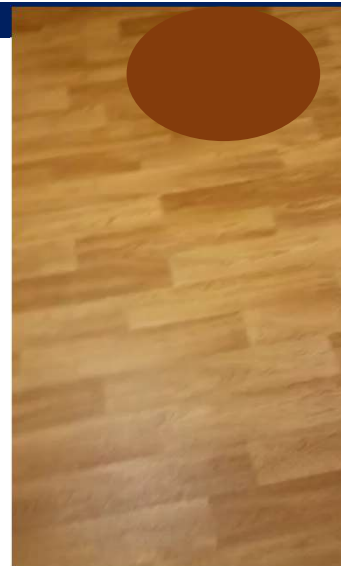
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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59



References:

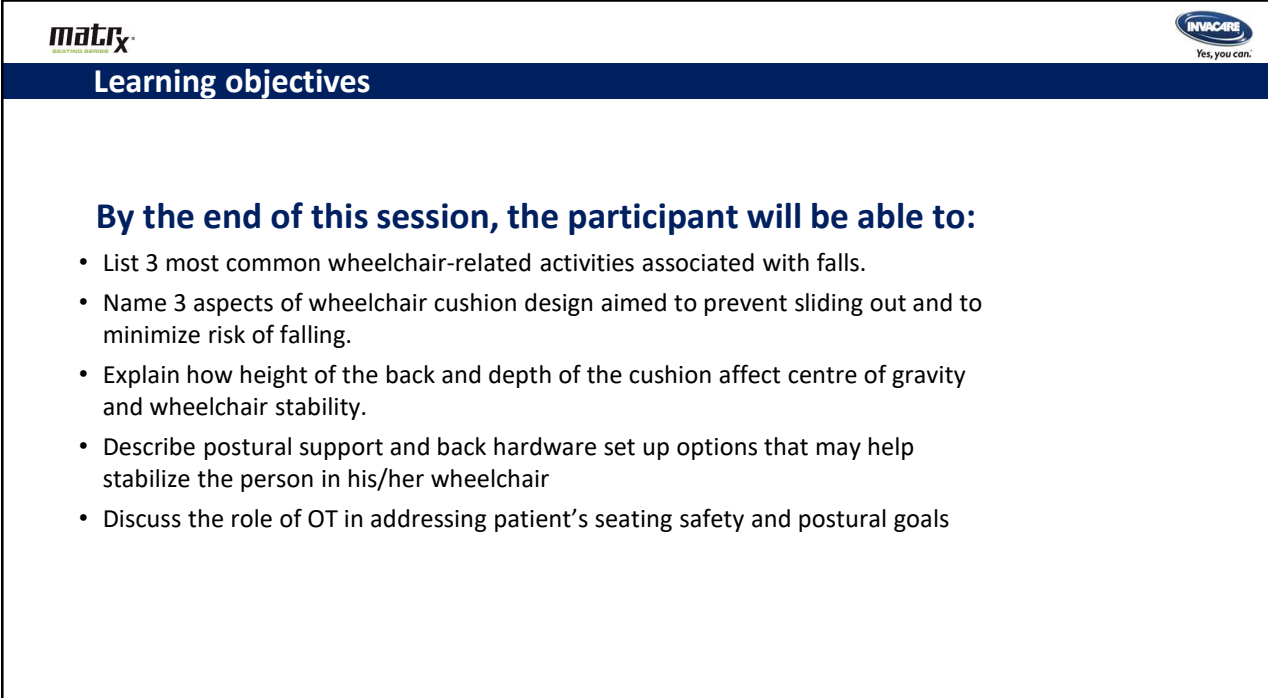
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Fall Prevention & Wheelchair Seating

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

1



matrix
SEATING SERIES

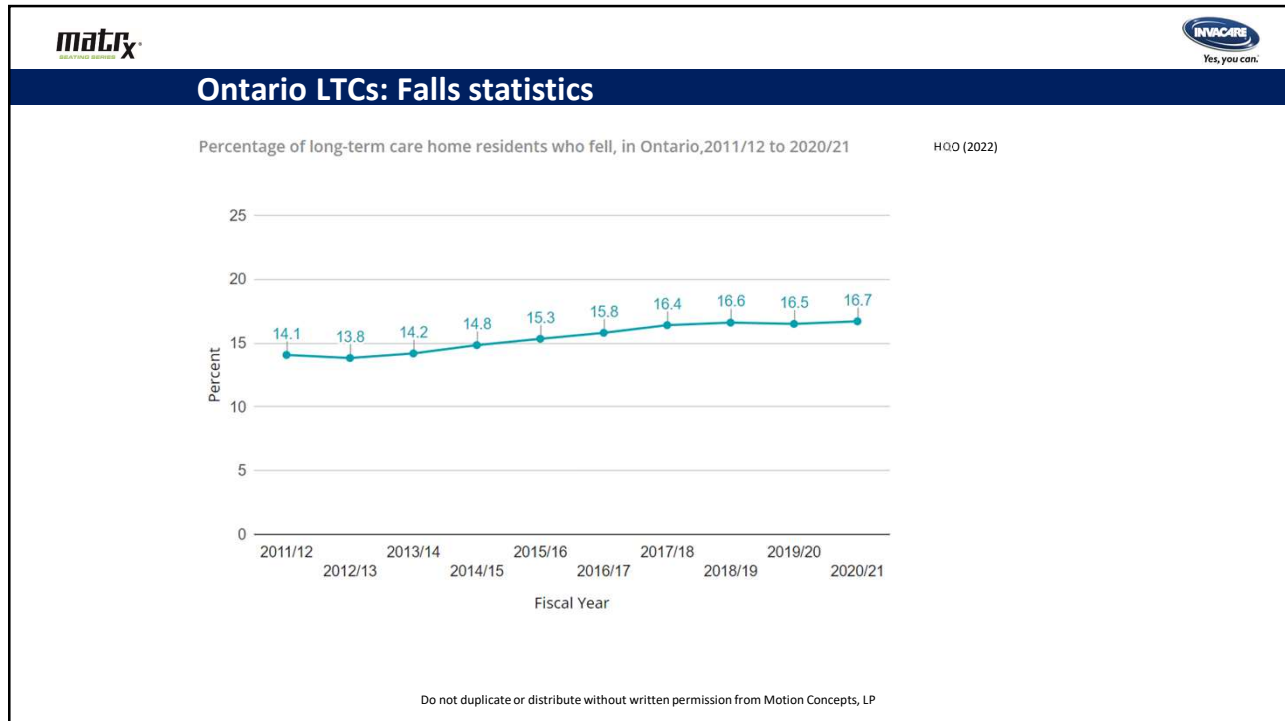
INVACARE
Yes, you can.

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



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

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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 %

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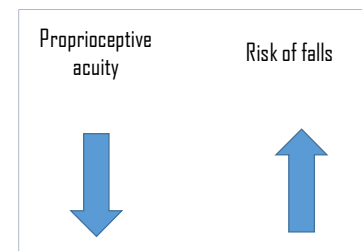
6

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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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

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

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8

Sitting down or lowering

Getting up or rising

Seat-to-stand



Stand-to-seat




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9

matrix SEATING FOR EVERYONE


INVACARE
Yes, you can.

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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10

matrix SEATING FOR EVERYONE

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge

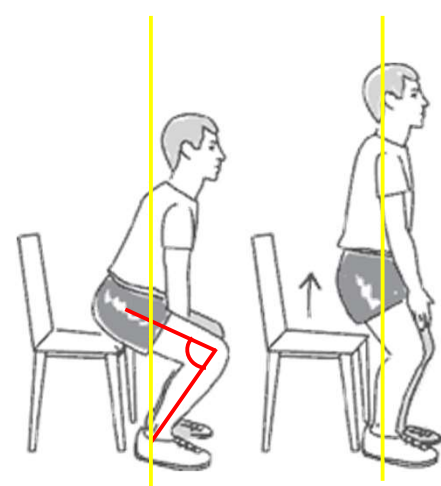


Waterfall front edge

- 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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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

Low profile

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

Preventing sliding out of a chair



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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection


21

matrix **INVACARE**
Yes, you can.

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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22




matrix **INVACARE**
Yes, you can.

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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23

matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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24

matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

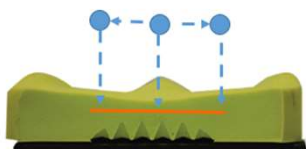
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25

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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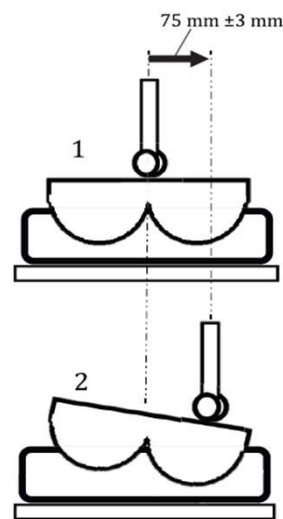
26

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



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Wheelchair cushion design: Abductor and adductor contouring

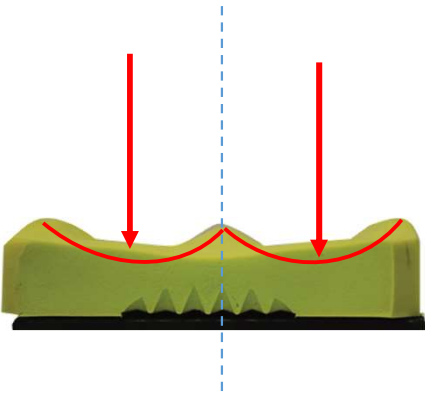
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

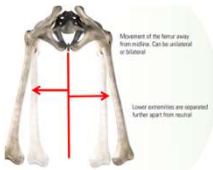
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

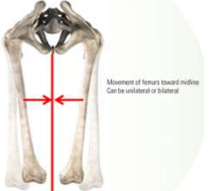


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx SMARTER SEATING **INVACARE**
Yes, you can.

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

matrx SMARTER SEATING **INVACARE**
Yes, you can.

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



Matrx PB Back

Matrx Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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33

matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

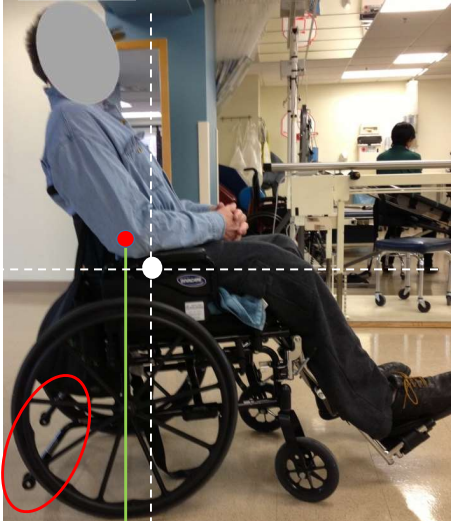
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38


matrix **INVACARE**
Yes, you can.

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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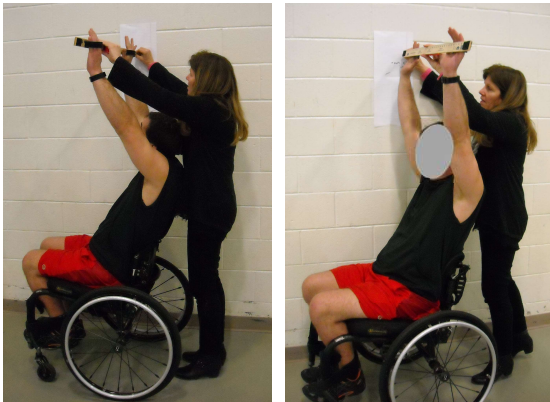
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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

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Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



41

matrx **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

42

42

matrx **INVACARE**
Yes, you can.

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

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

The diagrams illustrate the installation of Matrix EasySet hardware on an 18-inch wide chair. The left side shows E2S 1816 with a 1-inch gap on the left, an 18-inch seat width, and an 18-inch distance from the backrest to the seat edge. The right side shows E2S 1712 with a 17-inch distance from the backrest to the seat edge and a 3 1/2-inch gap on the right. A 1-inch gap is also indicated on the right side of the E2S 1712 setup.

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

The image displays several types of lateral and postural supports. On the left, two curved supports are shown: the E2 - 3" Contour and the E2 Deep - 6" Contour. In the center, there is a black plastic backrest support with two horizontal cutouts. On the right, a blue fabric support with a star and moon pattern is shown. Two inset photos on the far right show a person's hand adjusting the side of a chair seat.

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)

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48



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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51

51

Case study: Mr. Singh



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



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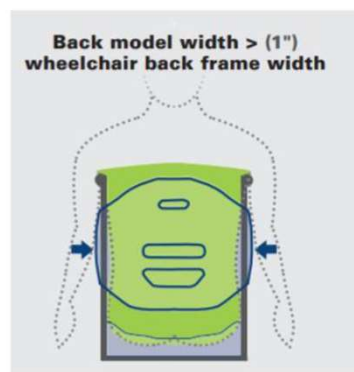
52

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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54

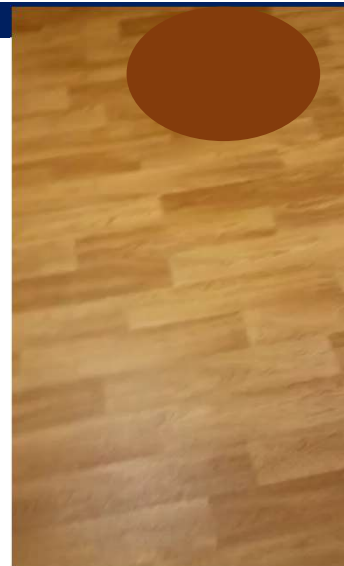
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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

56

matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity
It's important to find the perfect balance point

57



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58

THANK YOU!



59

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matrix
SEATING SERIES

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Fall Prevention & Wheelchair Seating

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

1

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SEATING SERIES

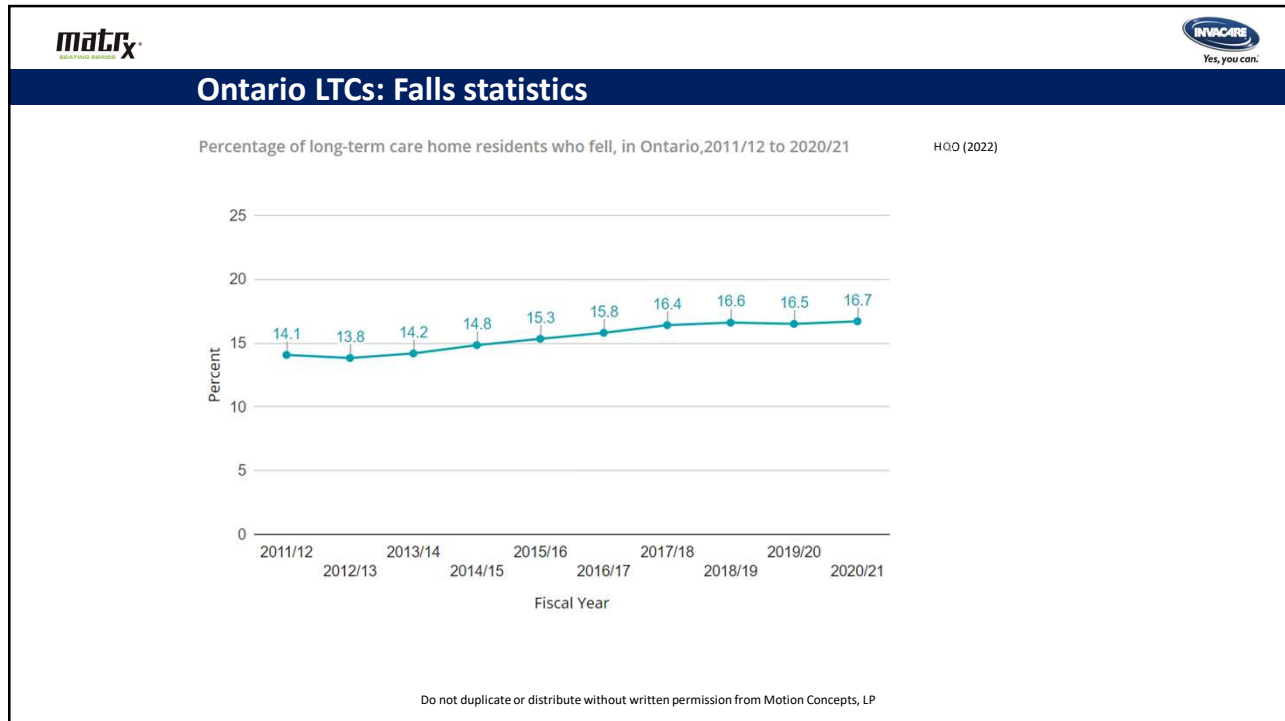
INVACARE
Yes, you can.

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



3

British Columbia LTC falls study: How do people fall? (Yang et al., 2017)

Falls captured on video in long-term care

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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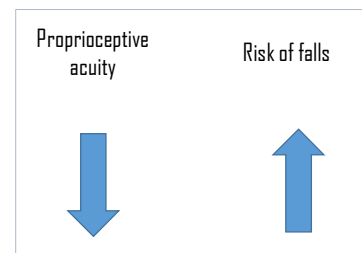
6

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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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

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

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8

Sitting down or lowering

Getting up or rising

Seat-to-stand



Stand-to-seat




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9

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INVACARE
Yes, you can.

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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INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge

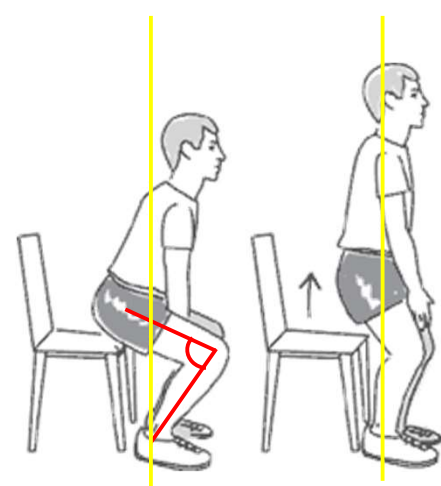


Waterfall front edge

- 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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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12

matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair

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

Low profile

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



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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix BEAT YOUR BARRIER **INVACARE**
Yes, you can.

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

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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matrix BEAT YOUR BARRIER **INVACARE**
Yes, you can.

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

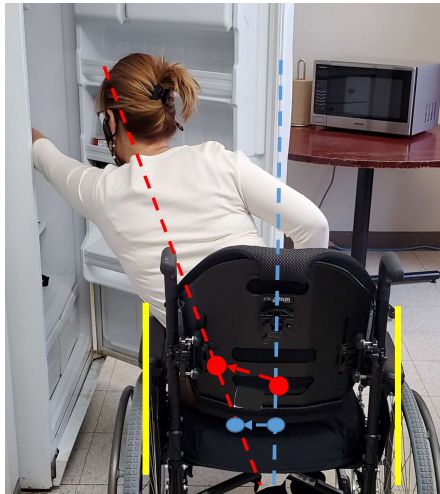
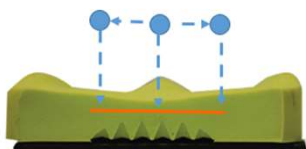
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25

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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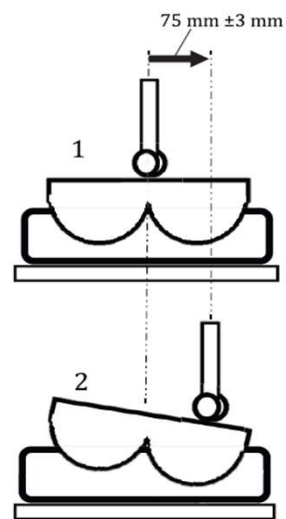
26

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



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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Abductor and adductor contouring

Importance of Midline Leg Positioning

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)

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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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction

Movement of femurs toward midline. Can be unilateral or bilateral.

Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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



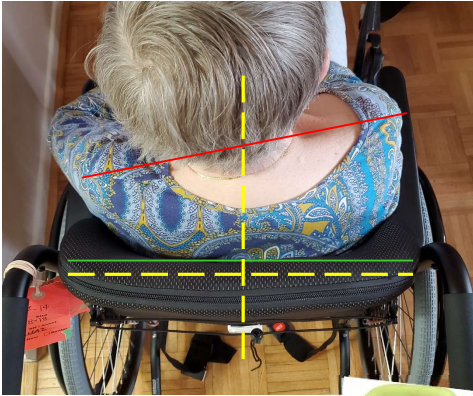

- Rt shoulder dislocated
- Fractured and dislocated Lt hip
- Scoliosis
- Osteoporosis
- Pain and intolerance of a seat belt
- Falls due to sliding out

31

matrx **INVACARE**
Yes, you can.

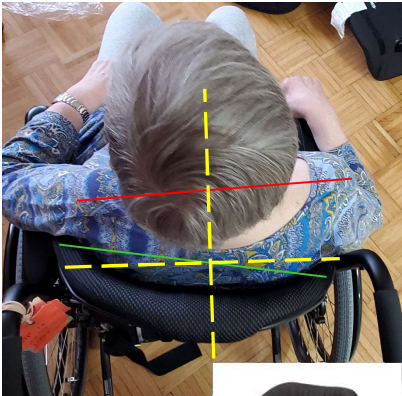
Nancy: addressing pain, postural collapse and falls for patient with extreme rotation






Matrx PB Back





Matrx Elite E2 Back



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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion



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



**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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34

matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

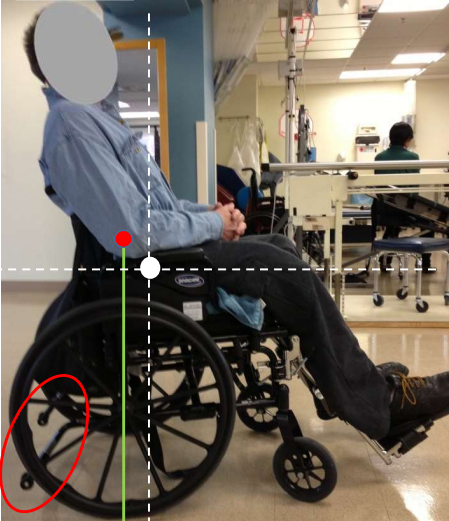
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matrix **INVACARE**
Yes, you can.

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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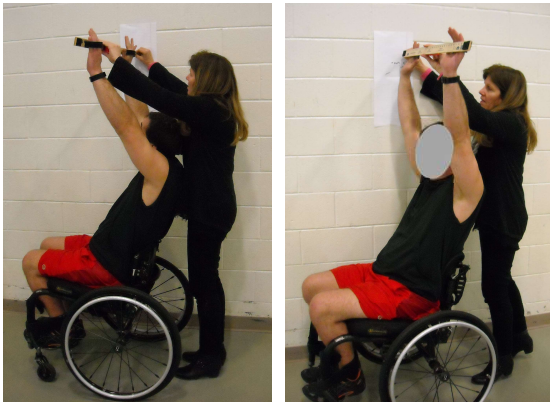
RESEARCH ARTICLE BY

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 Matrix backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:
- 9° better (less posterior) pelvic angle ($\bar{x}=96.92^\circ$)
- 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 ramp²



- 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

40




Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates four levels of backrest height: Full, High, Medium, and Short. Each level is represented by a horizontal dashed line and a vertical double-headed arrow. Below the diagram are four photographs of a person in a wheelchair, showing the backrest height for each level. The 'Full' level is the highest, reaching the top of the shoulders. The 'High' level reaches the upper chest. The 'Medium' level reaches the lower chest. The 'Short' level is the lowest, reaching the upper back.

42

42

matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports


E2 - 3" Contour

E2 Deep - 6" Contour

46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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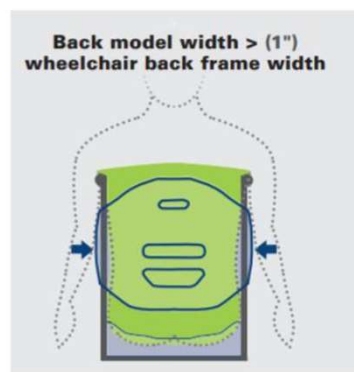
52

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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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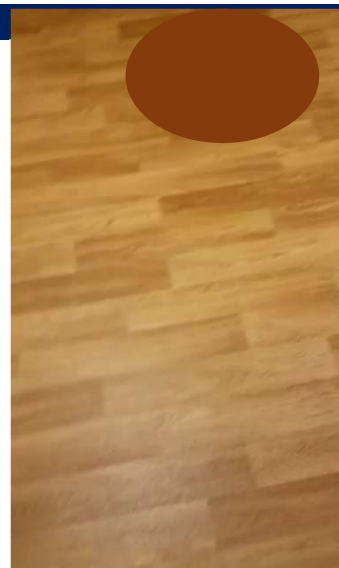
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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!



59

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matrx
SEATING SERIES

Motion
Concepts

Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

matrx
SEATING SERIES

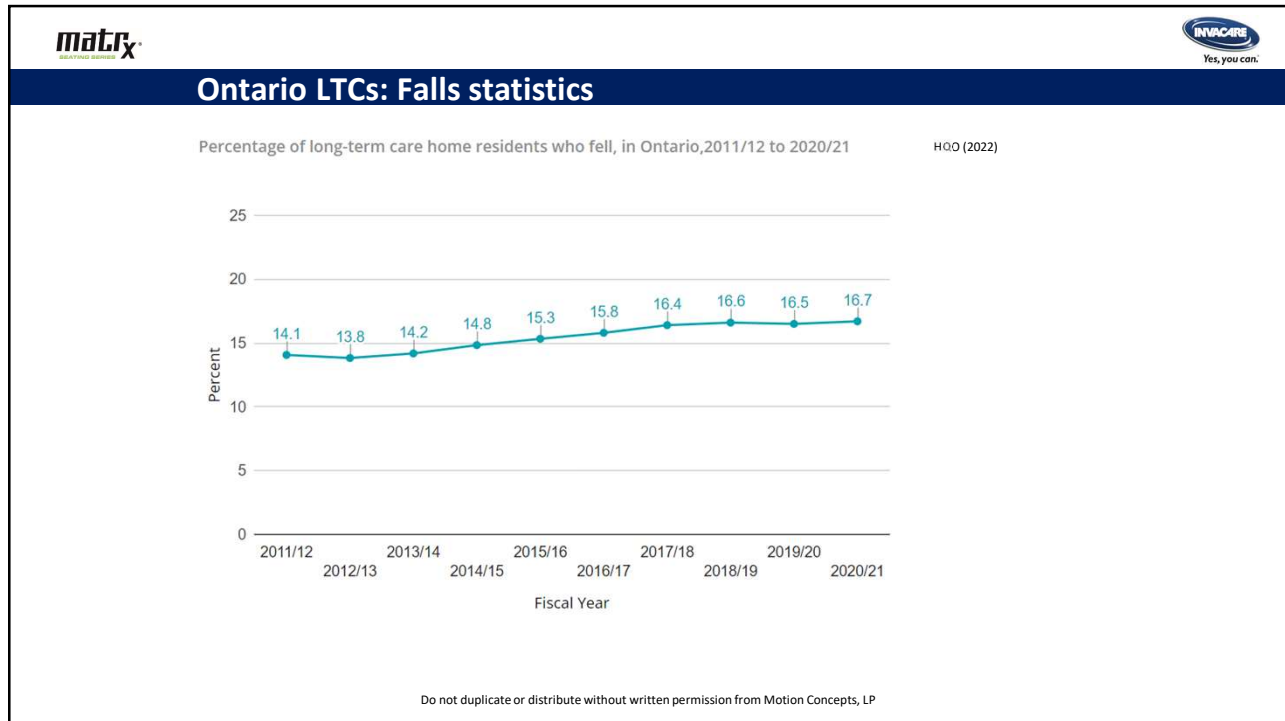
INVACARE
Yes, you can.

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



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

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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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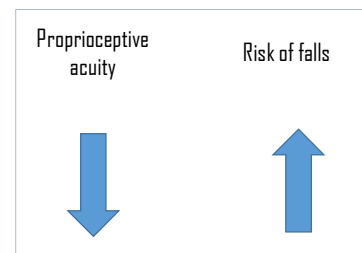
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9


matrix SEATING SOLUTIONS **INVACARE**
Yes, you can.

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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10

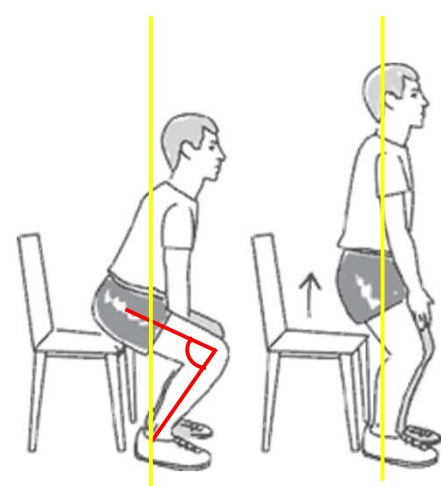
matrix SEATING SOLUTIONS **INVACARE**
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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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?)

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matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair

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

Low profile

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

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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection


21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

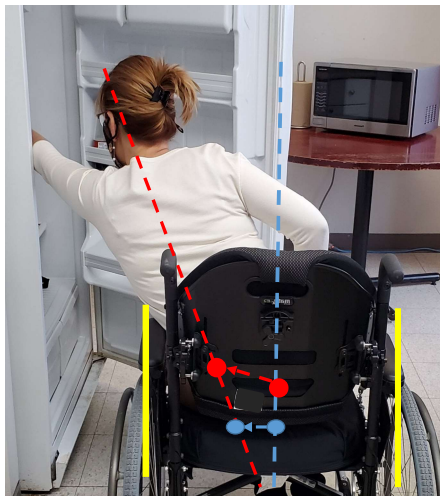
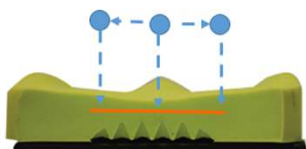
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Wheelchair-related risk factors: Centre of gravity

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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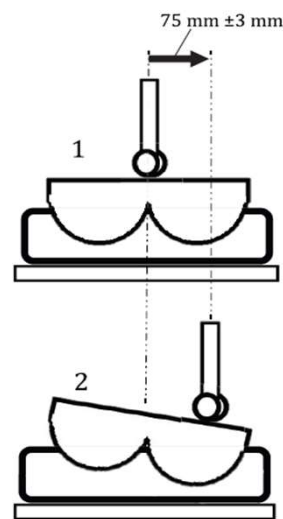
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Wheelchair-related risk factors: Cushion stability





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

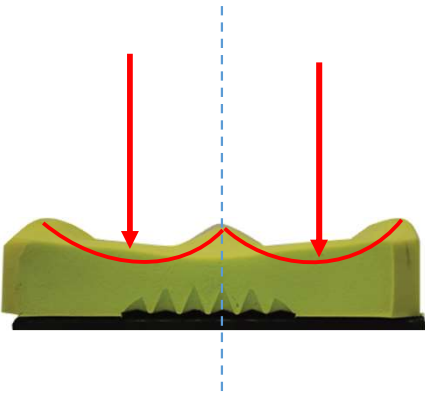
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

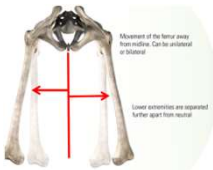
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

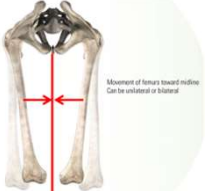


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

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matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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



Matrix PB Back

Matrix Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion



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




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

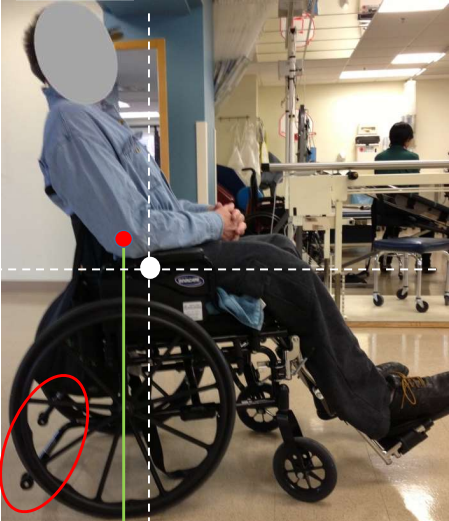
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matrix **INVACARE**
Yes, you can.

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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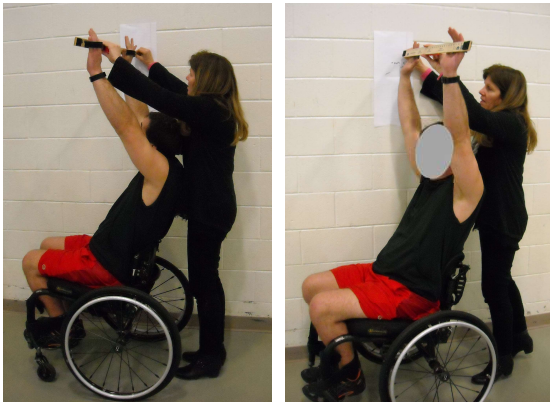
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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




Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates four levels of backrest height: Full, High, Medium, and Short. Each level is represented by a horizontal dashed line and a vertical double-headed arrow. Below the diagram are four photographs of a person in a wheelchair, showing the backrest height for each level. The 'Full' level is the highest, reaching the top of the person's back. The 'Short' level is the lowest, reaching only the lower back area.

42

42

matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43



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



E2S 1816 mounted onto 18" - wide chair



E2S 1712 mounted onto 18" - wide chair



44




Lateral and postural supports



46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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:

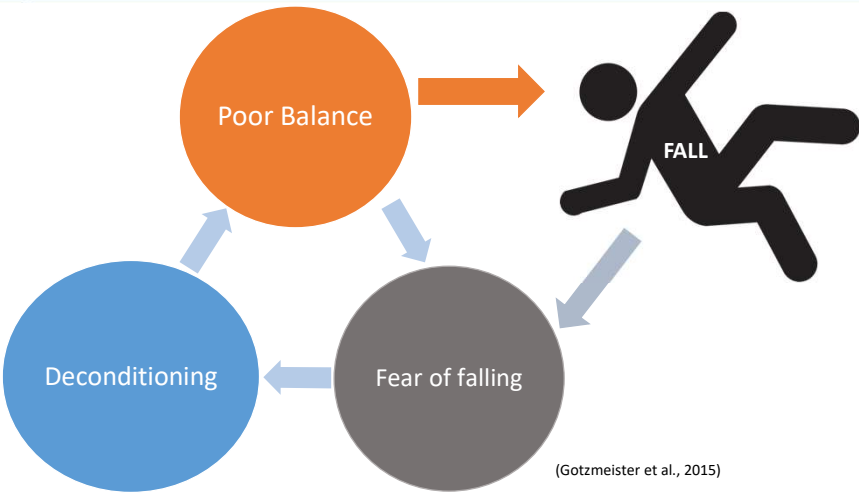
- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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matrix **INVACARE**
Yes, you can!

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



2.75"

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51

Case study: Mr. Singh



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



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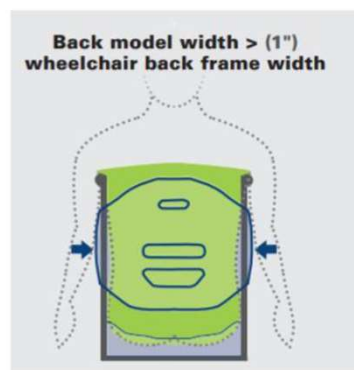
52

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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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matrix RESEARCH & CONSULTING

INVACARE
Yes, you can.

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

56

matrix RESEARCH & CONSULTING

INVACARE
Yes, you can.

SUPPORT + STABILITY = FUNCTION

Sitting is not a static activity
It's important to find the perfect balance point

57



Anna Sokol, RN, MN, BScKin, WOCC(C)

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58

THANK YOU!



59

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SEATING SERIES

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Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

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SEATING SERIES

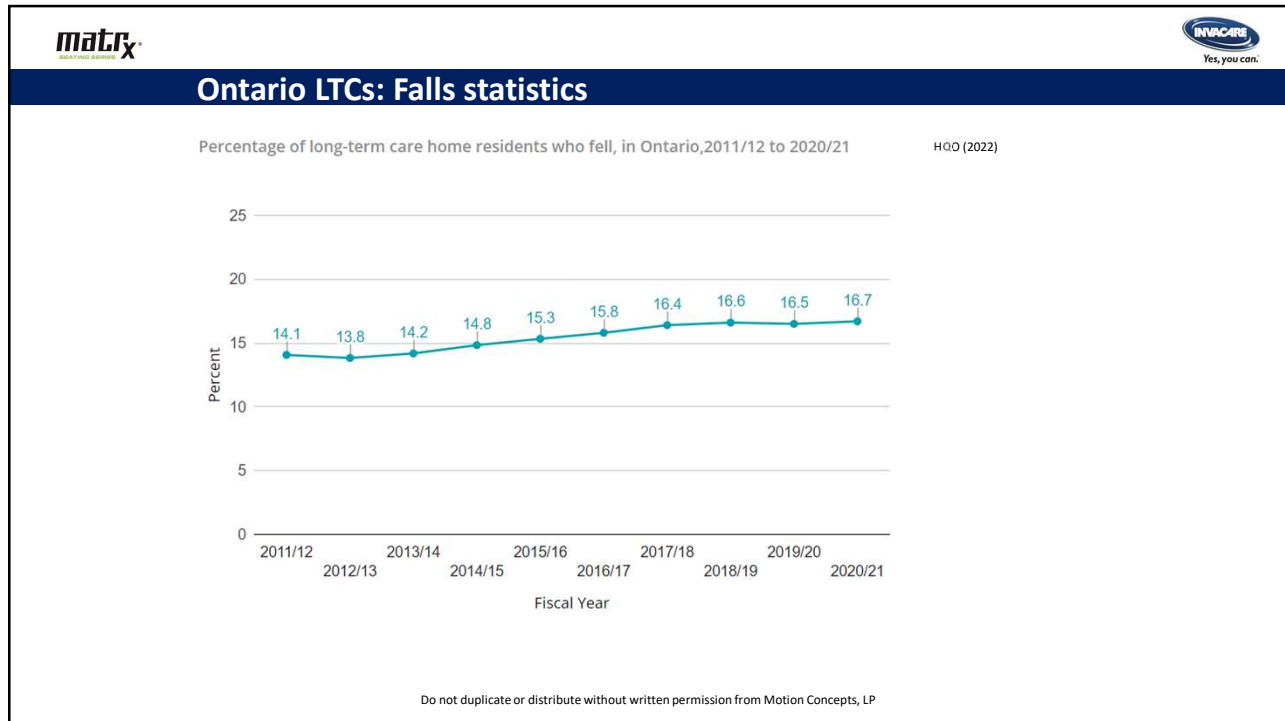
INVACARE
Yes, you can.

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



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

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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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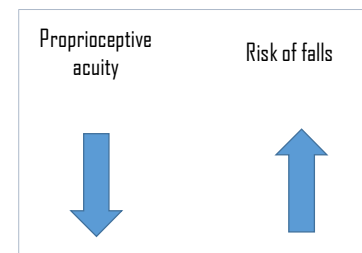
6

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

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

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8

Sitting down or lowering

Getting up or rising




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9


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Yes, you can.

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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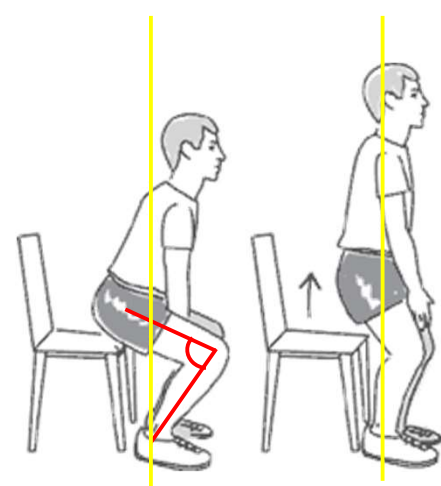
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Yes, you can.

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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INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair



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

Low profile

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

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

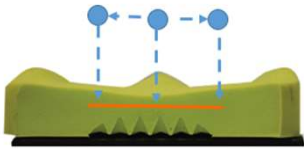
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Wheelchair-related risk factors: Centre of gravity

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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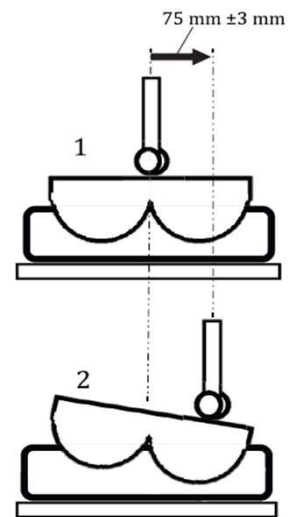
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Wheelchair-related risk factors: Cushion stability



INTERNATIONAL STANDARD ISO 16840-13

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



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matrix **INVACARE**
Yes, you can.

Wheelchair cushion design: Abductor and adductor contouring

Importance of Midline Leg Positioning

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)

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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matrix **INVACARE**
Yes, you can.

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction

Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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

matrx **INVACARE**
Yes, you can.

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





Matrx PB Back





Matrx Elite E2 Back



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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

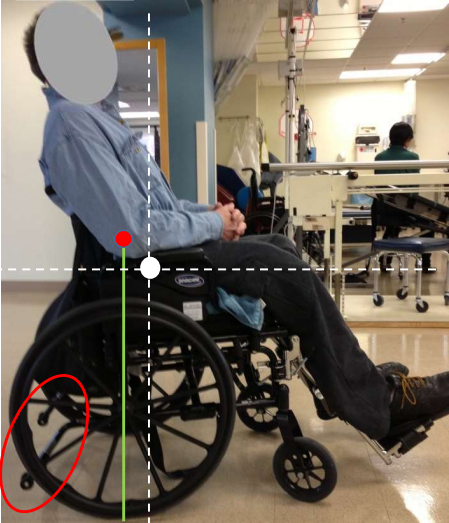
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38


matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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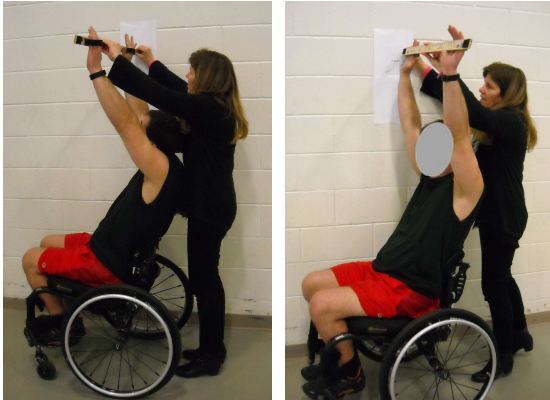
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

42

42

matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43



How to fix issue of sliding forward in a chair – Matrix® 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

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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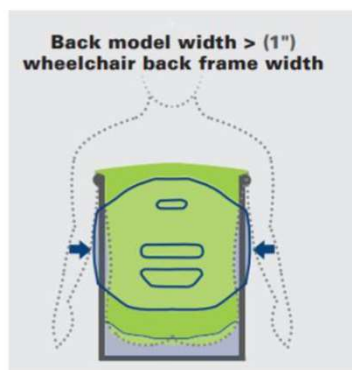
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Case study: Mr. Singh

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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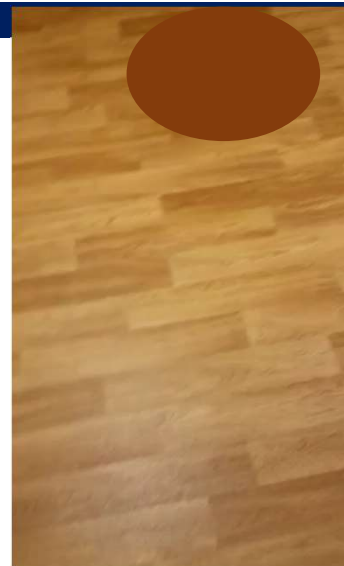
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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

56

matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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!



59

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Fall Prevention & Wheelchair Seating

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1

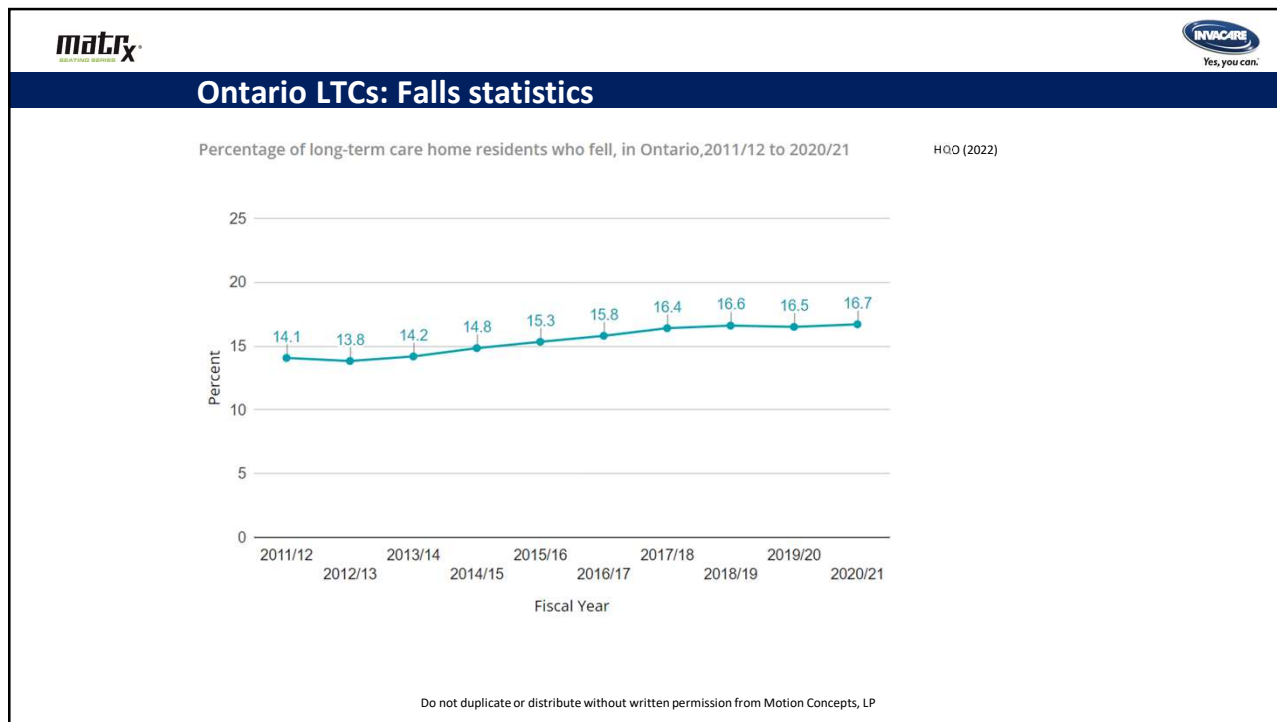



Learning objectives

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



3

British Columbia LTC falls study: How do people fall? (Yang et al., 2017)

Falls captured on video in long-term care

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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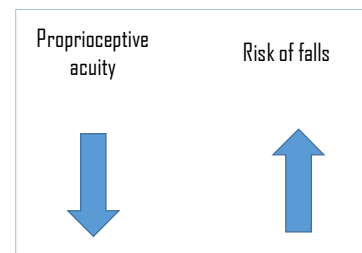
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix SEATING FOR EVERYONE


INVACARE
Yes, you can.

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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10

matrix SEATING FOR EVERYONE

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge



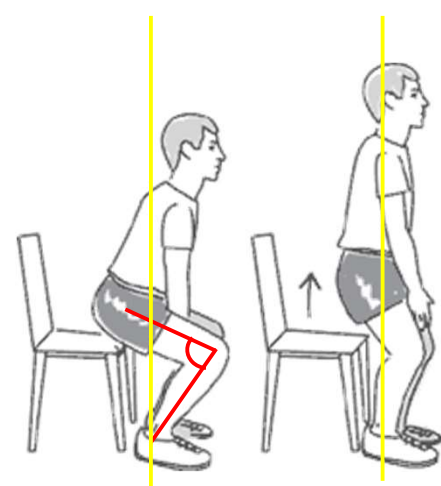
Waterfall front edge

- 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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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 keep centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.


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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

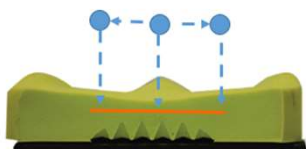
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Wheelchair-related risk factors: Centre of gravity

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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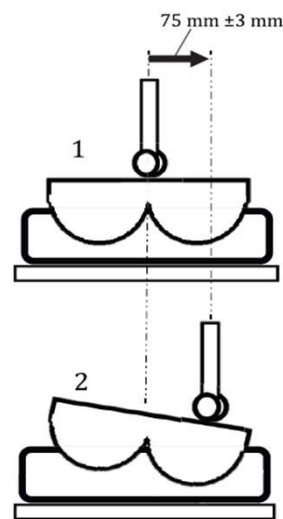
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Wheelchair-related risk factors: Cushion stability





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

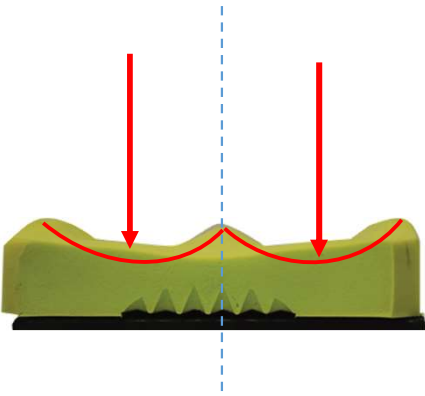
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

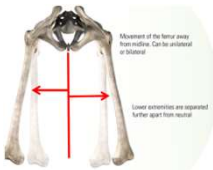
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28





Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

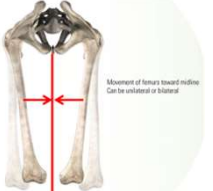


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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

matrx **INVACARE**
Yes, you can.

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





Matrx PB Back





Matrx Elite E2 Back



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32

matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion



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



**Invacare® Matrix®
Multi Cushion**

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33

matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

Upholstery backrest Support of a rigid backrest

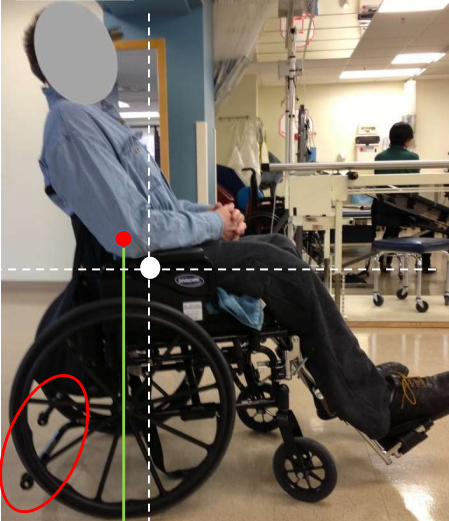
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matrix **INVACARE**
Yes, you can.

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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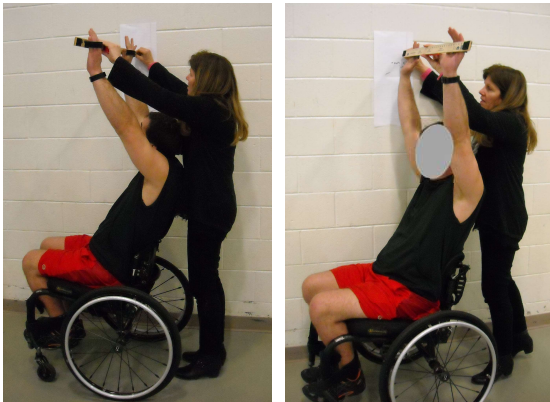
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates four backrest height settings: Full, High, Medium, and Short. Above the settings is a skeletal diagram of a human torso showing the spine. Dashed lines indicate the height of each setting relative to the spine. Below the settings are four photographs of a person in a wheelchair, showing the backrest height for each setting.

42

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matrix **INVACARE**
Yes, you can.

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

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports


E2 - 3" Contour

E2 Deep - 6" Contour

46

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matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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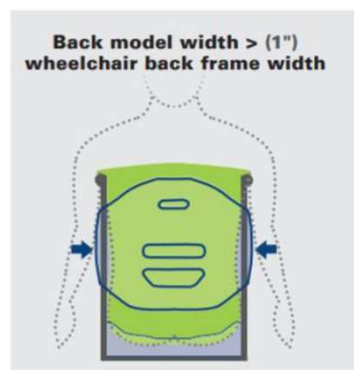
52

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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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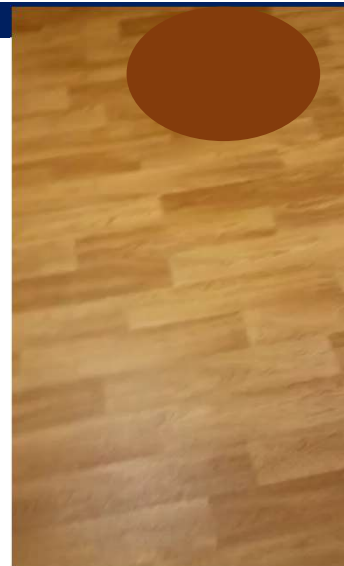
Case study: Mr. Singh

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:

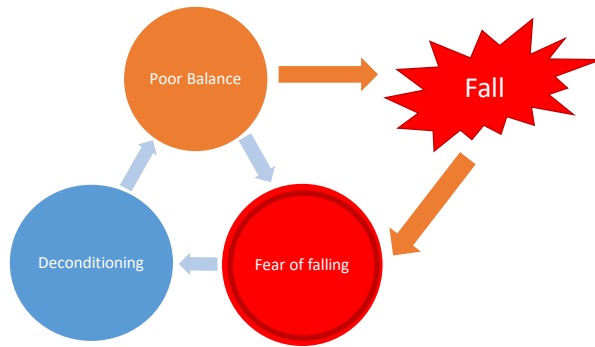
"...Mr. Singh shows marked improvements. This is not a typical trajectory for our patients".



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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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matrix
SEATING SERIES

Motion
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Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

matrix
SEATING SERIES

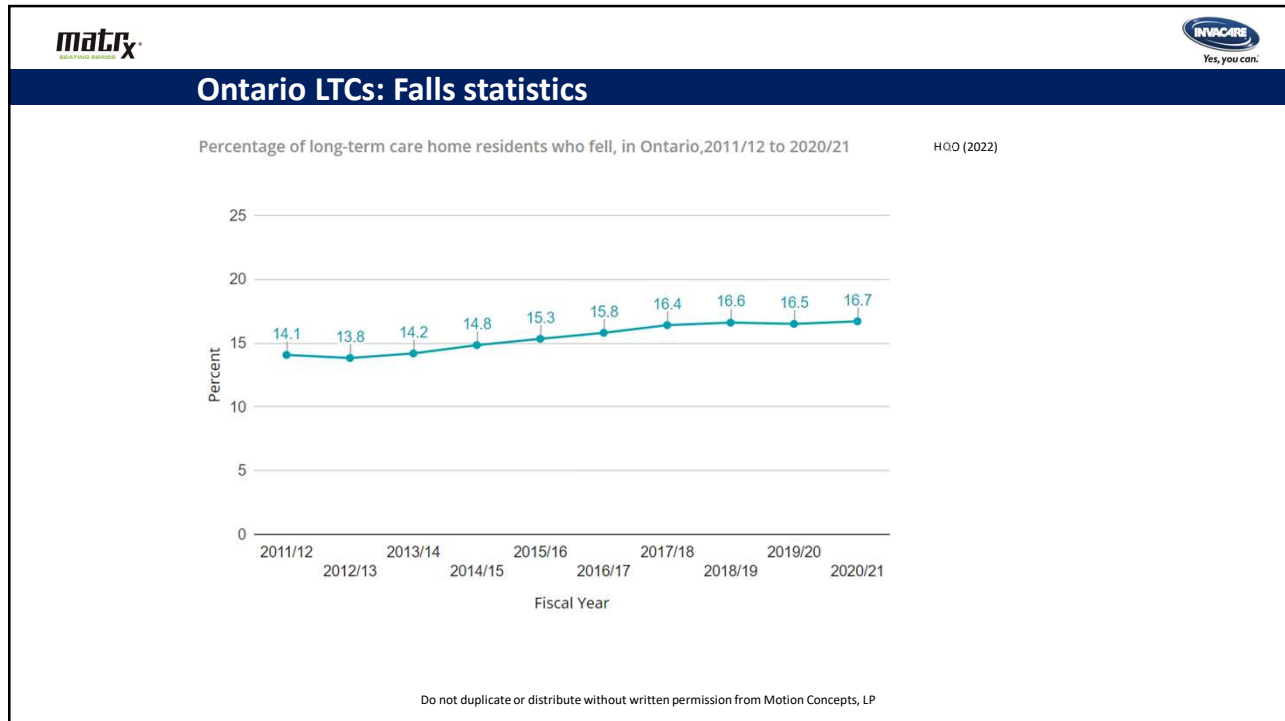
INVACARE
Yes, you can.

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



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

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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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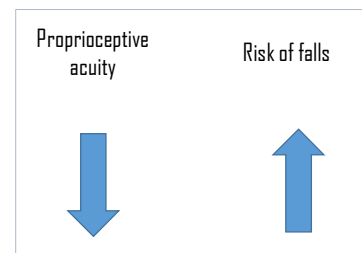
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix RESEARCH & DESIGN


INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge



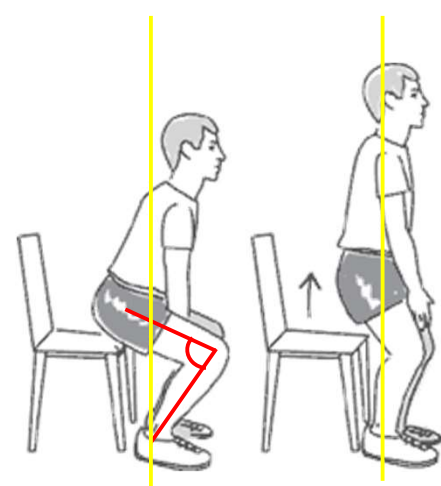
Waterfall front edge

- 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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair



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

Low profile

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

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection


21

matrix **INVACARE**
Yes, you can.

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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22




matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

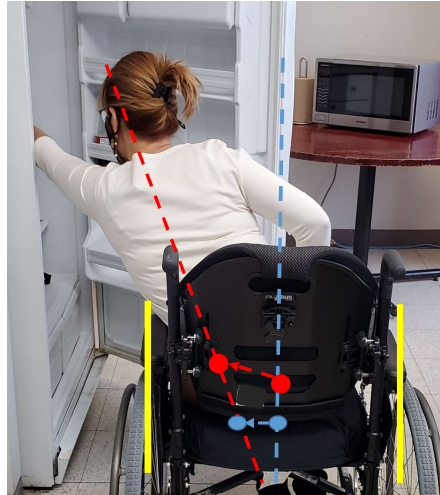
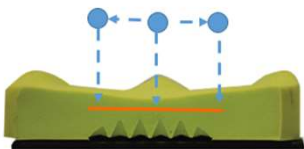
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Wheelchair-related risk factors: Centre of gravity

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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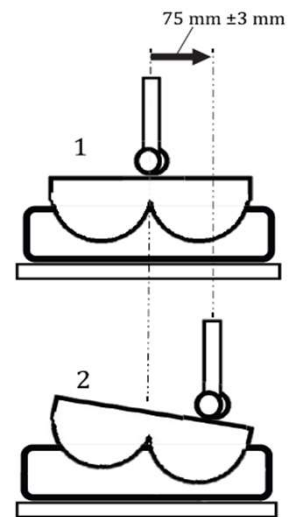
26

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



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27

matrix **INVACARE**
Yes, you can.

Wheelchair cushion design: Abductor and adductor contouring

Importance of Midline Leg Positioning

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)

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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matrix **INVACARE**
Yes, you can.

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction

Movement of femurs toward midline. Can be unilateral or bilateral.

Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



rotation

Matrix PB Back

Matrix Elite E2 Back

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32

matrix **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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33

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

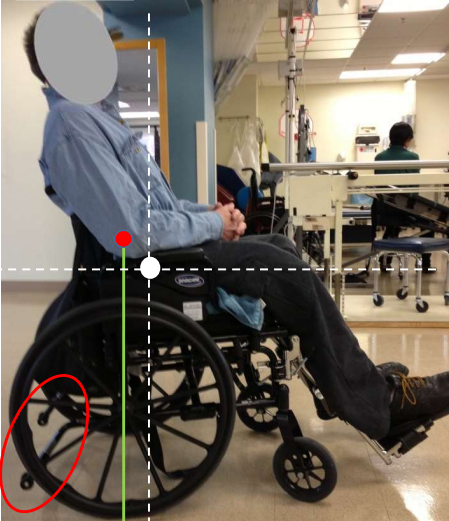
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matrix **INVACARE**
Yes, you can.

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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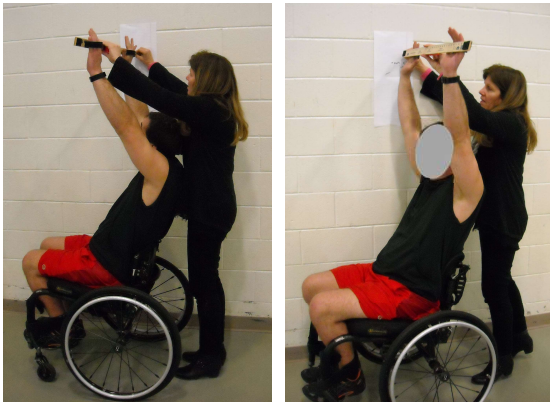
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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




Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

42

42

matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

E2 - 3" Contour

E2 Deep - 6" Contour

matrix 700 FLEX

46

46



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)

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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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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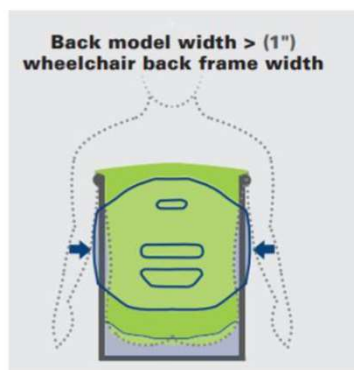
52

52

Case study: Mr. Singh

January 14 Final adjustments

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




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matrix Rx **INVACARE**
Yes, you can.

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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matrix Rx **INVACARE**
Yes, you can.

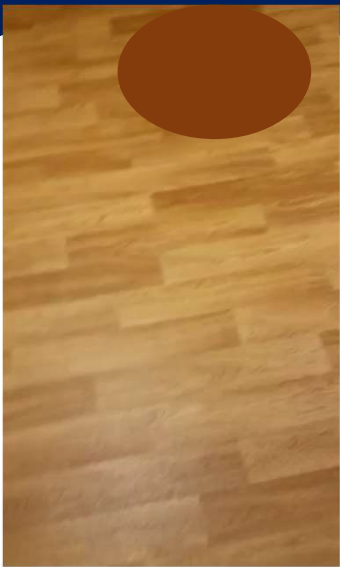
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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

56

matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrx
SEATING SERIES

Motion
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Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

matrx
SEATING SERIES

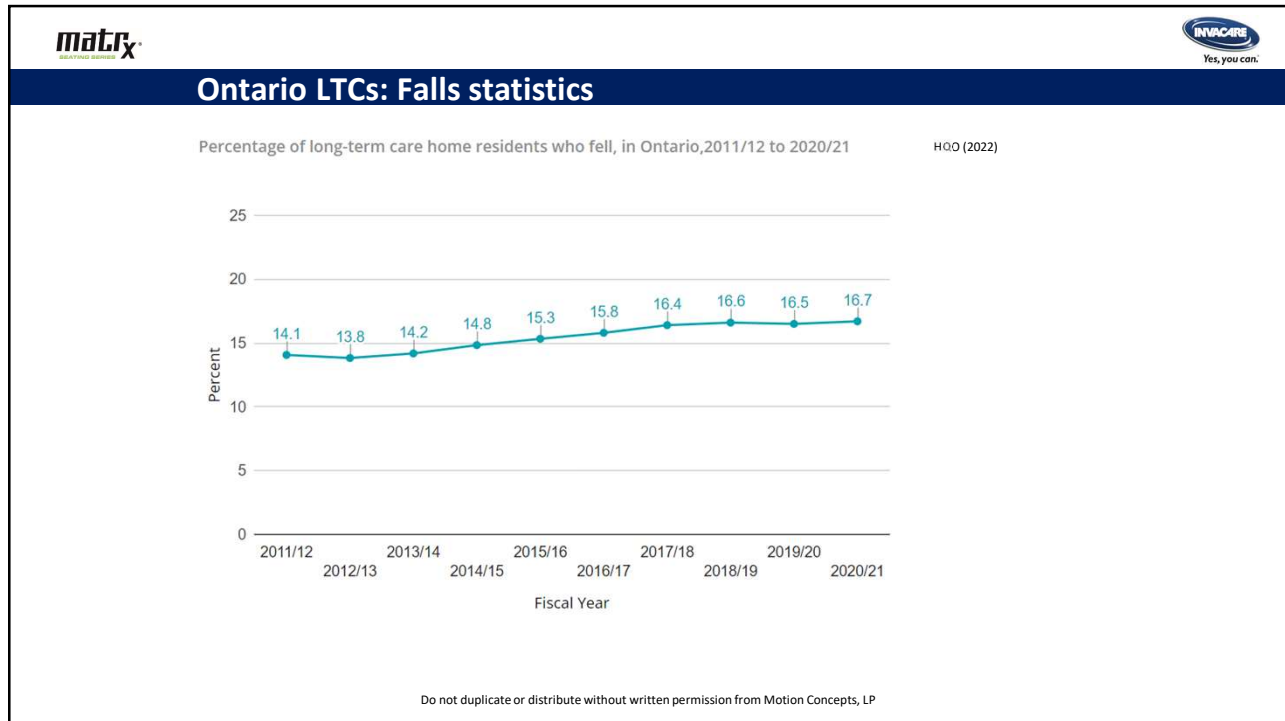
INVACARE
Yes, you can.

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



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

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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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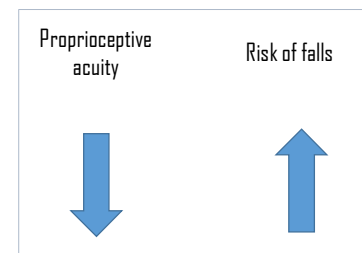
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix SEATING FOR EVERYONE


INVACARE
Yes, you can.

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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matrix SEATING FOR EVERYONE

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Yes, you can.

Wheelchair cushion design: Waterfall front edge



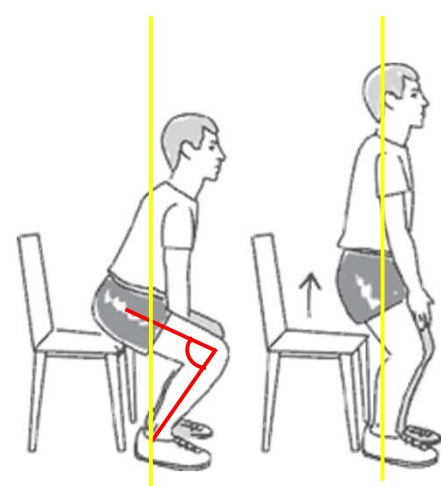
Waterfall front edge

- 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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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12

matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair

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

Low profile

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



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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection


21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

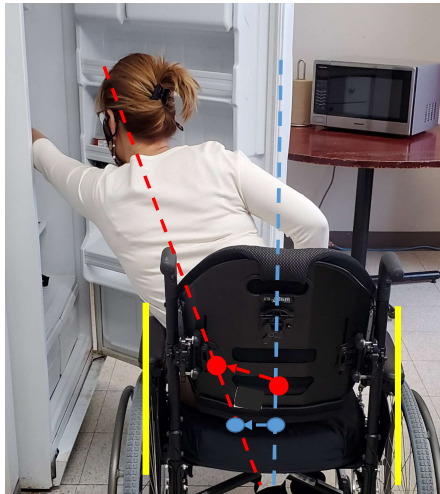
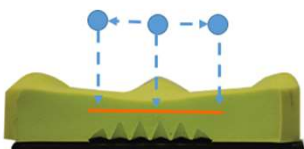
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Wheelchair-related risk factors: Centre of gravity

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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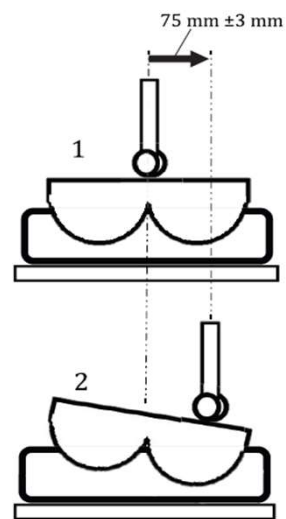
26

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



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Wheelchair cushion design: Abductor and adductor contouring

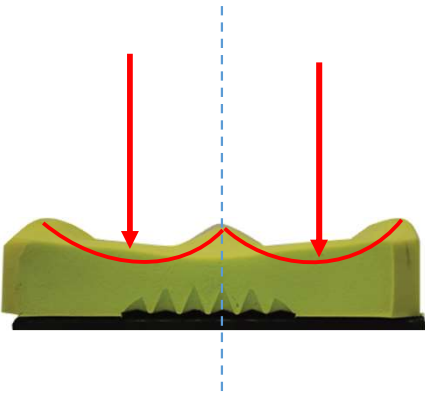
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

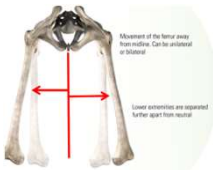
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

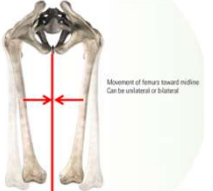


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Matrix PB Back

Matrix Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

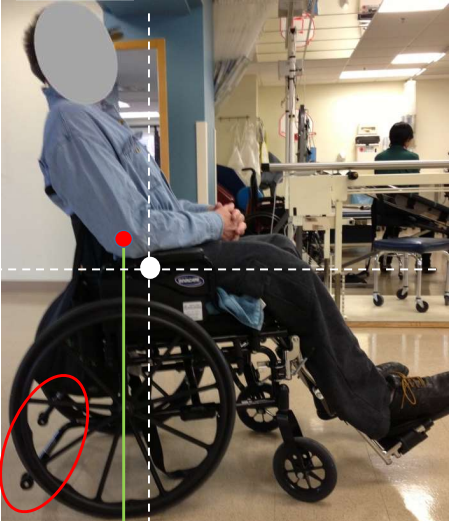
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matrix **INVACARE**
Yes, you can.

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


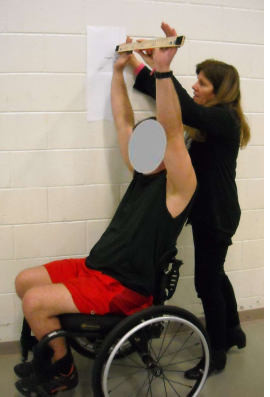
- has longer functional life
- reduces occupant's risks of falling backward
- reduces occupant's sliding forward (sliding out)
- reduces shear forces (risky for skin)

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RESEARCH ARTICLE BY Shirley Ryan AbilityLab

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 Matrix 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 ramp²



- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options



E2 - 3\" Contour



		WIDTH						
		14"	15"	16"	17"	18"	19"	20"
HEIGHT	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"	•	•	•	•	•	•	•	



E2 Deep - 6\" Contour



• MiniSet Hardware • EasySet Hardware




41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

42

42

matrix **INVACARE**
Yes, you can.

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

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

E2 - 3" Contour


E2 Deep - 6" Contour

matrix FLEX

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matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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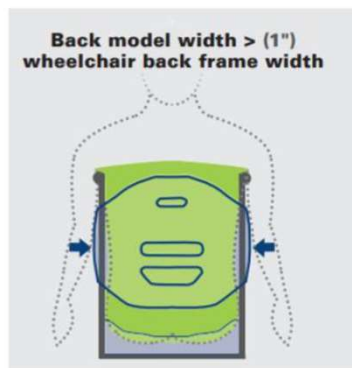
52

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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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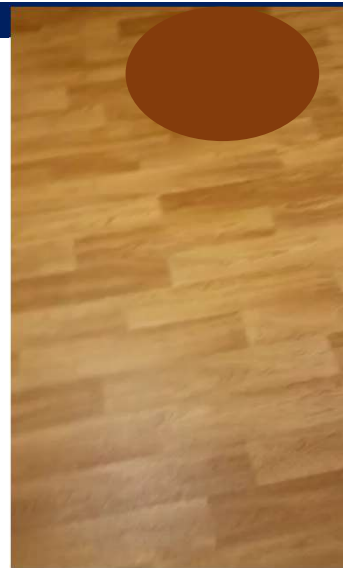
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix
SEATING SERIES

Motion
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Fall Prevention & Wheelchair Seating

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1

matrix
SEATING SERIES

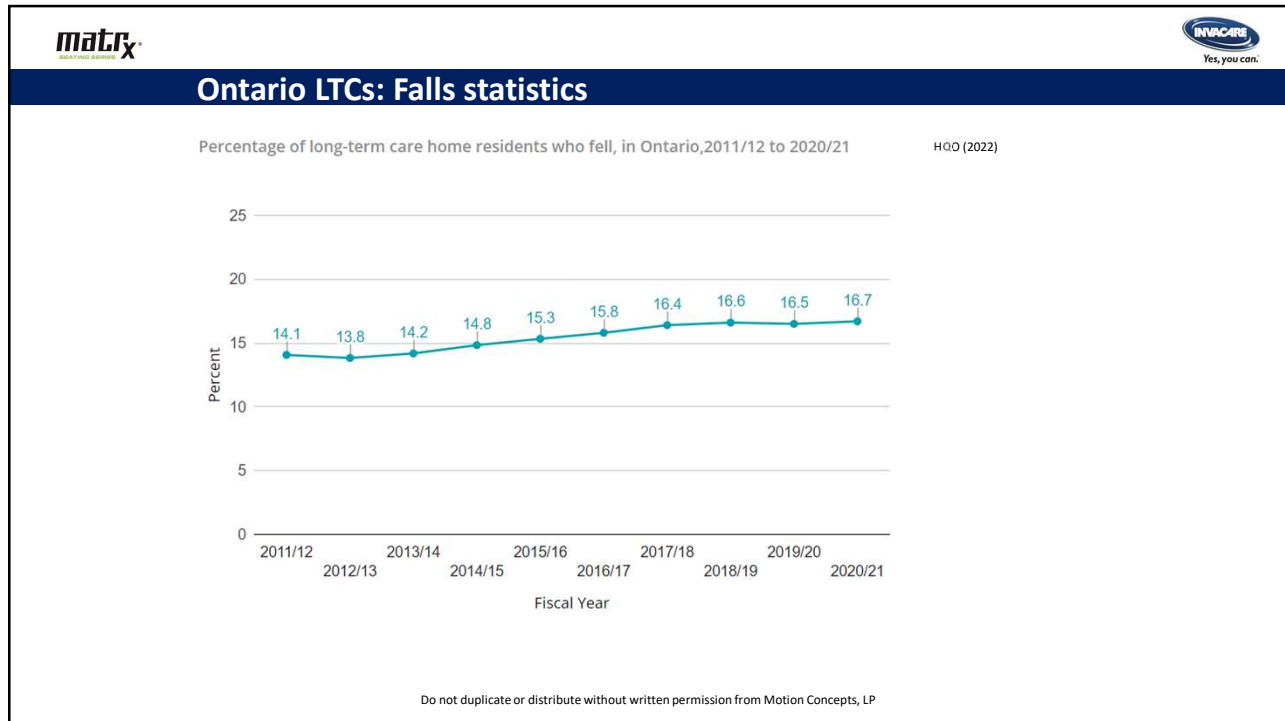
INVACARE
Yes, you can.

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



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

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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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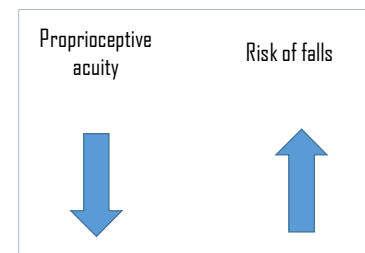
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix SEATING SOLUTIONS


INVACARE
Yes, you can.

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



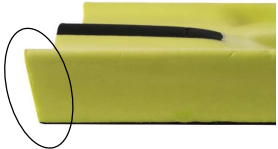
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INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge



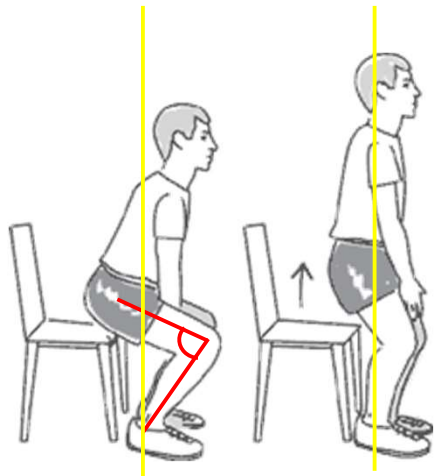
Waterfall front edge

- 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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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12

matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair

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 pelvic stability
- Prevents knees from moving medially or laterally

Low profile

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

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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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22


matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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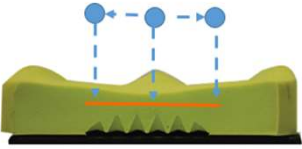
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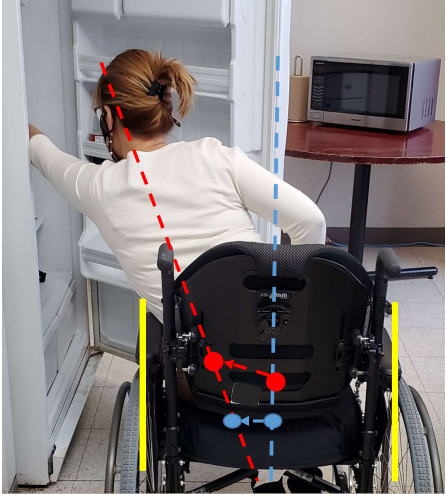
matrix RESEARCH & DESIGN **INVACARE**
Yes, you can.

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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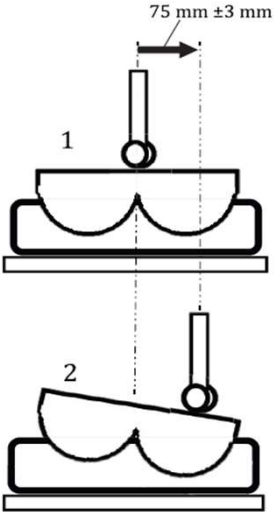
matrix RESEARCH & DESIGN **INVACARE**
Yes, you can.

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

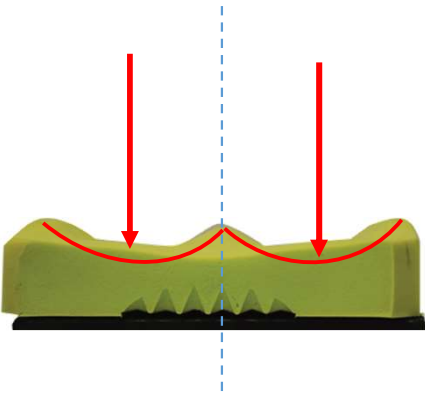
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

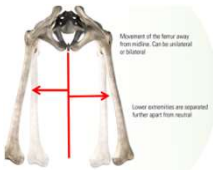
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

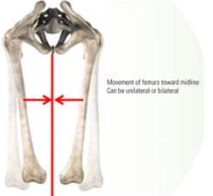


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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

matrx **INVACARE**
Yes, you can.

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



Matrx PB Back Matrx Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion



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



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Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

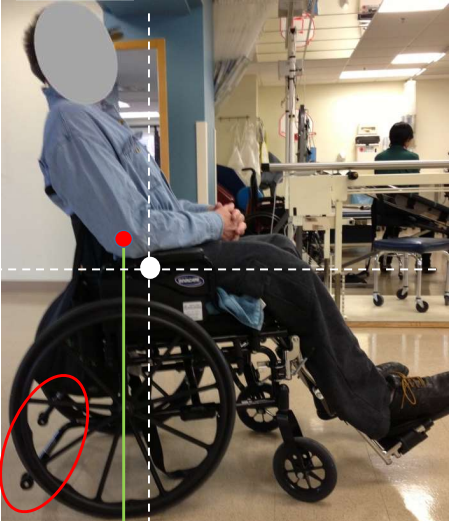
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matrix **INVACARE**
Yes, you can.

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

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 Matrix 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 ramp²

- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options

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

• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour

E2 Deep - 6" Contour

41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

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matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43



How to fix issue of sliding forward in a chair – Matrix® 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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46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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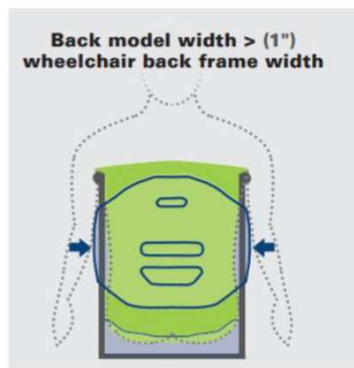
52

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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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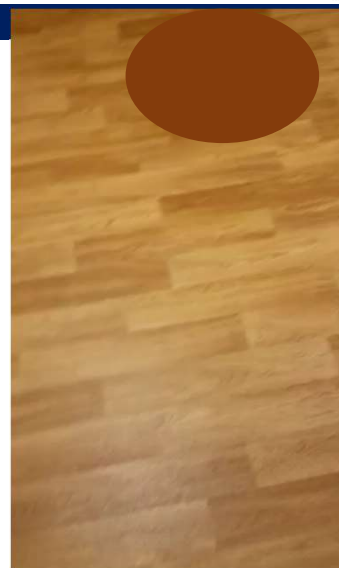
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrx
SEATING SERIES

Motion
Concepts

Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

matrx
SEATING SERIES

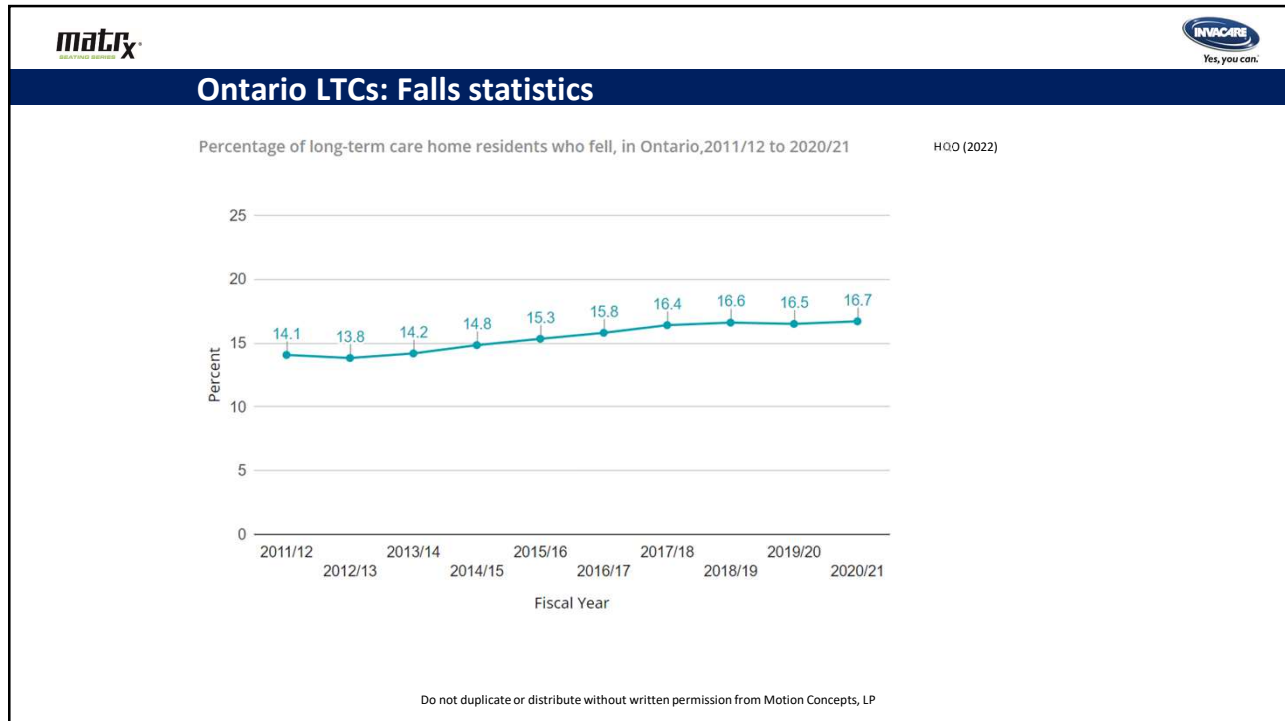
INVACARE
Yes, you can.

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



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

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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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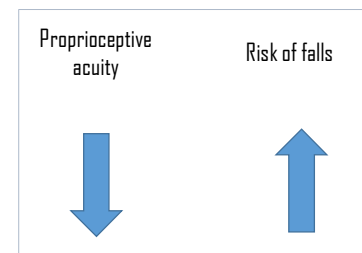
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9


matrix SEATING SOLUTIONS **INVACARE**
Yes, you can.

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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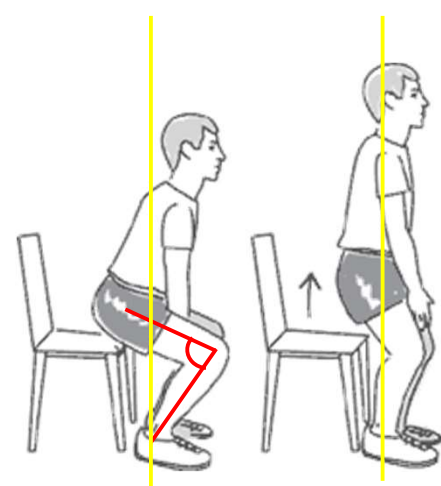
matrix SEATING SOLUTIONS **INVACARE**
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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 keep centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix BEYOND BARRIERS **INVACARE**
Yes, you can.

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

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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matrix BEYOND BARRIERS **INVACARE**
Yes, you can.

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

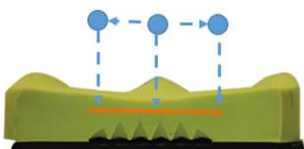
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Wheelchair-related risk factors: Centre of gravity

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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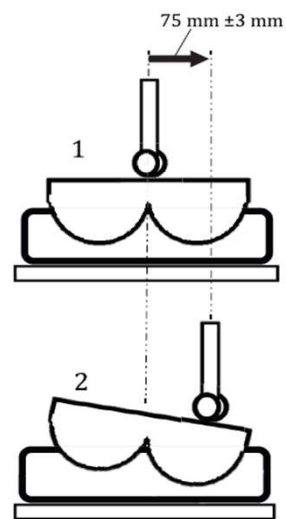
26

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



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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Abductor and adductor contouring

Importance of Midline Leg Positioning

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)

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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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction

Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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

matrx **INVACARE**
Yes, you can.

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



Matrx PB Back

Matrx Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

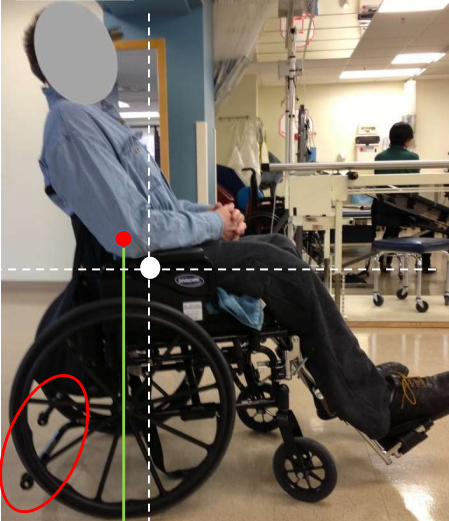
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matrix **INVACARE**
Yes, you can.

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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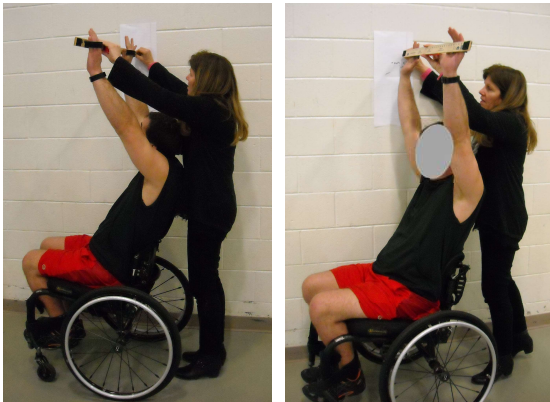
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



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matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

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42

matrix **INVACARE**
Yes, you can.

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



E2S 1816 mounted onto 18" - wide chair



E2S 1712 mounted onto 18" - wide chair



44



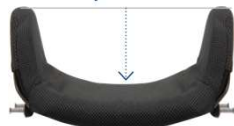
Lateral and postural supports



E2 - 3" Contour




E2 Deep - 6" Contour



46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> Fall((FALL))
      FearOfFalling((Fear of falling)) --> Deconditioning
      FearOfFalling --> PoorBalance
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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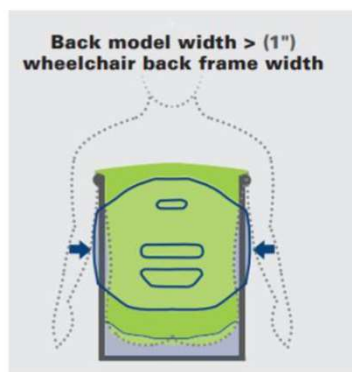
52

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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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matrix Rx **INVACARE**
Yes, you can.

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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matrix Rx **INVACARE**
Yes, you can.

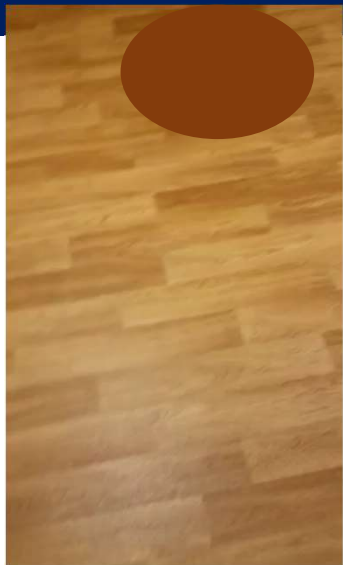
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrx
SEATING SERIES

Motion
Concepts

Fall Prevention & Wheelchair Seating

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

1

matrx
SEATING SERIES

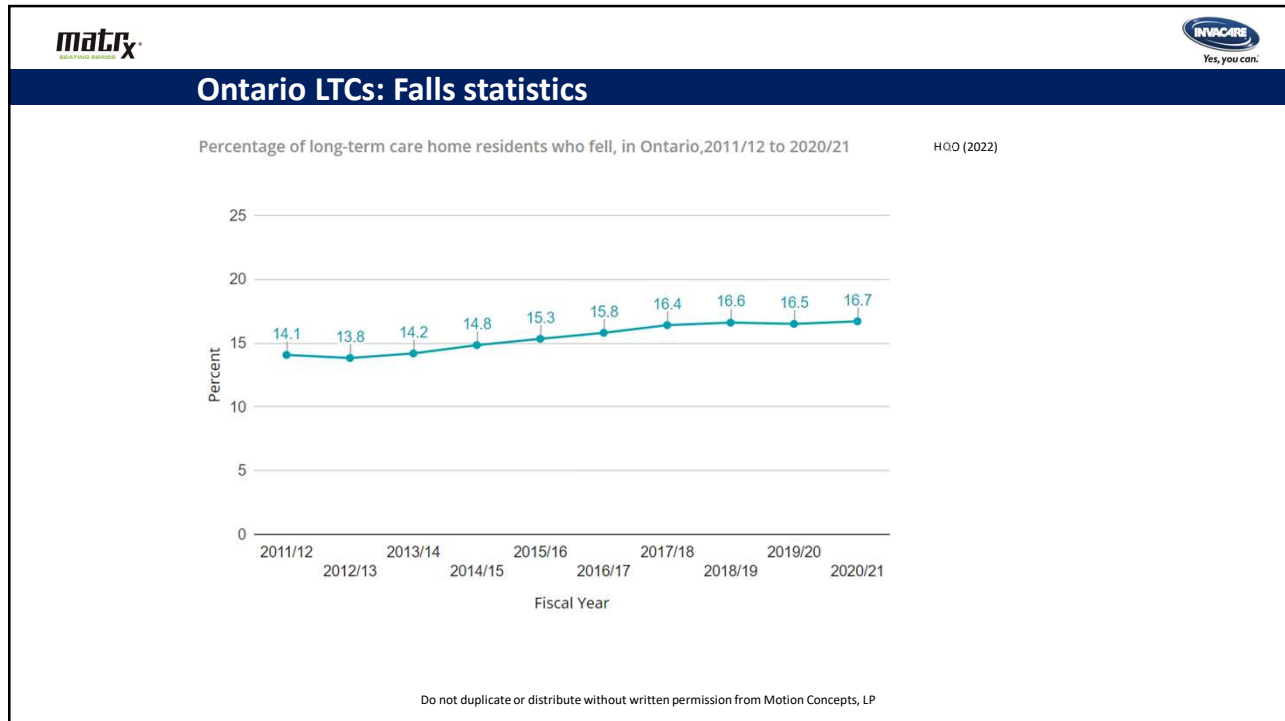
INVACARE
Yes, you can.

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



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

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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 %

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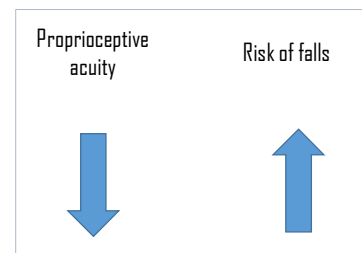
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9


matrix SEATING SOLUTIONS **INVACARE**
Yes, you can.

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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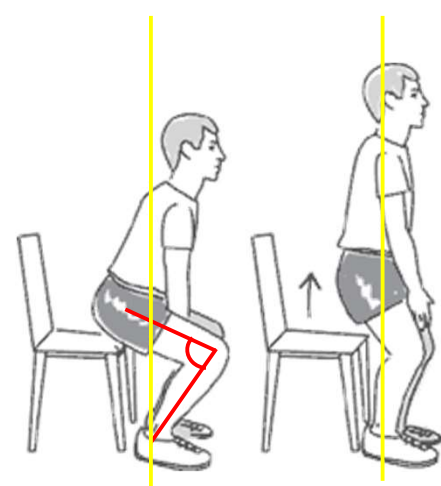
matrix SEATING SOLUTIONS **INVACARE**
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair

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

Low profile

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

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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23

matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

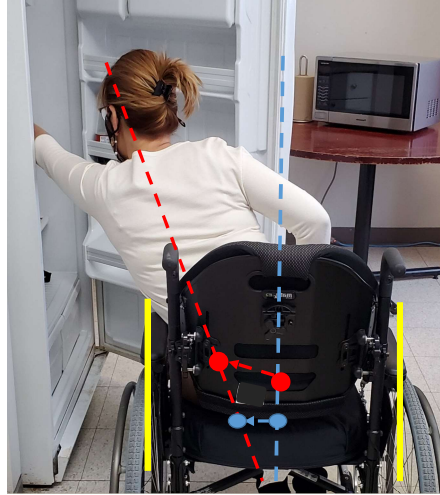
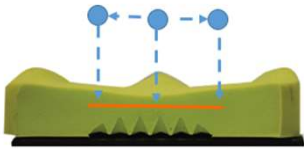
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Wheelchair-related risk factors: Centre of gravity

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)

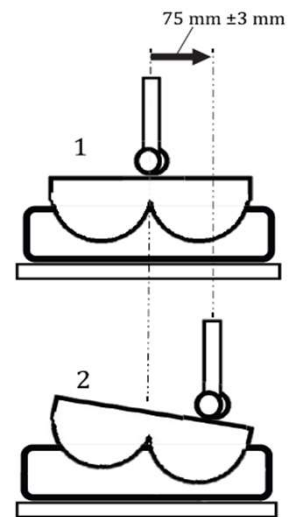
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Wheelchair-related risk factors: Cushion stability





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

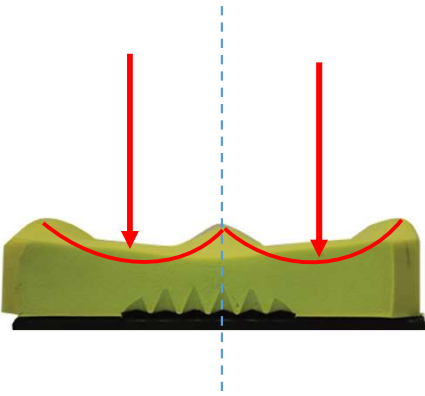
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

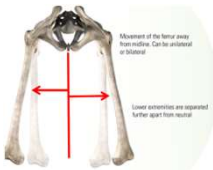
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



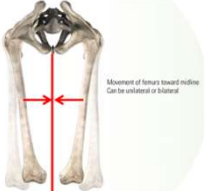



Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction





Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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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matrx **INVACARE**
Yes, you can.

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



Matrx PB Back

Matrx Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

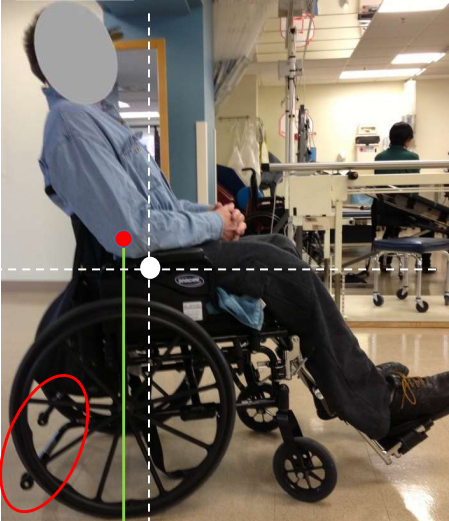
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matrix **INVACARE**
Yes, you can.

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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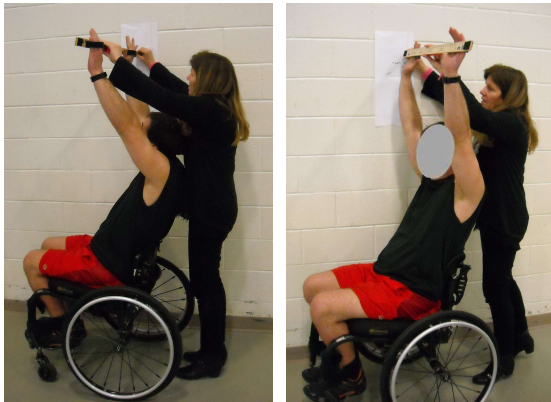
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options



		WIDTH						
		14"	15"	16"	17"	18"	19"	20"
HEIGHT	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

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates four levels of backrest height: Full, High, Medium, and Short. Each level is represented by a green box with a vertical double-headed arrow indicating the height. Below the skeleton diagram, four photographs show a person in a wheelchair from the back, demonstrating the effect of each height level on their posture.

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42

matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43



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

The diagram illustrates two configurations of the Matrix EasySet chair backrest. On the left, the E2S 1816 is mounted on an 18-inch wide chair. A 1-inch gap is shown between the chair's backrest and the chair's frame. The E2S 1816 is 18 inches wide. On the right, the E2S 1712 is mounted on an 18-inch wide chair. The E2S 1712 is 17 inches wide, leaving a 3 1/2 inch gap between the chair's backrest and the chair's frame.

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

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Lateral and postural supports

The image displays several types of lateral and postural supports. On the left, two curved supports are shown: the E2 - 3" Contour and the E2 Deep - 6" Contour. In the center, a black plastic backrest with two horizontal cutouts is shown. On the right, two photographs show a person's hands adjusting a blue lateral support on a chair. Below the photographs is a star-patterned support with the Matrix logo.

E2 - 3" Contour

E2 Deep - 6" Contour

46

46



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)

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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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FALL((FALL))
      FearOfFalling((Fear of falling)) --> Deconditioning
      FearOfFalling --> FALL
  
```

(Gotzmeister et al., 2015)

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matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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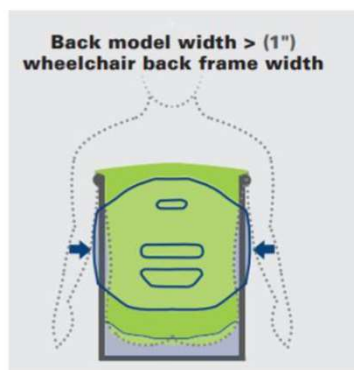
52

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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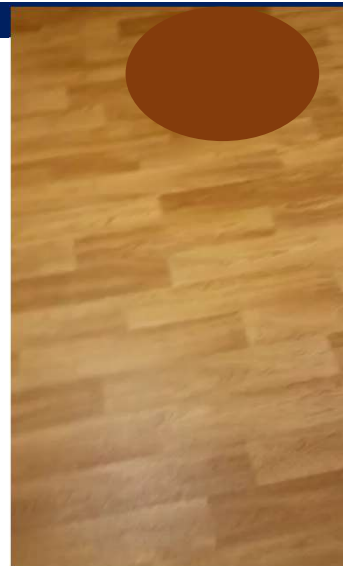
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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!



59

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Fall Prevention & Wheelchair Seating

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1

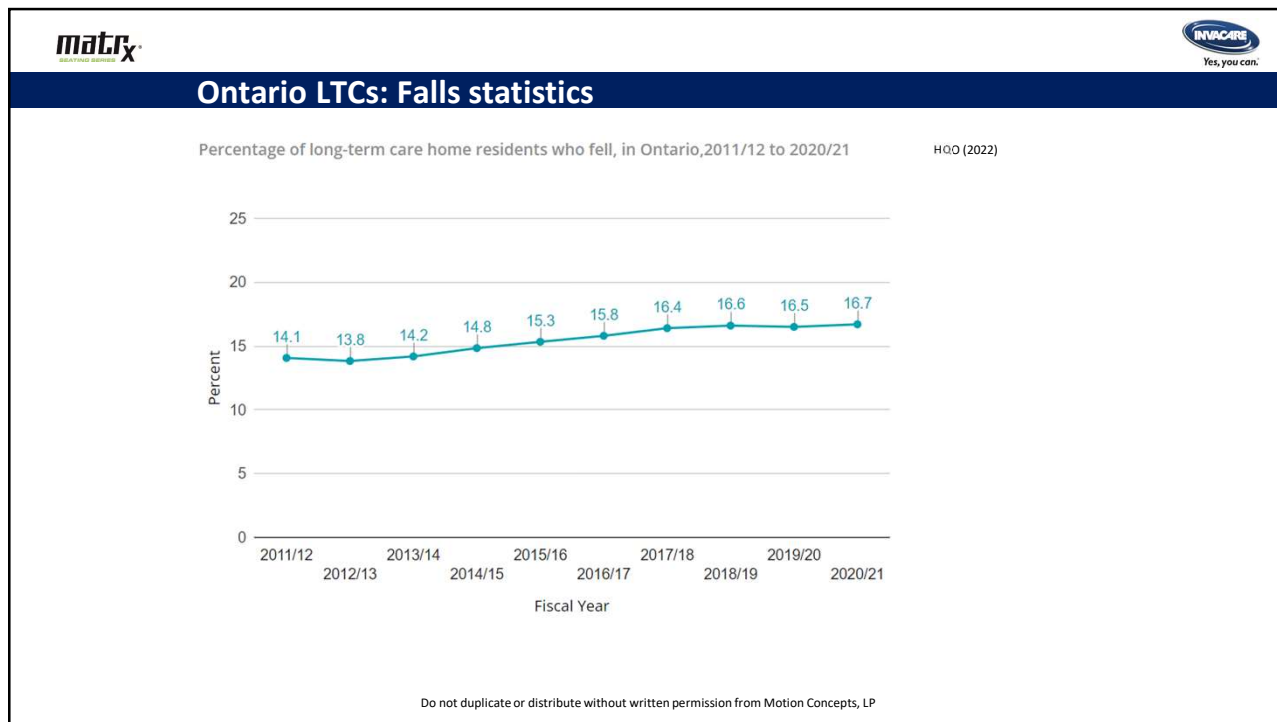



Learning objectives

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



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

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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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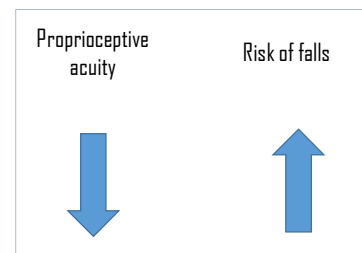
6

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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix SEATING FOR ALL


INVACARE
Yes, you can.

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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10

matrix SEATING FOR ALL

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge



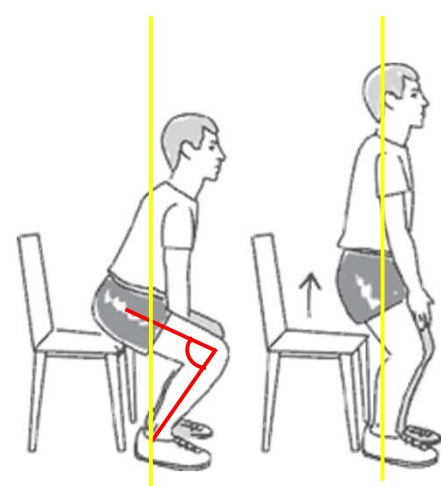
Waterfall front edge

- 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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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?)

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matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair

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

Low profile

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



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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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INVACARE
Yes, you can.

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

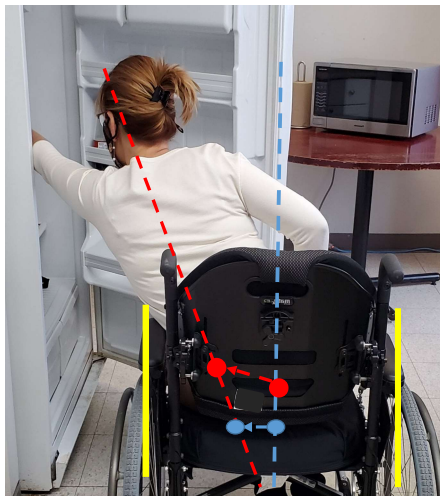
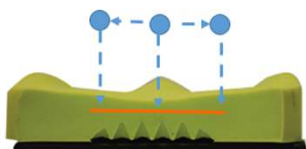
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Wheelchair-related risk factors: Centre of gravity

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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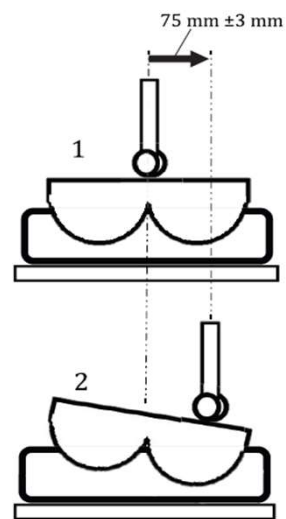
26

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



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Wheelchair cushion design: Abductor and adductor contouring

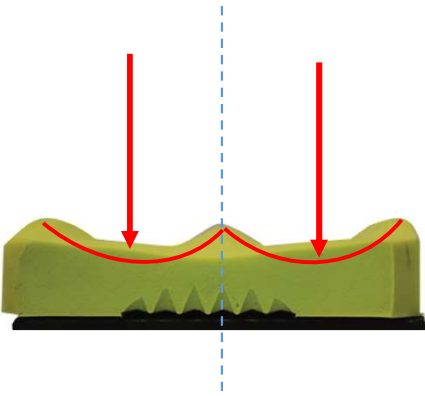
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

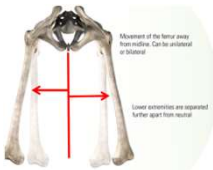
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

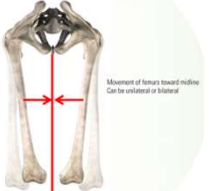


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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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matrx **INVACARE**
Yes, you can.

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





Matrx PB Back





Matrx Elite E2 Back



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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion



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




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

Upholstery backrest Support of a rigid backrest

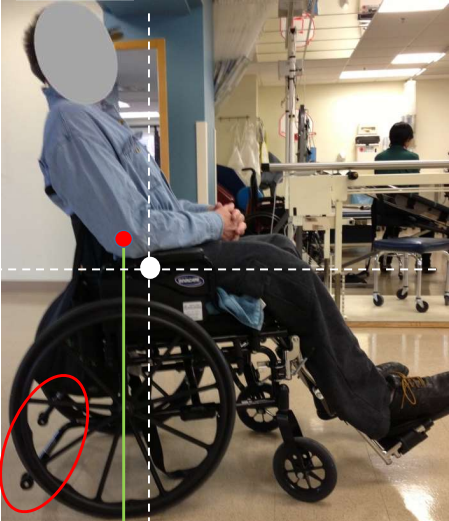
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matrix **INVACARE**
Yes, you can.

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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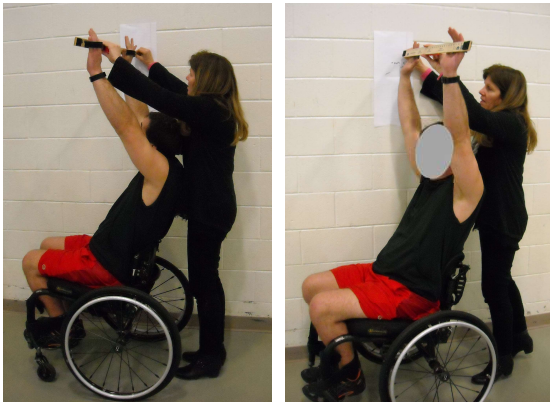
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



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matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

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matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

E2 - 3" Contour


E2 Deep - 6" Contour

matrix FLEX

46

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matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> Fall((FALL))
      FearOfFalling((Fear of falling)) --> Deconditioning
      FearOfFalling --> Fall
  
```

(Gotzmeister et al., 2015)

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matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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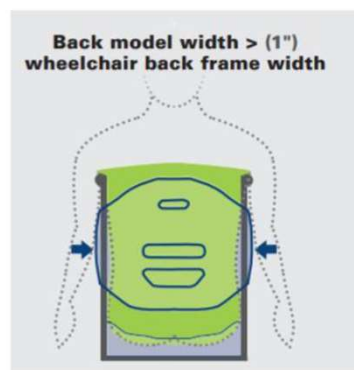
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Case study: Mr. Singh

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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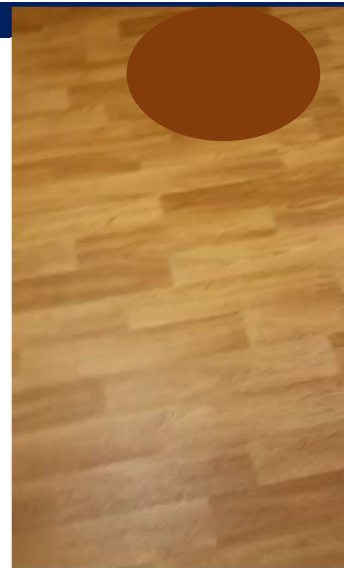
Case study: Mr. Singh

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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matrix RESEARCH & CONSULTING

INVACARE
Yes, you can.

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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matrix RESEARCH & CONSULTING

INVACARE
Yes, you can.

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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SEATING SERIES

Motion
Concepts

Fall Prevention & Wheelchair Seating

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

1

matrx
SEATING SERIES

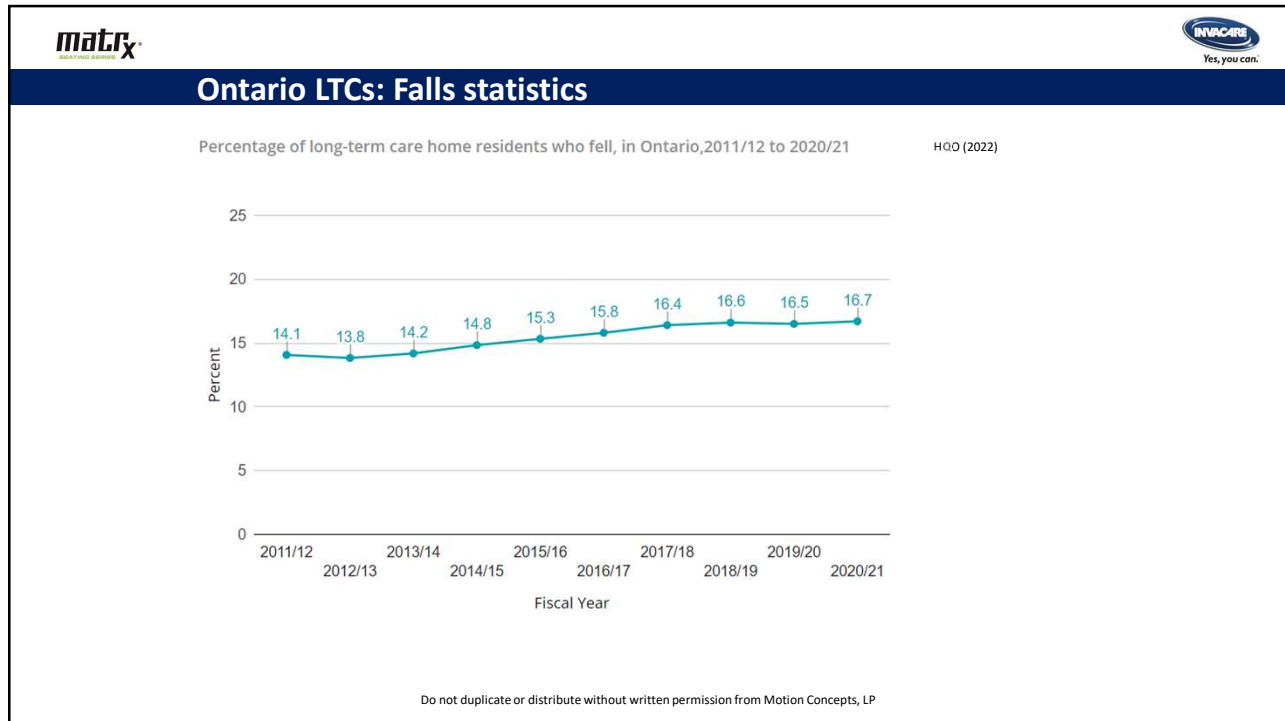
INVACARE
Yes, you can.

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



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

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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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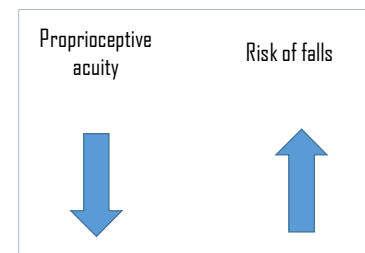
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix RESEARCH & DESIGN


INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge



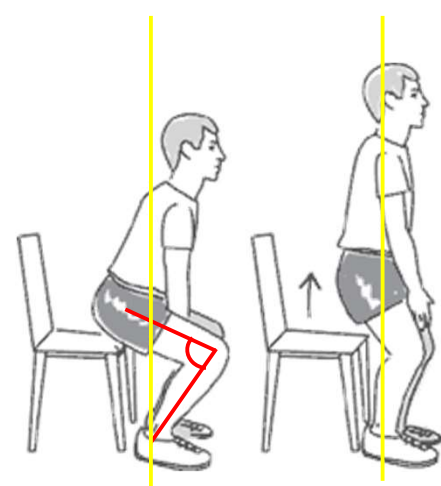
Waterfall front edge

- 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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INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair



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

Low profile

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

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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection


21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

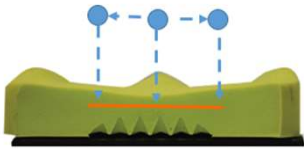
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Wheelchair-related risk factors: Centre of gravity

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)

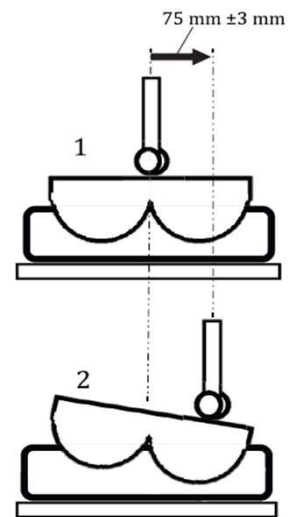
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Wheelchair-related risk factors: Cushion stability





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

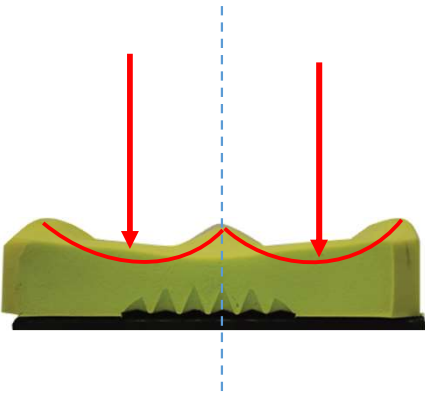
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

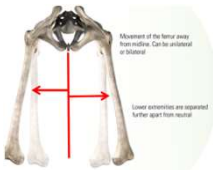
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.

Lower extremities are supported further apart from neutral.

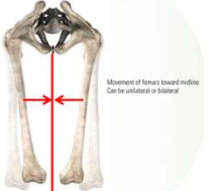


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Matrix PB Back

Matrix Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion



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




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

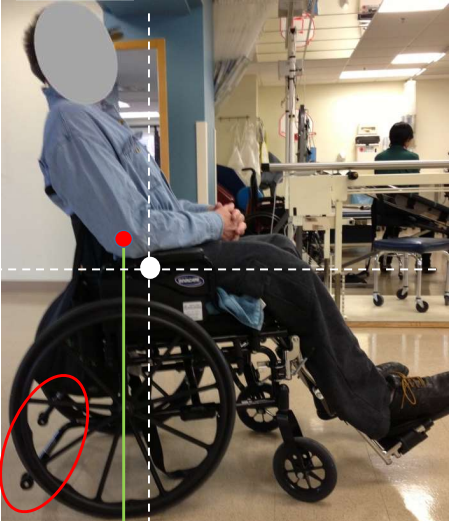
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matrix **INVACARE**
Yes, you can.

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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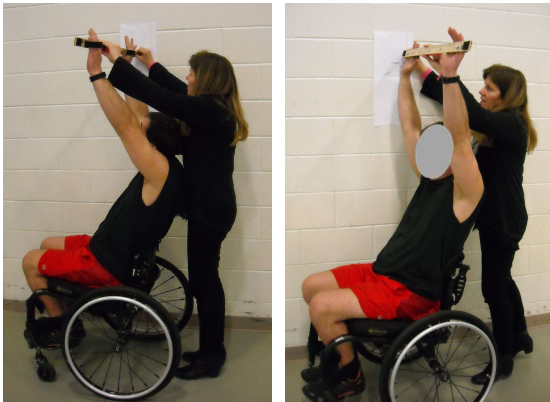
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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

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Matrix® E2 Back Models and Sizes: Infinite Height Options



		WIDTH						
		14"	15"	16"	17"	18"	19"	20"
HEIGHT	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

matrx **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

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42

matrx **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports


E2 - 3" Contour

E2 Deep - 6" Contour

46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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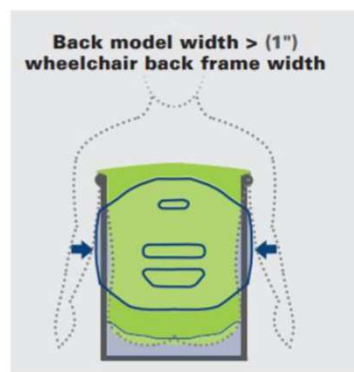
52

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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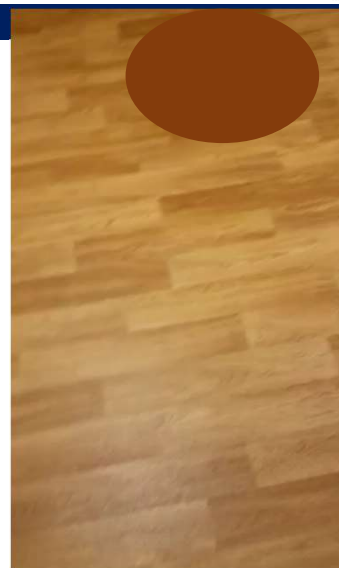
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrx
SEATING SERIES

Motion
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Fall Prevention & Wheelchair Seating

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

1

matrx
SEATING SERIES

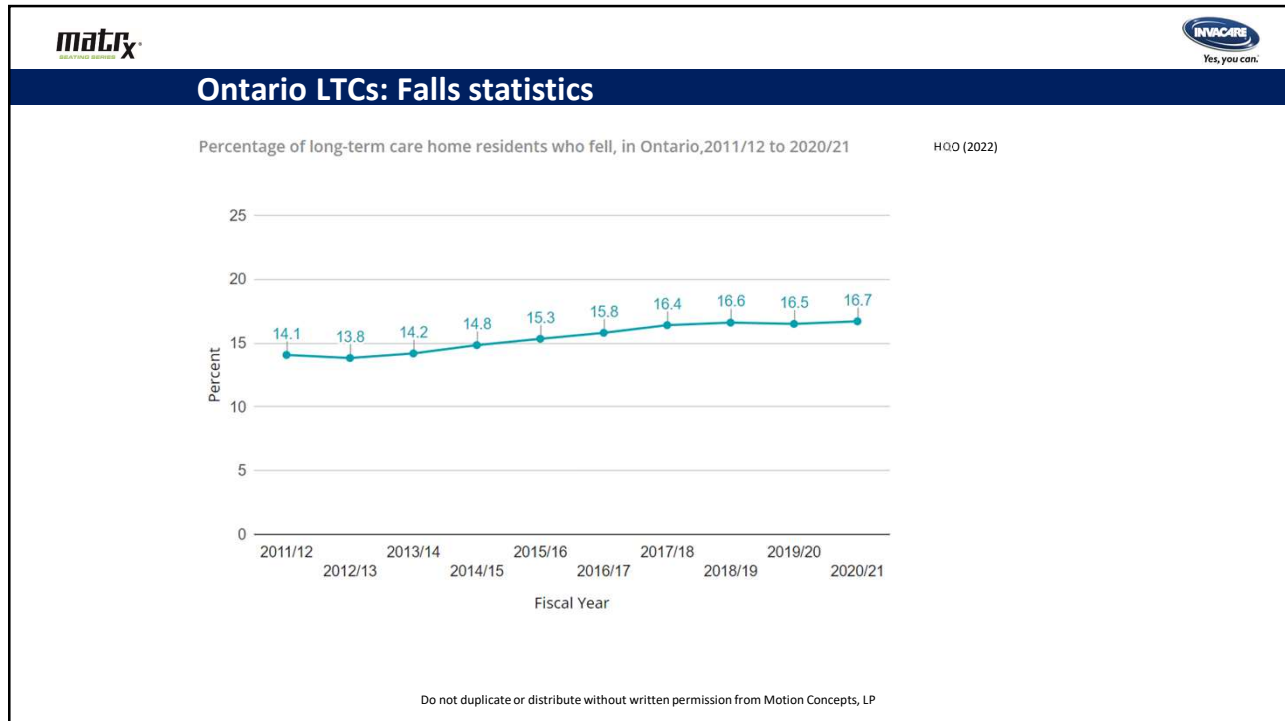
INVACARE
Yes, you can.

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



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

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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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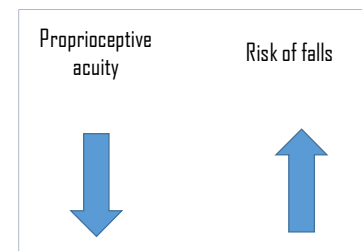
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix SEATING FOR EVERYONE


INVACARE
Yes, you can.

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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matrix SEATING FOR EVERYONE

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge

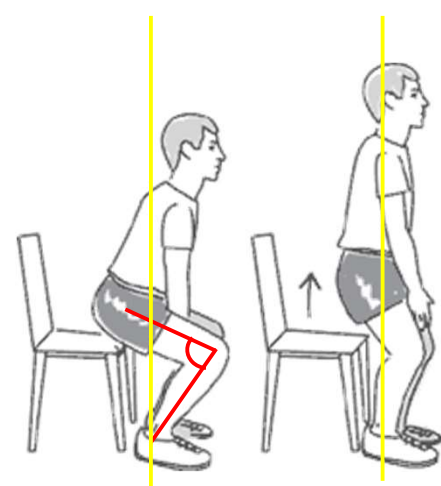


Waterfall front edge

- 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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair



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

Low profile

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

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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21


9

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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Yes, you can.

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

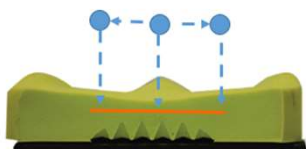
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25

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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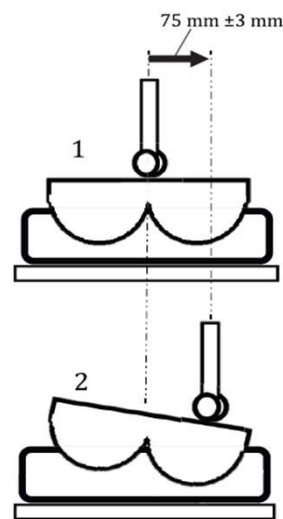
26

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



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Wheelchair cushion design: Abductor and adductor contouring

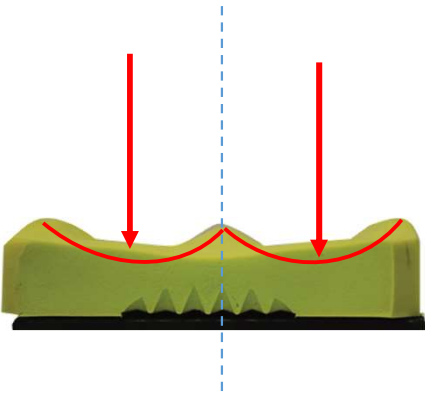
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

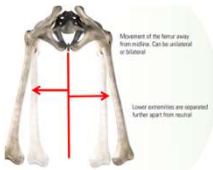
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

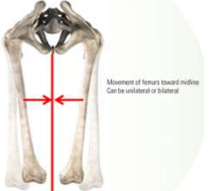


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Matrix PB Back

Matrix Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

Upholstery backrest Support of a rigid backrest

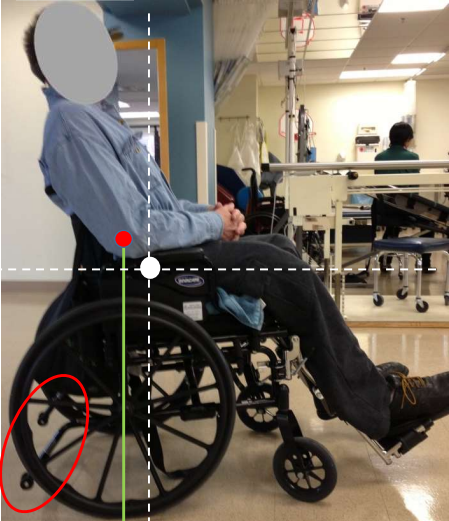
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matrix **INVACARE**
Yes, you can.

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

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 Matrix backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:
- 9° better (less posterior) pelvic angle ($\bar{x}=96.92^\circ$)
- 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 ramp²

- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options

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

E2 - 3" Contour

E2 Deep - 6" Contour

• MiniSet Hardware • EasySet Hardware

41

matrx **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs of a person in a wheelchair demonstrate the effect of each height. The 'Full' height provides the most support, while the 'Short' height provides the least.

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matrx **INVACARE**
Yes, you can.

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

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

E2 - 3" Contour


E2 Deep - 6" Contour

matrix FLEX

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matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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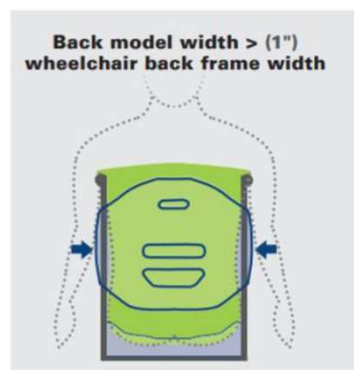
52

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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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matrix Rx **INVACARE**
Yes, you can.

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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matrix Rx **INVACARE**
Yes, you can.

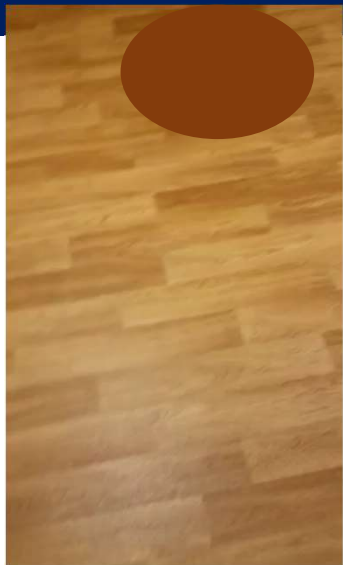
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix
SEATING SERIES

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Fall Prevention & Wheelchair Seating

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

1

matrix
SEATING SERIES

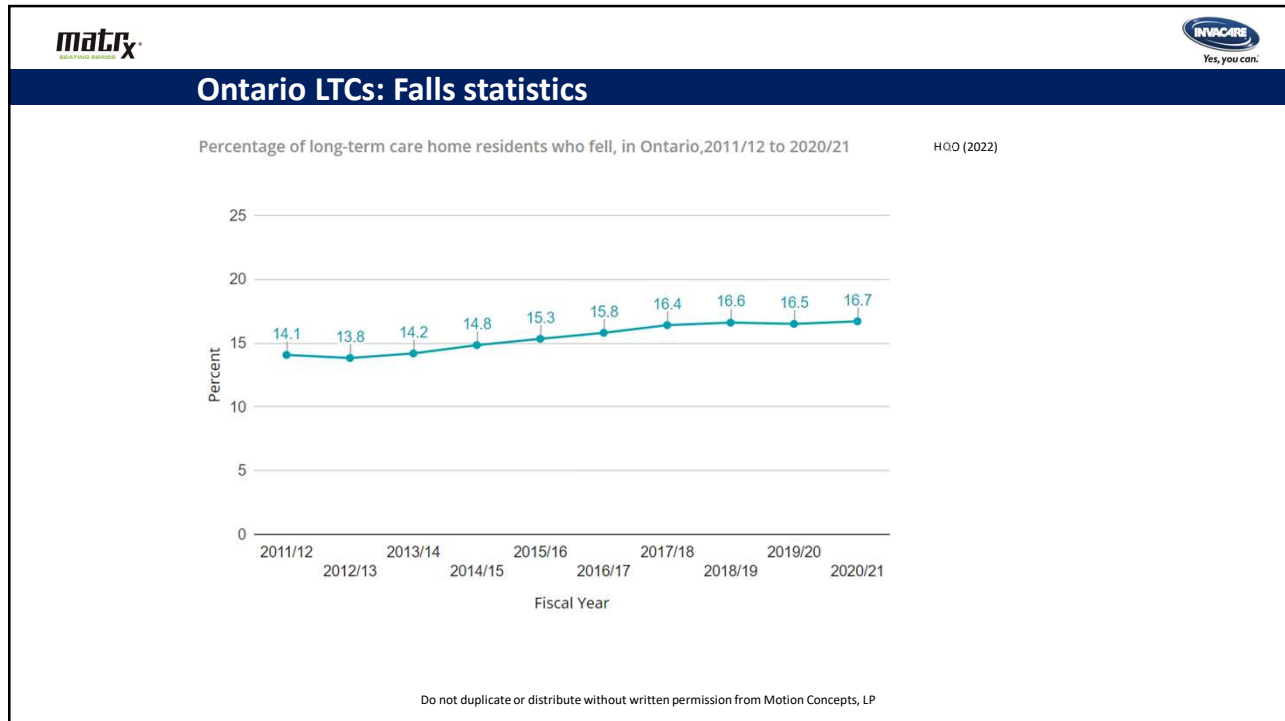
INVACARE
Yes, you can.

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



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

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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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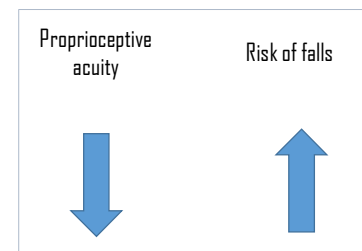
6

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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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

(Halbach, 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




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9

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INVACARE
Yes, you can.

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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matrix SEATING FOR EVERYONE

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Yes, you can.

Wheelchair cushion design: Waterfall front edge



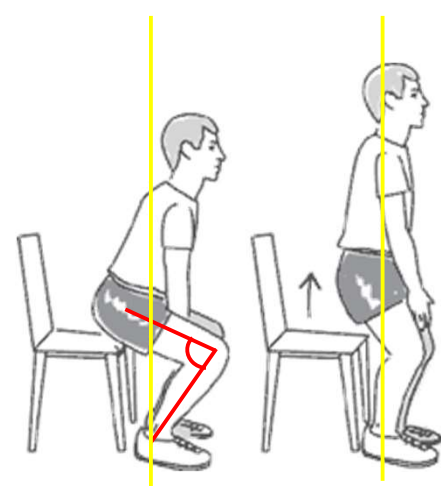
Waterfall front edge

- 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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INVACARE
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

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Yes, you can.

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?)

15

matrix **INVACARE**
Yes, you can.

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

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Yes, you can.

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



Preventing sliding out of a chair



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 pelvic stability
- Prevents knees from moving medially or laterally

Low profile

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

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

matrix **INVACARE**
Yes, you can.

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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Yes, you can.

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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Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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Yes, you can.

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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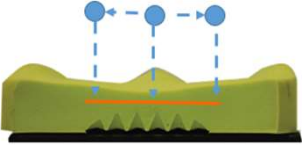
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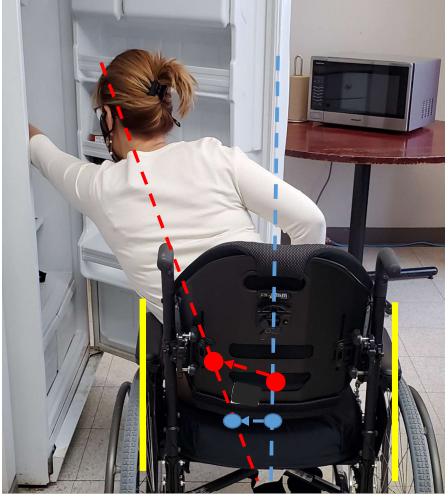



Wheelchair-related risk factors: Centre of gravity

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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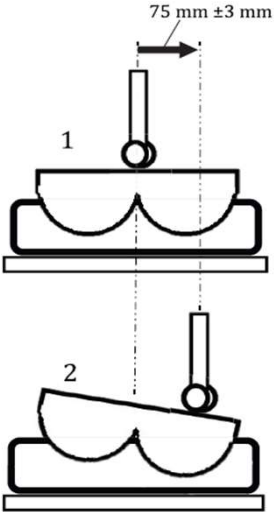



Wheelchair-related risk factors: Cushion stability



INTERNATIONAL STANDARD ISO 16840-13

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



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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Abductor and adductor contouring

Importance of Midline Leg Positioning

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)

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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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction

Movement of femurs toward midline. Can be unilateral or bilateral.

Abductor

improve midline leg positioning for patients with excessive **ad**duction

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29

matrx **INVACARE**
Yes, you can.

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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matrx **INVACARE**
Yes, you can.

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





Matrx PB Back





Matrx Elite E2 Back



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Yes, you can.

Nancy: comfortable deep cushion



Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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INVACARE
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

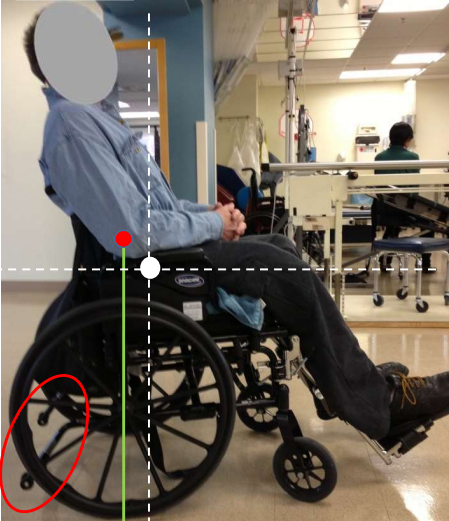
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Yes, you can.

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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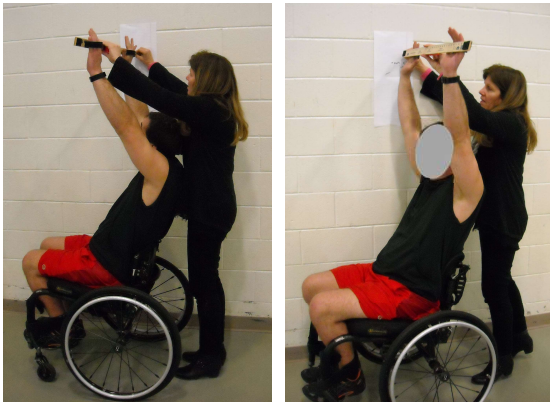
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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




Matrix® E2 Back Models and Sizes: Infinite Height Options



		WIDTH						
		14"	15"	16"	17"	18"	19"	20"
HEIGHT	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

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

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42

matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43



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



44




Lateral and postural supports



46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> Fall((FALL))
      FearOfFalling((Fear of falling)) --> Deconditioning
      FearOfFalling --> Fall
  
```

(Gotzmeister et al., 2015)

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matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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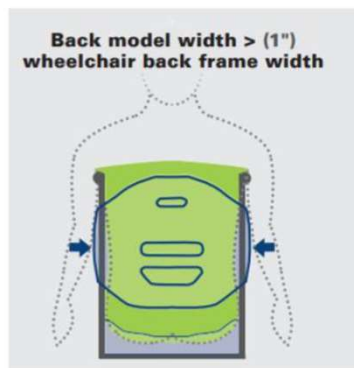
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Case study: Mr. Singh

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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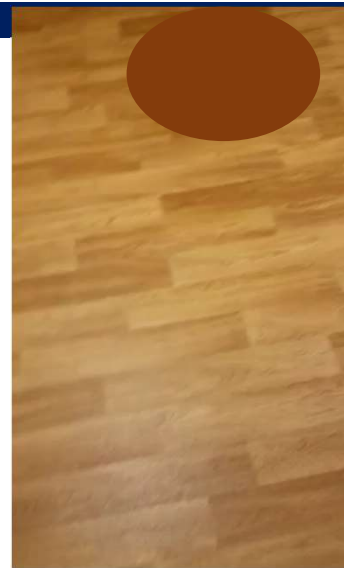
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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

56

matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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!



59

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matrx
SEATING SERIES

Motion
Concepts

Fall Prevention & Wheelchair Seating

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

1

matrx
SEATING SERIES

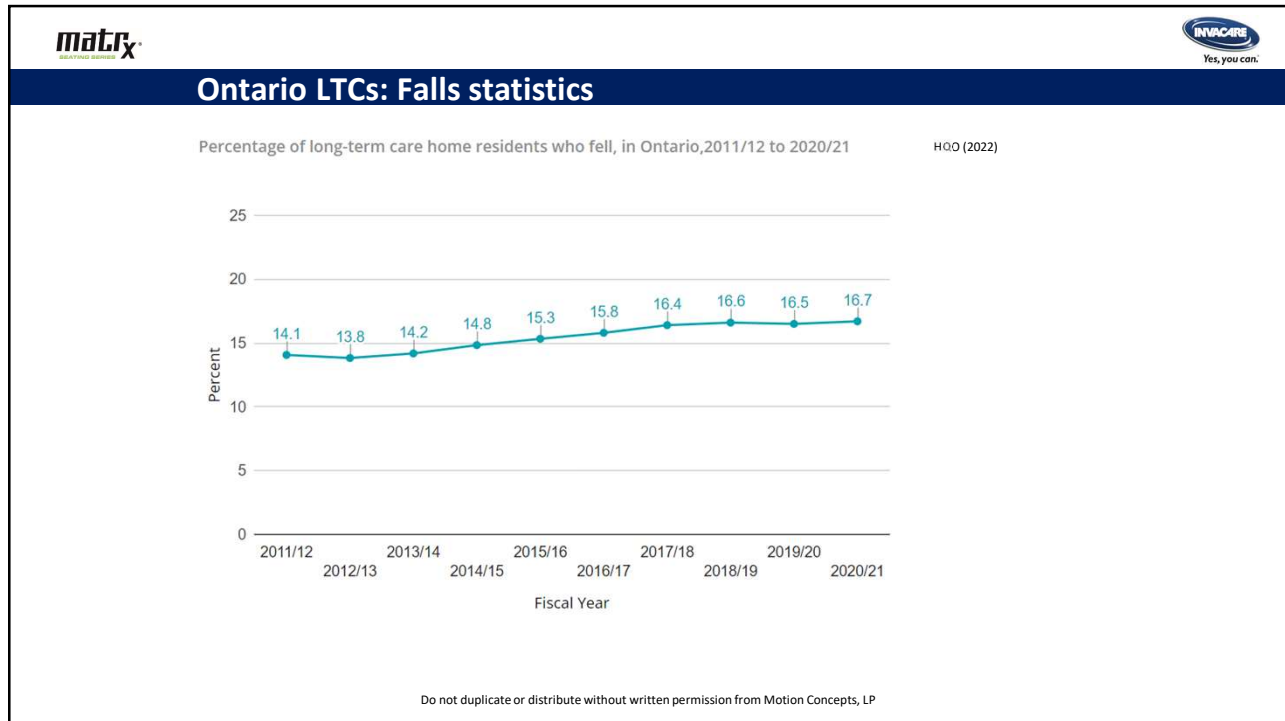
INVACARE
Yes, you can.

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



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

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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 %

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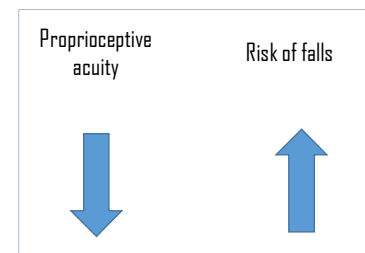
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix SEATING FOR EVERYONE


INVACARE
Yes, you can.

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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10

matrix SEATING FOR EVERYONE

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge

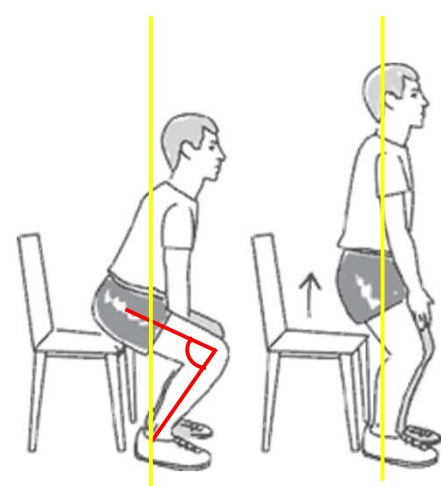


Waterfall front edge

- 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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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 keep centre of gravity low
- Along with anatomical contour, helps to prevent falls during propelling and transfers

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection


21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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23

matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

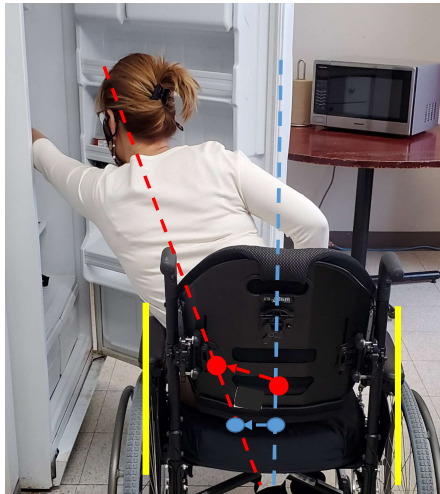
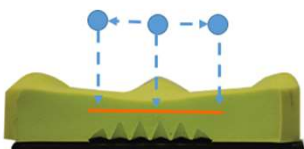
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Wheelchair-related risk factors: Centre of gravity

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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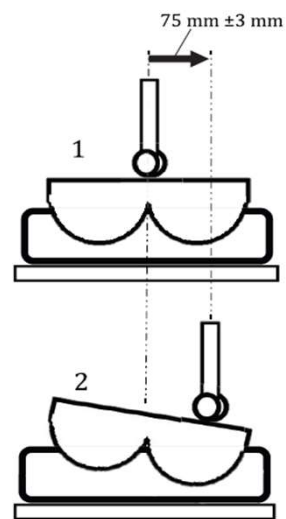
26

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



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Wheelchair cushion design: Abductor and adductor contouring

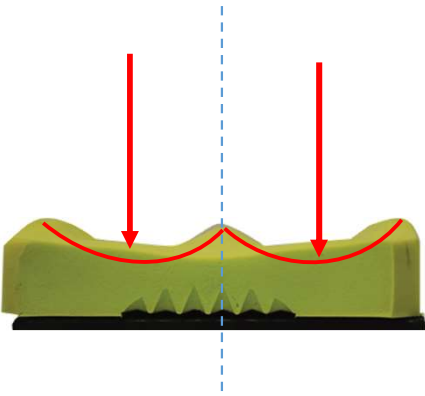
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

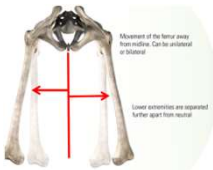
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

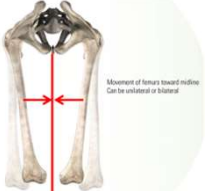


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Matrix PB Back

Matrix Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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33

matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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34

matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back



Upholstery backrest



Support of a rigid backrest

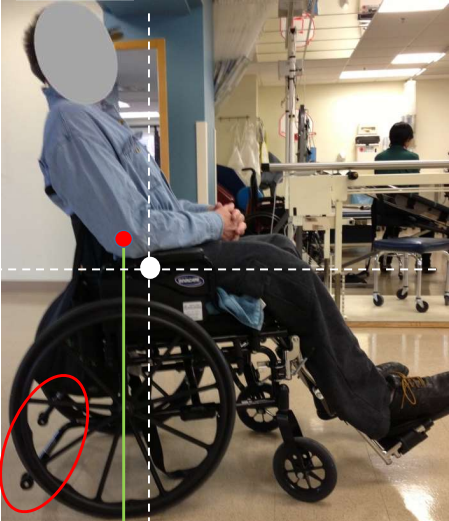
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matrix **INVACARE**
Yes, you can.

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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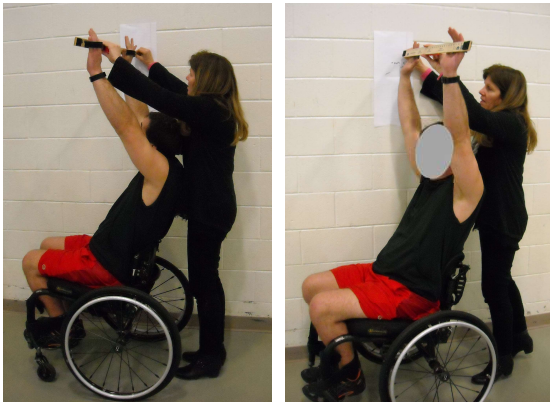
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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

40




Matrix® E2 Back Models and Sizes: Infinite Height Options



		WIDTH						
		14"	15"	16"	17"	18"	19"	20"
HEIGHT	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

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates four levels of backrest height: Full, High, Medium, and Short. A human skeleton is shown with dashed lines indicating the vertical extent of each level. Below the skeleton, four photographs of a person in a wheelchair demonstrate the corresponding backrest heights. The 'Full' level reaches the top of the head, 'High' reaches the shoulders, 'Medium' reaches the upper back, and 'Short' reaches the lower back.

42

42

matrix **INVACARE**
Yes, you can.

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

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

43

43



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



E2S 1816 mounted onto 18" - wide chair



E2S 1712 mounted onto 18" - wide chair



44



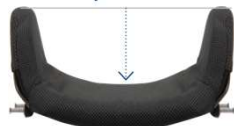
Lateral and postural supports



E2 - 3" Contour




E2 Deep - 6" Contour



46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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48

48

matrix Rx **INVACARE**
Yes, you can.



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

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49

49

matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FALL((FALL))
      FALL --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"


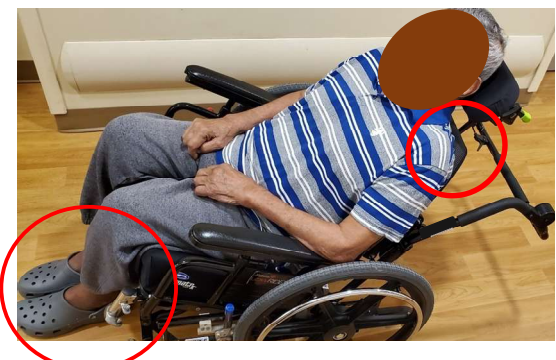
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51

51

matrix Rx **INVACARE**
Yes, you can.

Case study: Mr. Singh

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

52

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52


matrix Rx **INVACARE**
Yes, you can.

Case study: Mr. Singh

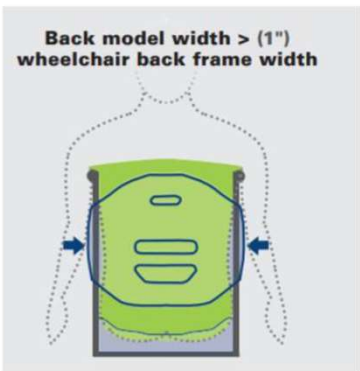
January 14 Final adjustments

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





**Back model width > (1")
wheelchair back frame width**



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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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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

56

matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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!



59

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Fall Prevention & Wheelchair Seating

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Clinical Education Specialist
Motion Concepts

1

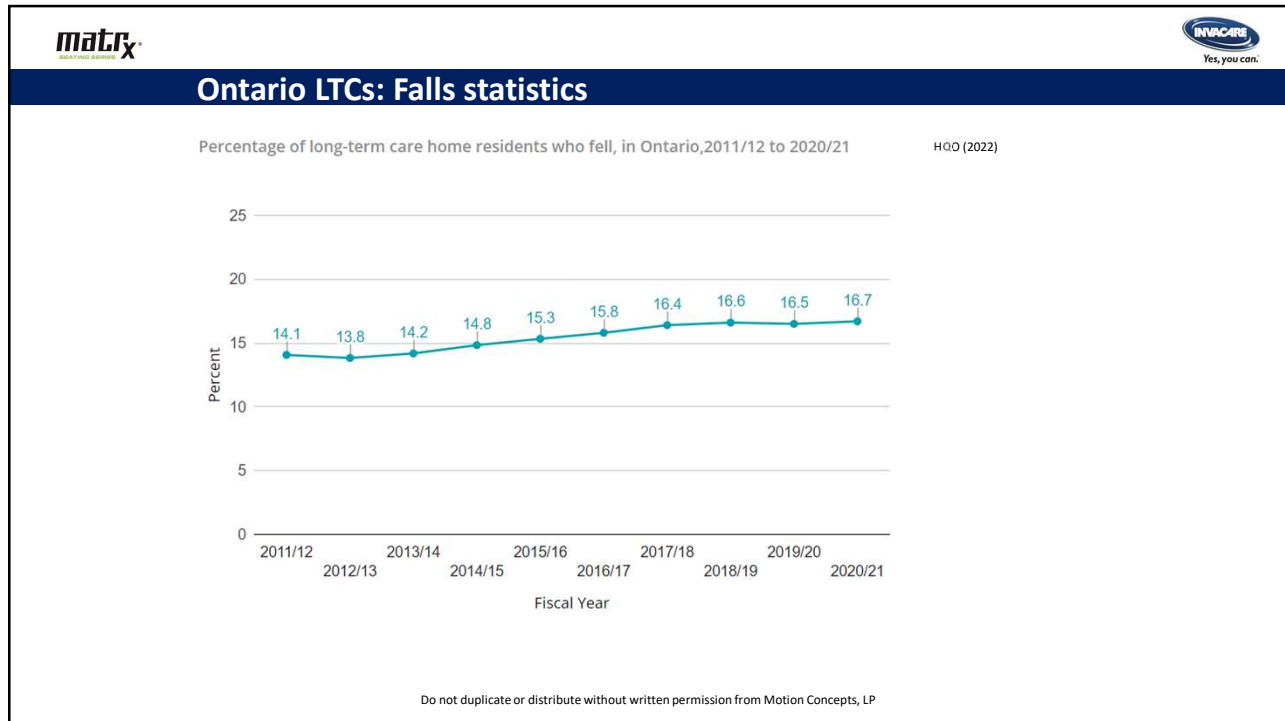



Learning objectives

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



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

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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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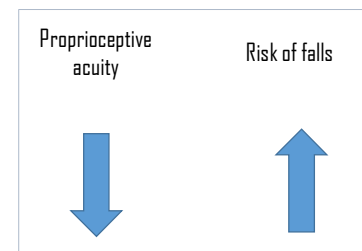
6

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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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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix RESEARCH AND DESIGN


INVACARE
Yes, you can.

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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10

matrix RESEARCH AND DESIGN

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge

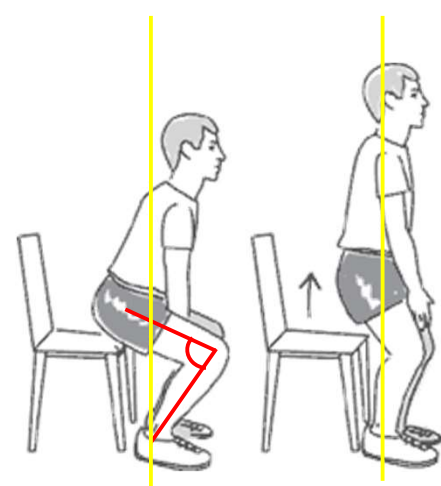


Waterfall front edge

- 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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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12

matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair



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

Low profile

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

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20




MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

9

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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23

matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

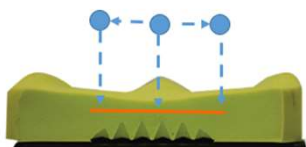
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25

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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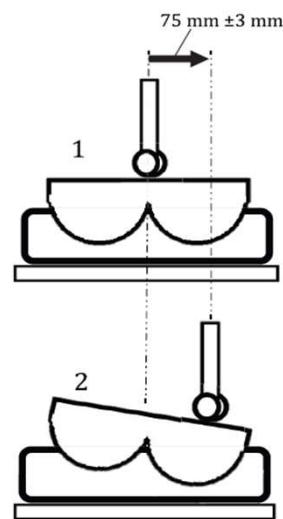
26

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



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Wheelchair cushion design: Abductor and adductor contouring

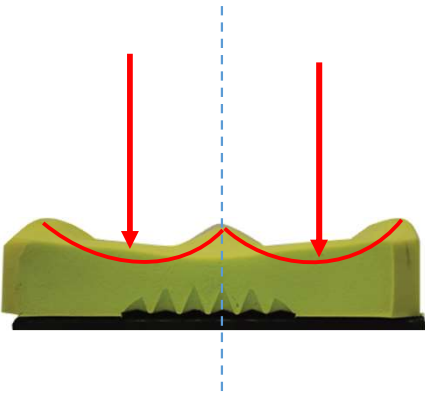
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

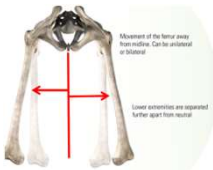
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28


Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.

Lower extremities are supported further apart from neutral.

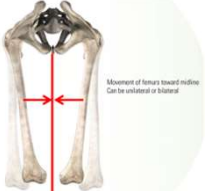


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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

matrx **INVACARE**
Yes, you can.

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





Matrx PB Back





Matrx Elite E2 Back



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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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33

matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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34

matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

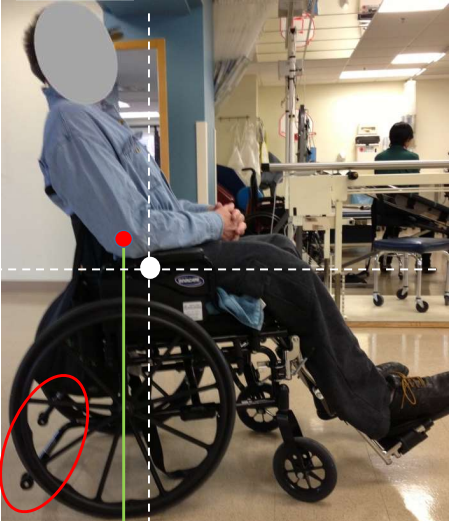
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38


matrix **INVACARE**
Yes, you can.

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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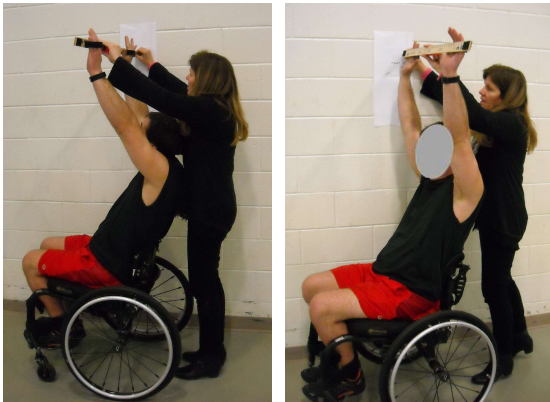
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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




Matrix® E2 Back Models and Sizes: Infinite Height Options



		WIDTH						
		14"	15"	16"	17"	18"	19"	20"
HEIGHT	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

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

42

42

matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18"- wide chair

E2S 1712 mounted onto 18"- wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

E2 - 3" Contour


E2 Deep - 6" Contour

matrix 700 FLEX

46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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51

51

Case study: Mr. Singh



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



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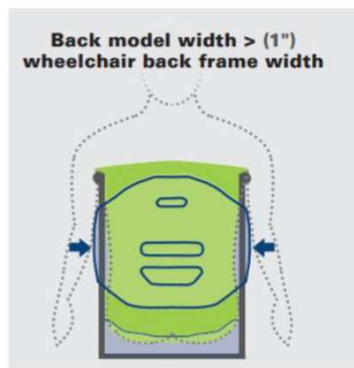
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Case study: Mr. Singh

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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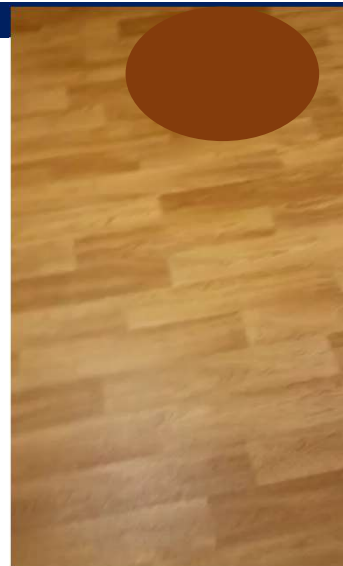
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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!



59

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Fall Prevention & Wheelchair Seating

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Motion Concepts

1

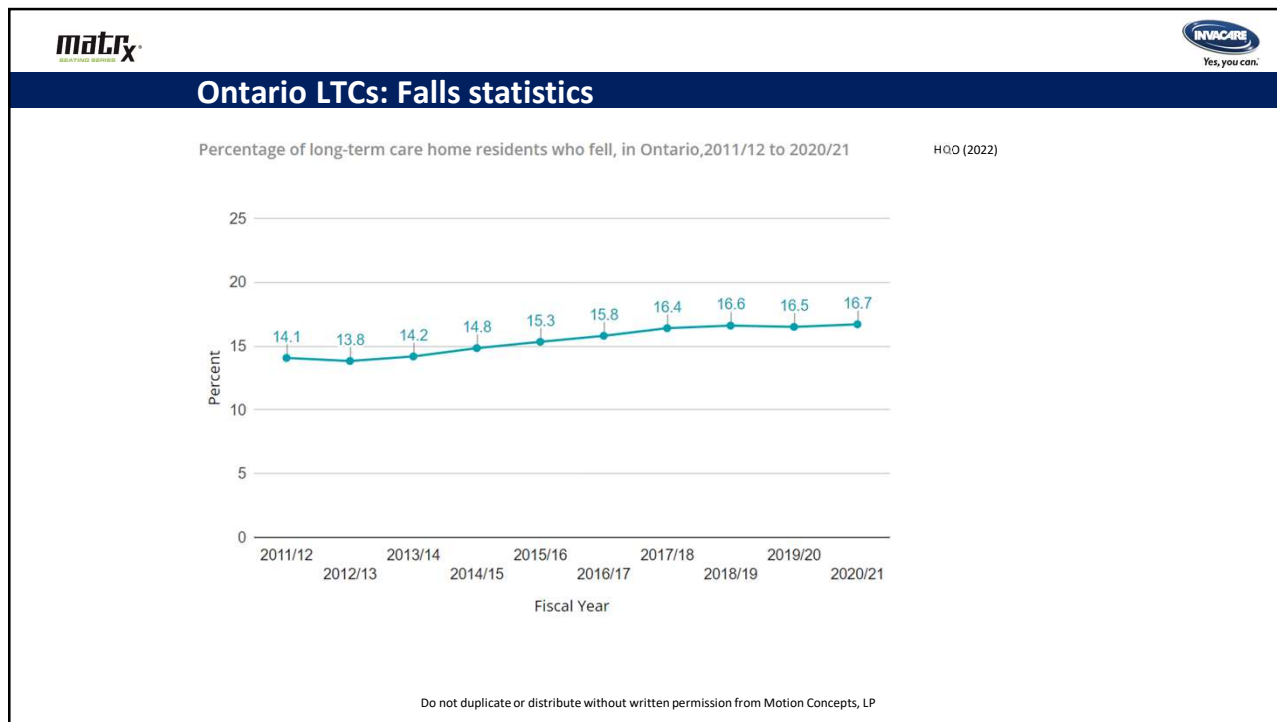



Learning objectives

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



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

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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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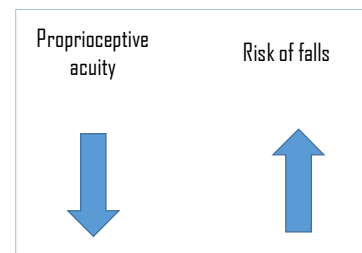
6

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

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

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8

Sitting down or lowering

Getting up or rising




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9

matrix SEATING FOR EVERYONE


INVACARE
Yes, you can.

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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10

matrix SEATING FOR EVERYONE

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge



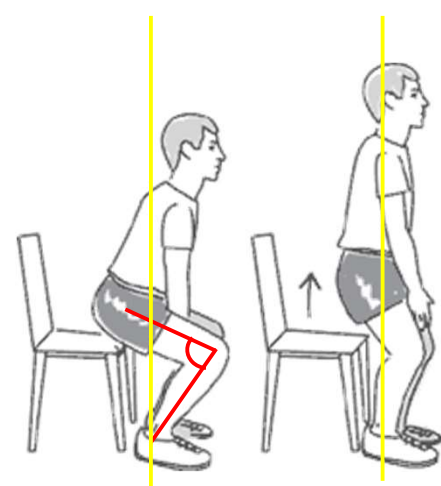
Waterfall front edge

- 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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair



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

Low profile

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

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21

9

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.


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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

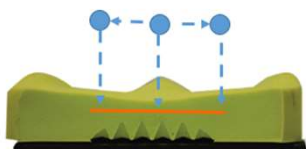
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25

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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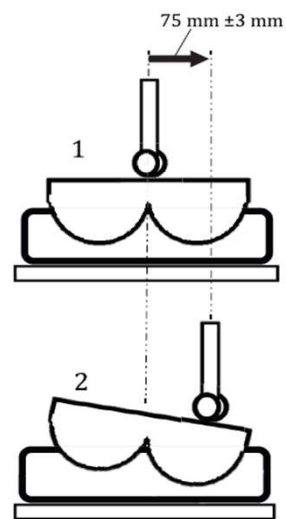
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Wheelchair-related risk factors: Cushion stability





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

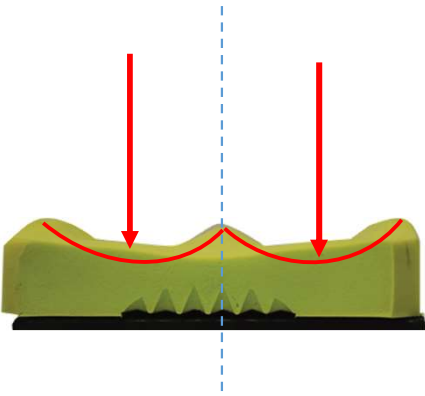
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

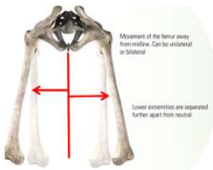
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

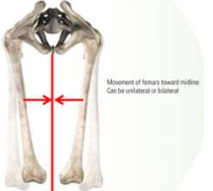


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrx **INVACARE**
Yes, you can.

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

matrx **INVACARE**
Yes, you can.

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



Matrx PB Back

Matrx Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

Upholstery backrest Support of a rigid backrest

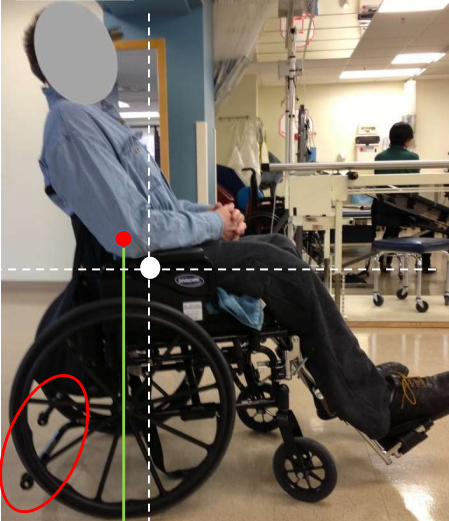
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matrix **INVACARE**
Yes, you can.

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

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 Matrix 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 ramp²

- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options

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

E2 - 3" Contour

E2 Deep - 6" Contour

• MiniSet Hardware • EasySet Hardware

41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

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42

matrix **INVACARE**
Yes, you can.

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



E2S 1816 mounted onto 18" - wide chair



E2S 1712 mounted onto 18" - wide chair



44



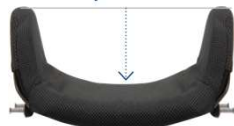
Lateral and postural supports



E2 - 3" Contour




E2 Deep - 6" Contour



46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FALL((FALL))
      FearOfFalling((Fear of falling)) --> Deconditioning
      FearOfFalling --> FALL
      PoorBalance --> FearOfFalling
  
```

(Gotzmeister et al., 2015)

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50

50

matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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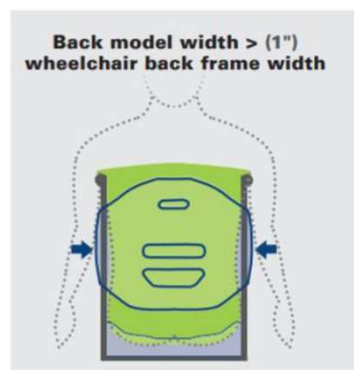
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Case study: Mr. Singh

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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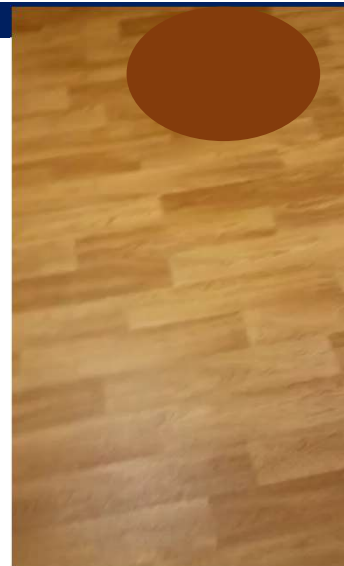
Case study: Mr. Singh

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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INVACARE
Yes, you can.

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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INVACARE
Yes, you can.

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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SEATING SERIES

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Fall Prevention & Wheelchair Seating

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Motion Concepts

1

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SEATING SERIES

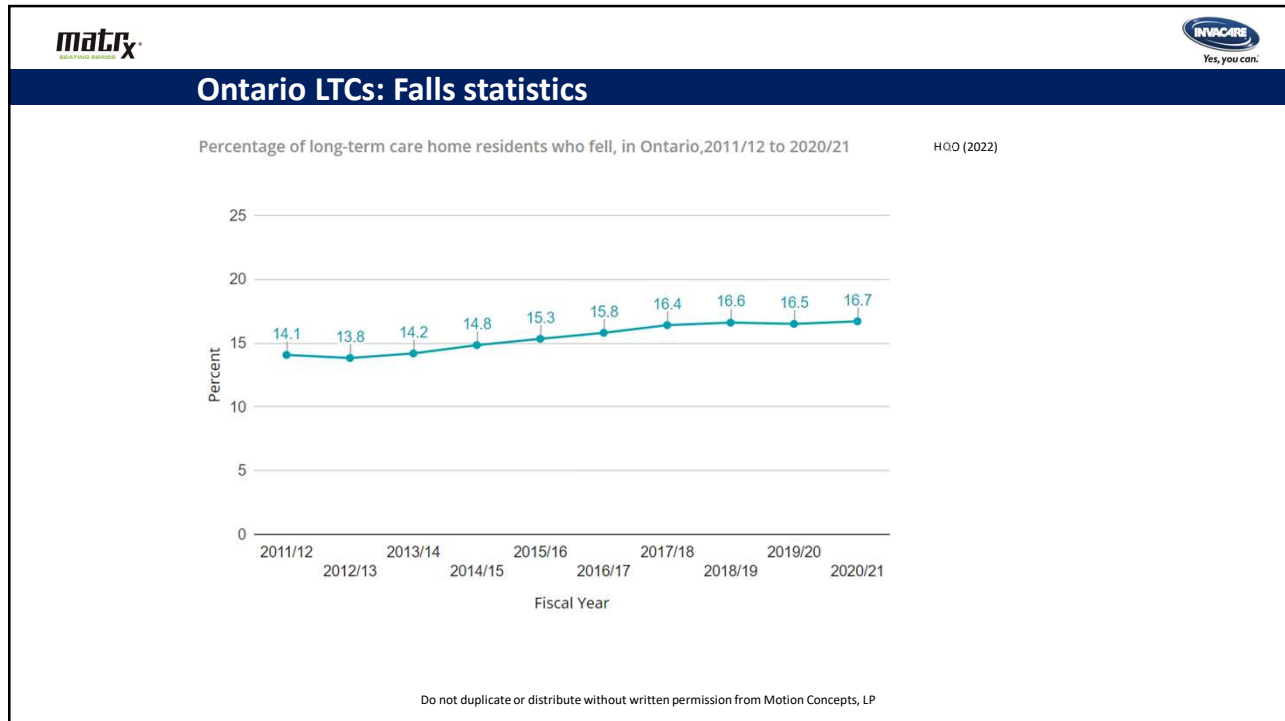
INVACARE
Yes, you can.

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



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

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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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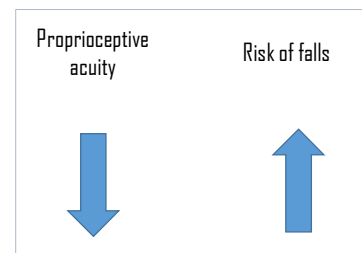
6

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

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

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8

Sitting down or lowering

Getting up or rising




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9

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INVACARE
Yes, you can.

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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INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge



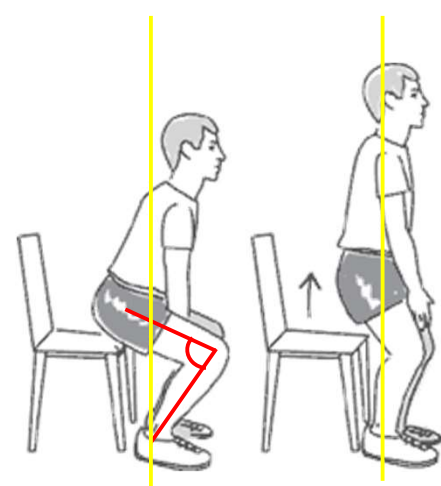
Waterfall front edge

- 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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INVACARE
Yes, you can.

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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matrix SMARTER. SAFER. SIMPLER.

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair



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

Low profile

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

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection

21


9

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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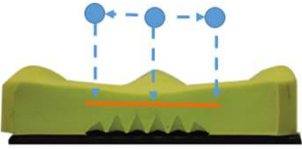
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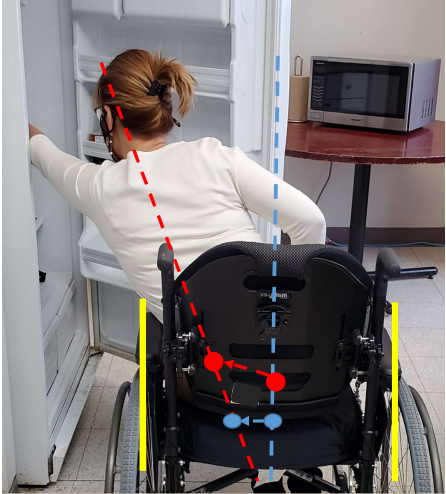
matrix RESEARCH & DESIGN **INVACARE**
Yes, you can.

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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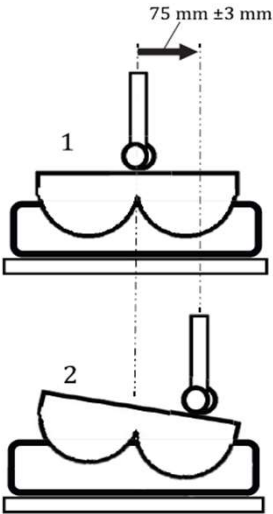
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Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair cushion design: Abductor and adductor contouring

Importance of Midline Leg Positioning

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)

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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Yes, you can.

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction

Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Matrix PB Back Matrix Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

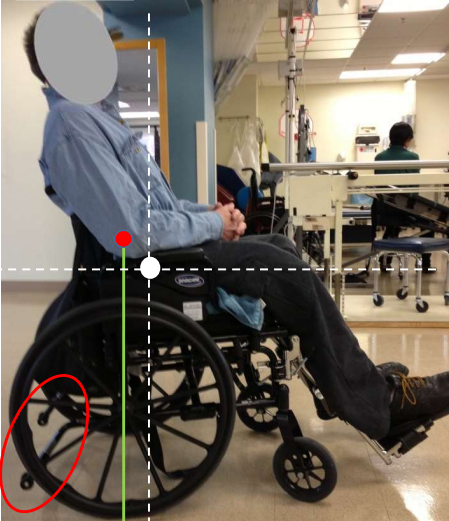
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matrix **INVACARE**
Yes, you can.

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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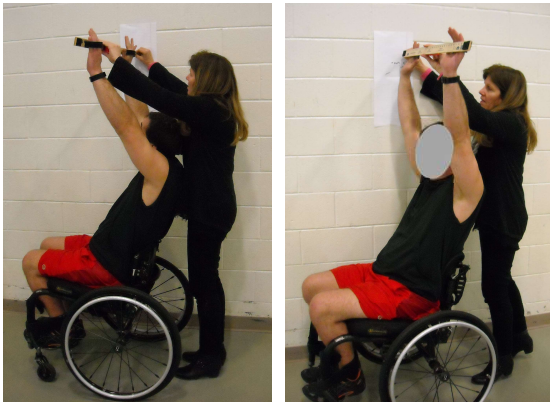
RESEARCH ARTICLE BY

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 Matrix backrests versus upholstery back with their usual cushions on the ultralight manual chairs demonstrated:
- 9° better (less posterior) pelvic angle ($\bar{x}=96.92^\circ$)
- 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 ramp²



- 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

40




Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



41

matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates four levels of backrest height: Full, High, Medium, and Short. Each level is represented by a green box with a vertical double-headed arrow indicating the height. Below the skeleton diagram, four photographs show a person in a wheelchair from the back, demonstrating the effect of each height level on their posture.

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matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

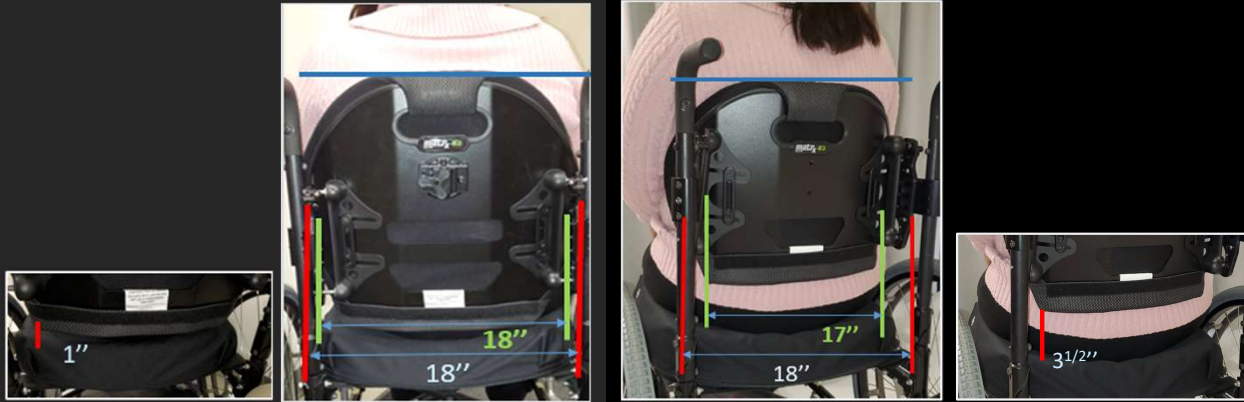
- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

43



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



E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

44




Lateral and postural supports



46

46

matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
      PoorBalance --> Fall[FALL]
  
```

(Gotzmeister et al., 2015)

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matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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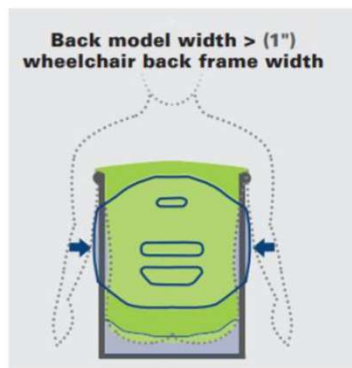
52

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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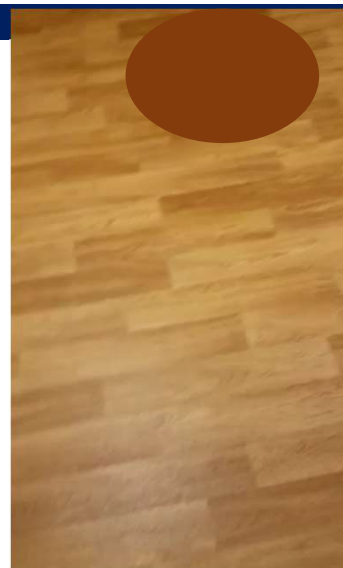
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

Role of balance in prevention of falls

```

graph TD
    D((Deconditioning)) --> PB((Poor Balance))
    F((Fear of falling)) --> PB
    PB --> F1((Fall))
    F --> F1
  
```

(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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrx
SEATING SERIES

Motion
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Fall Prevention & Wheelchair Seating

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

1

matrx
SEATING SERIES

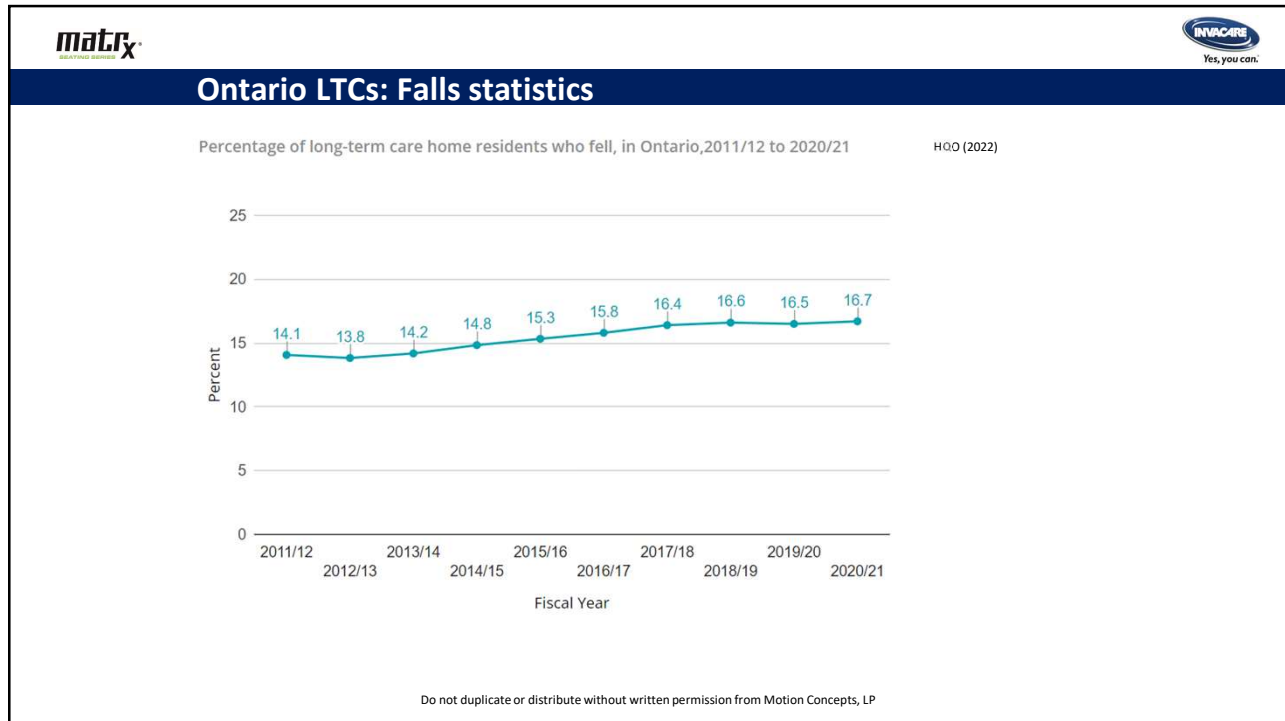
INVACARE
Yes, you can.

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



3

British Columbia LTC falls study: How do people fall? (Yang et al., 2017)

Falls captured on video in long-term care

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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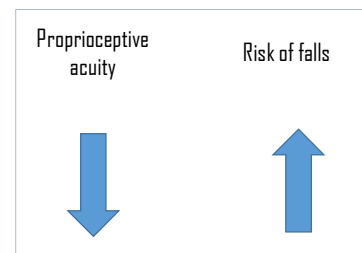
6

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

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

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8

Sitting down or lowering

Getting up or rising

Seat-to-stand



Stand-to-seat




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9


matrix SEATING FOR ALL **INVACARE**
Yes, you can.

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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10

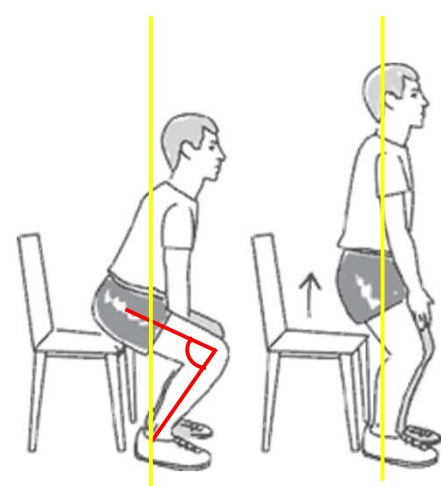
matrix SEATING FOR ALL **INVACARE**
Yes, you can.

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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INVACARE
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

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Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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

matrx **INVACARE**
Yes, you can.

Wheelchair cushion design for fall prevention

Preventing sliding out of a chair

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

Low profile

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

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matrx **INVACARE**
Yes, you can.

MATRIX 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
<u>Positioning</u>	<u>Skin Protection and Positioning</u>	<u>Skin Protection and Positioning</u>	<u>Skin Protection and Positioning</u>	<u>Adjustable Skin Protection and Positioning</u>

← Degrees of Skin Protection →


21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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INVACARE
Yes, you can.

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

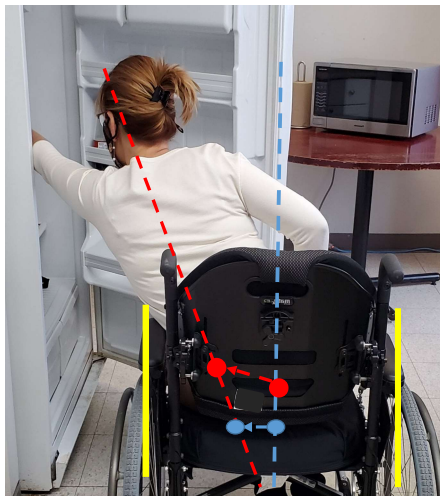
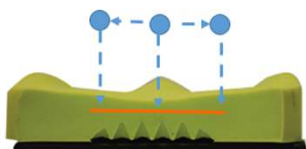
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Wheelchair-related risk factors: Centre of gravity

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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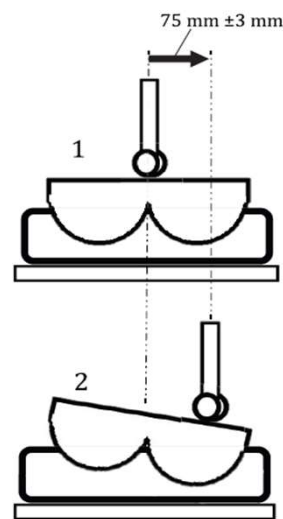
26

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



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Wheelchair cushion design: Abductor and adductor contouring

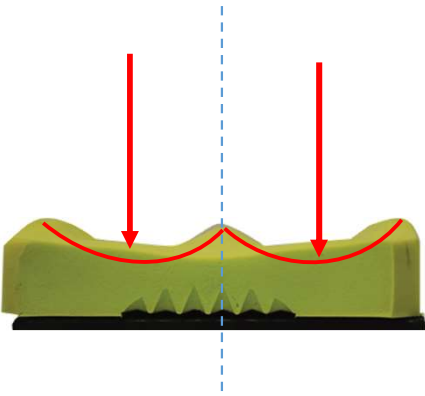
For elderly females **sit-to-stand** task with adducted hips presents

- 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)

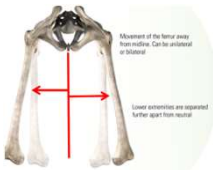
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Wheelchair cushion design: Customized abductor and adductor contouring

Abduction



Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

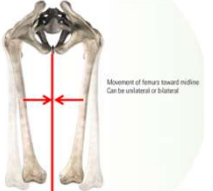


Components of Libra Fit Kit:


Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction



Movement of femurs toward midline. Can be unilateral or bilateral.



Abductor

improve midline leg positioning for patients with excessive **ad**duction

29

29

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Matrix PB Back

Matrix Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion




Top layer
SuperSoft BreZZy Viscofoam

Middle layer
Anatomically molded Viscofoam

Bottom layer
Anatomically contoured HR Foam




**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

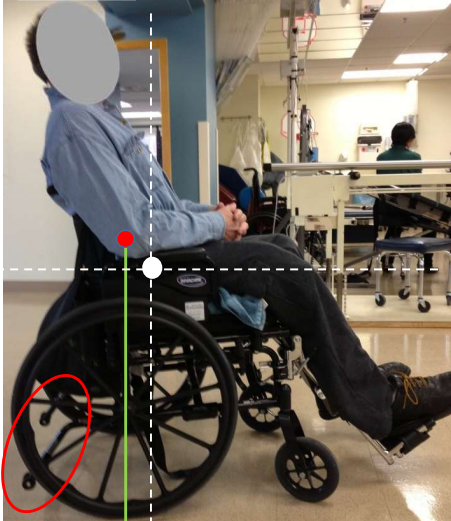
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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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

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 Matrix 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 ramp²

- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options

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

E2 - 3" Contour

E2 Deep - 6" Contour

• MiniSet Hardware • EasySet Hardware

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matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates the relationship between backrest height and posture. A human skeleton is shown with four horizontal dashed lines indicating different backrest heights: Full (top), High, Medium, and Short (bottom). Below the skeleton, four photographs show a person in a wheelchair from the back, with the backrest adjusted to each of these four levels. The 'Full' level is the highest, followed by 'High', 'Medium', and 'Short'.

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matrix **INVACARE**
Yes, you can.

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

EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

Extended Range EasySet

43

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

The diagrams illustrate the installation of Matrix EasySet hardware on an 18-inch wide chair. The left side shows E2S 1816 with a 1-inch measurement on the left side and 18-inch measurements for the seat width and backrest width. The right side shows E2S 1712 with a 3 1/2-inch measurement on the left side, a 17-inch measurement for the backrest width, and an 18-inch measurement for the seat width.

E2S 1816 mounted onto 18"- wide chair

E2S 1712 mounted onto 18"- wide chair

44

matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

The images show different types of lateral and postural supports. On the left, two curved supports are shown: 'E2 - 3" Contour' and 'E2 Deep - 6" Contour'. In the center, there is a black plastic backrest support with two horizontal cutouts. On the right, there are two photographs showing a hand adjusting a blue lateral support on a chair. Below these is a star-patterned support with the Matrix logo.


E2 - 3" Contour

E2 Deep - 6" Contour

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matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls

```

    graph TD
      Deconditioning((Deconditioning)) --> PoorBalance((Poor Balance))
      PoorBalance --> FALL((FALL))
      FALL --> FearOfFalling((Fear of falling))
      FearOfFalling --> Deconditioning
  
```

(Gotzmeister et al., 2015)

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matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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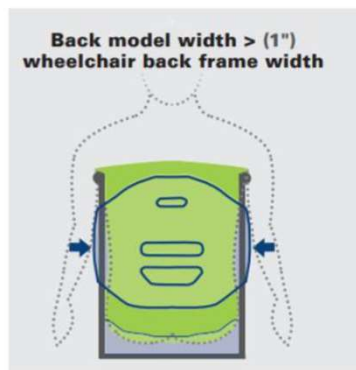
52

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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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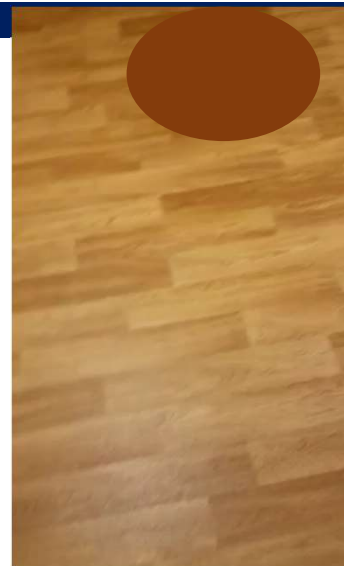
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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

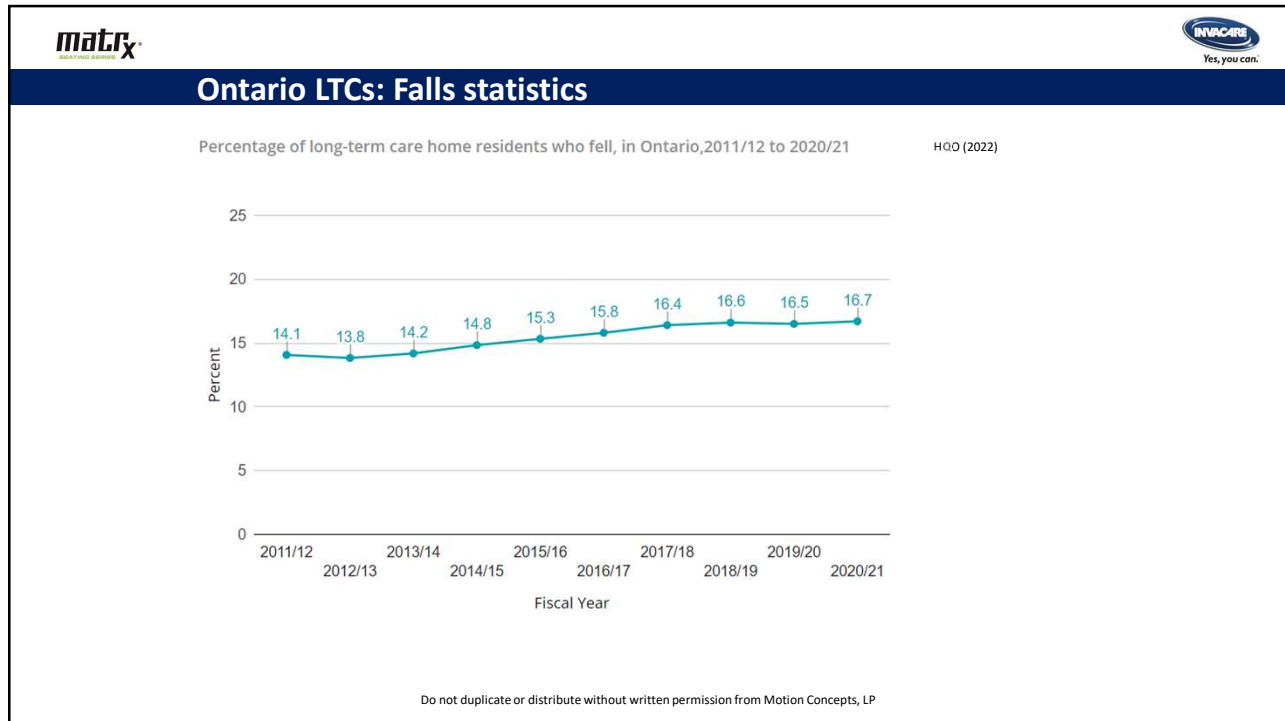



Learning objectives

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



3

British Columbia LTC falls study: How do people fall? (Yang et al., 2017)

Falls captured on video in long-term care

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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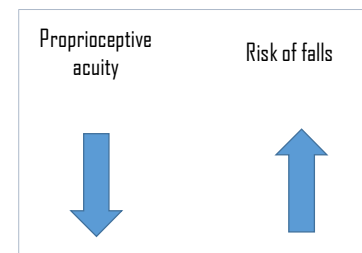
6

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

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

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8

Sitting down or lowering

Getting up or rising

Seat-to-stand



Stand-to-seat




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9

matrix SEATING SOLUTIONS


INVACARE
Yes, you can.

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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10

matrix SEATING SOLUTIONS

INVACARE
Yes, you can.

Wheelchair cushion design: Waterfall front edge

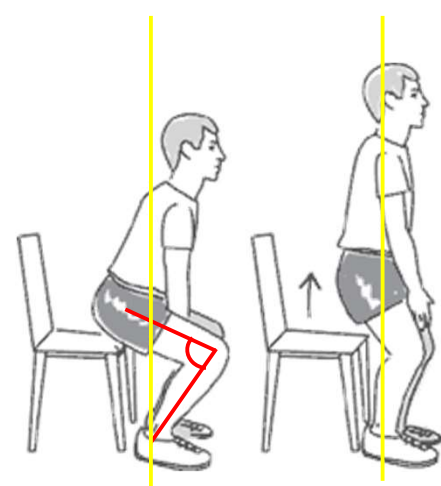


Waterfall front edge

- 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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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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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

matrix **INVACARE**
Yes, you can.

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

matrix **INVACARE**
Yes, you can.

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



Preventing sliding out of a chair



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 pelvic stability
- Prevents knees from moving medially or laterally

Low profile

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

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MATRIX CUSHIONS CONTINUUM OF SKIN PROTECTION



**Invacare® Matrix®
PS Cushion**



Positioning



**Invacare® Matrix®
PSP Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Multi Cushion**



Skin Protection and Positioning



**Invacare® Matrix®
Vi Cushion**



Skin Protection and Positioning



**Libra/Libra Adjust
Cushion**



Adjustable Skin Protection and Positioning



Degrees of Skin Protection


21

matrix **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.


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

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

Educate patients
Educate all caregivers
Use effective reminders and cues

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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matrix HEALTHCARE SOLUTIONS

INVACARE
Yes, you can.

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

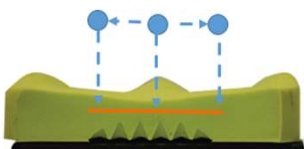
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Wheelchair-related risk factors: Centre of gravity

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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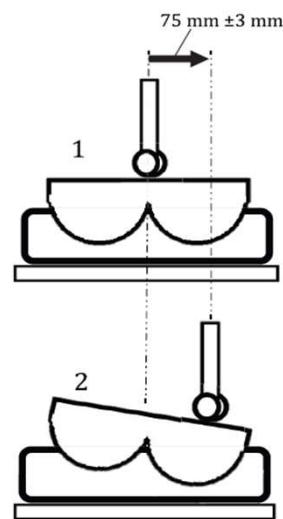
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Wheelchair-related risk factors: Cushion stability



INTERNATIONAL STANDARD ISO 16840-13

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



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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Abductor and adductor contouring

Importance of Midline Leg Positioning

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)

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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matrx **INVACARE**
Yes, you can.

Wheelchair cushion design: Customized abductor and adductor contouring

Abduction

Movement of the femur away from midline. Can be unilateral or bilateral.
Lower extremities are supported further apart from neutral.

Components of Libra Fit Kit:

Lateral wedges

improve midline leg positioning for patients with excessive **ab**duction

Adduction

Movement of femurs toward midline. Can be unilateral or bilateral.

Abductor

improve midline leg positioning for patients with excessive **ad**duction

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29

matrx **INVACARE**
Yes, you can.

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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matrx **INVACARE**
Yes, you can.

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



Matrx PB Back Matrx Elite E2 Back

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

Nancy: comfortable deep cushion



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



**Invacare® Matrix®
Multi Cushion**

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matrix HEALTHCARE SOLUTIONS **INVACARE**
Yes, you can.

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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matrix **INVACARE**
Yes, you can.

Wheelchair-related risk factors: rigid backrest vs upholstery back

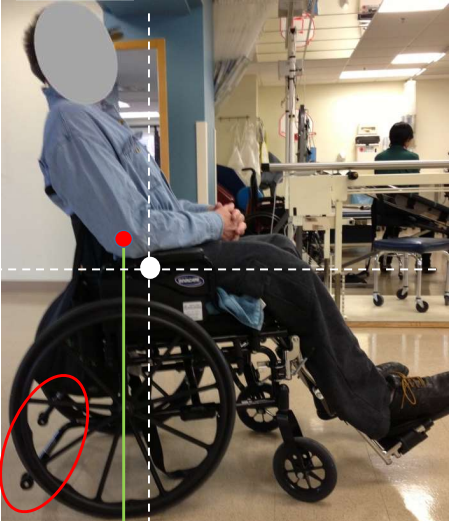
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matrix **INVACARE**
Yes, you can.

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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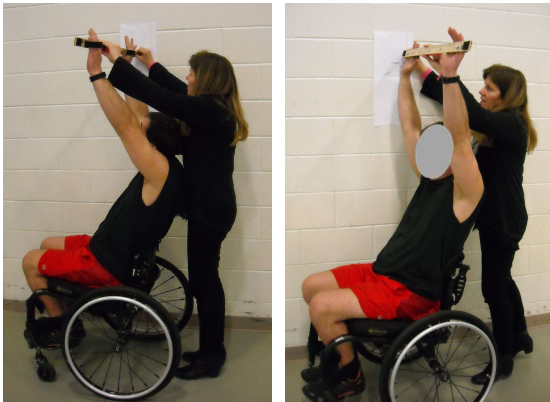
RESEARCH ARTICLE BY

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 Matrix 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 ramp²



- 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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Matrix® E2 Back Models and Sizes: Infinite Height Options



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



• MiniSet Hardware • EasySet Hardware

E2 - 3" Contour





E2 Deep - 6" Contour



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matrix **INVACARE**
Yes, you can.

Height of the back: postural support vs freedom of movement

The diagram illustrates four levels of backrest height: Full (top), High, Medium, and Short (bottom). Below the skeleton, four images of a person in a wheelchair show the backrest height relative to their back. The 'Full' level is at the top of the back, 'High' is at the shoulder level, 'Medium' is at the mid-back level, and 'Short' is at the lower back level.

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matrix **INVACARE**
Yes, you can.

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

EasySet

Extended Range EasySet

- flattening of the lumbar
- posterior pelvic rotation

- Improved lumbar curve
- neutral pelvic rotation

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matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

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

E2S 1816 mounted onto 18" - wide chair

E2S 1712 mounted onto 18" - wide chair

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matrix SEATING & ACCESSORIES **INVACARE**
Yes, you can.

Lateral and postural supports

E2 - 3" Contour


E2 Deep - 6" Contour

matrix FLEX

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matrix Rx **INVACARE**
Yes, you can.



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)

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matrix Rx **INVACARE**
Yes, you can.



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:

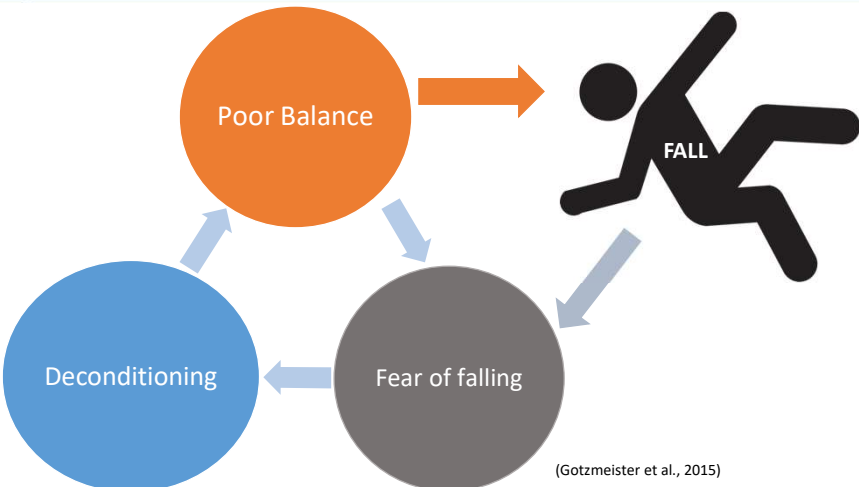
- Mr. Singh was not getting up or propelling the wheelchair
- wasn't communicating

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matrix **INVACARE**
Yes, you can!

Role of balance in prevention of falls



(Gotzmeister et al., 2015)

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matrix **INVACARE**
Yes, you can!

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

2.75"

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Case study: Mr. Singh



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



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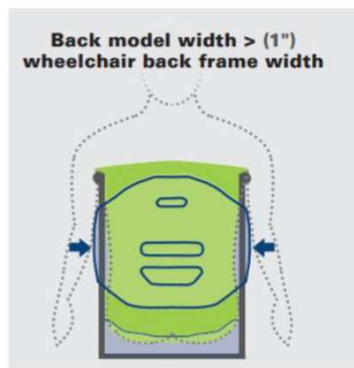
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Case study: Mr. Singh

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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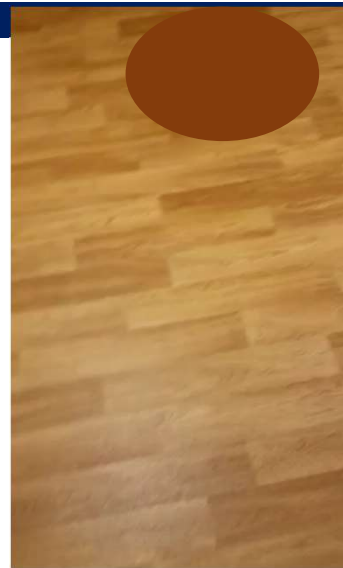
Case study: Mr. Singh

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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matrix RESEARCH & DESIGN

INVACARE
Yes, you can.

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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