



Rehabilitation  
Engineering &  
Applied  
Research

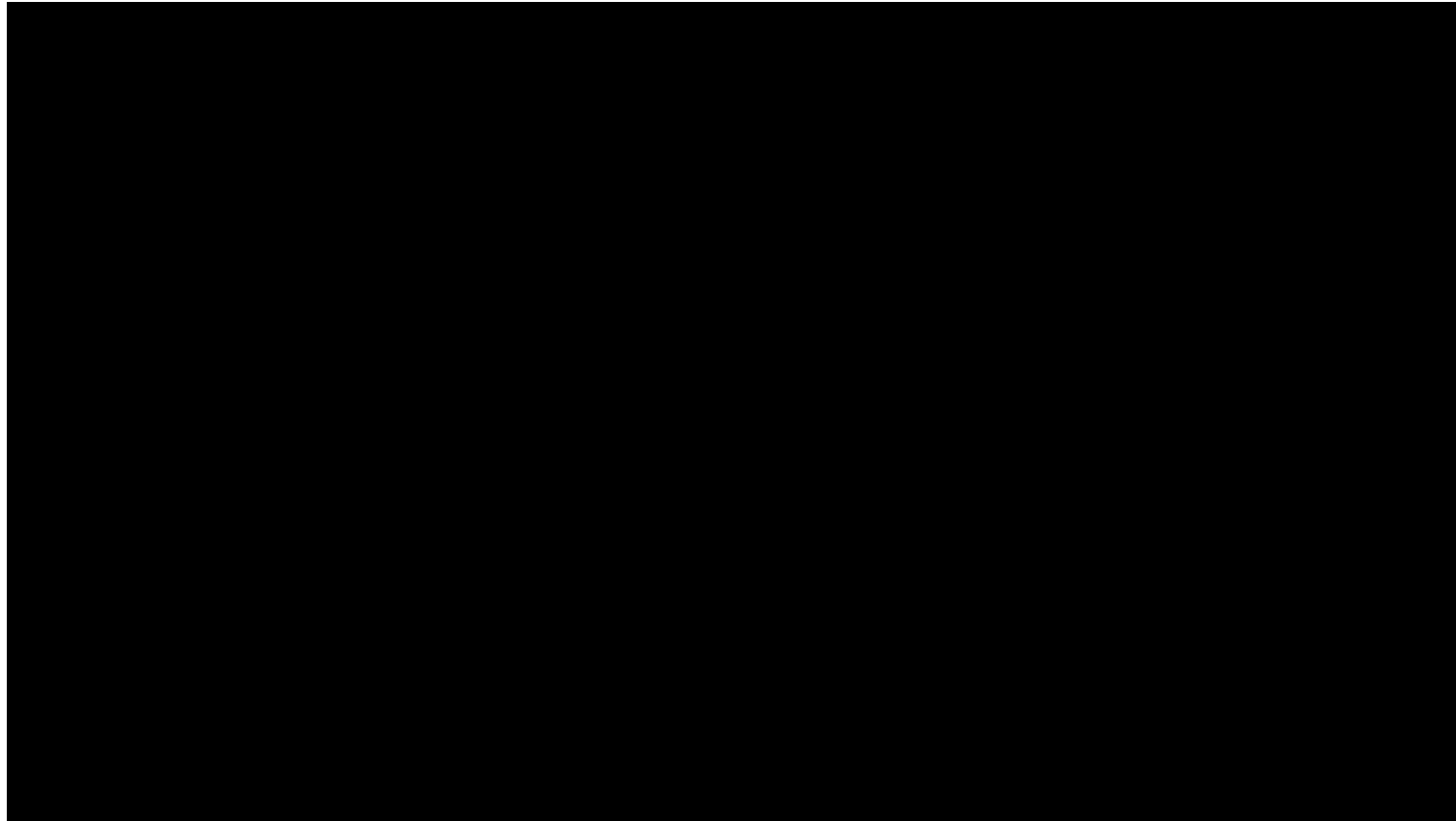
## You Got To Move It, Move It!

Pressure Relief Behaviors and Weight Shifting Activities to Prevent Pressure Ulcers  
in Persons with SCI

Sharon Sonenblum, PhD & Trevor Dyson-Hudson, MD

March 3<sup>rd</sup>, 2016

# “I Like to Move It, Move It!”



I like to move it move it, Madagascar  
HD  
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# Disclosures

Sharon Sonenblum has received travel support from Ride Designs. Other than this travel support, she has no financial interest to disclose.

Trevor Dyson-Hudson has no financial interest to disclose.

# Objectives

At the end of this session, you should be able to:

1. Recognize how dedicated pressure reliefs and other weight-shift activities have a protective influence on skin in persons with SCI.
2. Describe different ways in which full-time manual wheelchair users with SCI move in their wheelchairs.
3. Discuss the impact and role functional movements can have on developing clinical interventions to prevent pressure ulcers in persons with SCI.

# Let's consider groups of Pressure Ulcer causation

- *Sustained* violation of load-duration thresholds
  - We do not know this threshold for individuals
    - Individualistic factors are in play
  - *Equipment & equipment fit are often culprits*
- *Episodic* events
  - Bump in transfer
  - Stuck in a poor surface or position
  - Absence of attendant care
  - Equipment problem
- Combination of the two



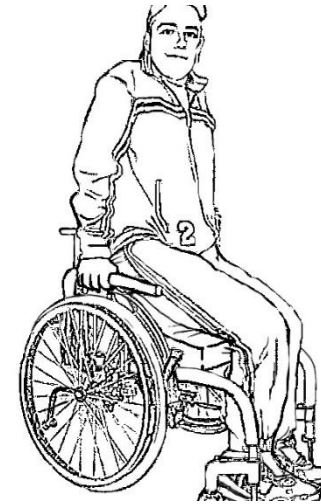
Evaluation & training are interventions used for both categories

# *Sustained violation of load-duration thresholds*

- Addressed by equipment and training
  - Reduce magnitude of loading
    - Posture & seating system
  - Reduce duration of loading
    - Weight shifting activities

# Weight Shifting & Pressure Reliefs

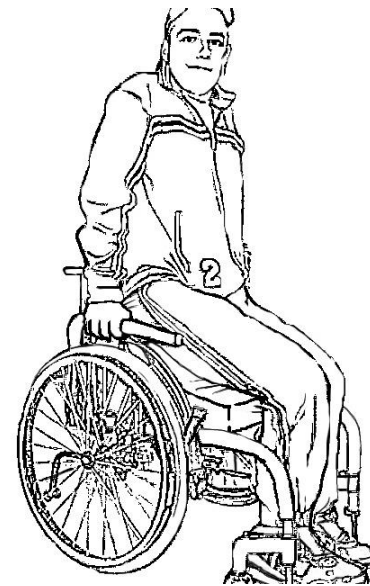
- Guidelines vary
  - 30 second weight shift every 30 minutes
  - 60 sec weight shift every hour
  - 30 sec weight shift every 15 minutes
- The wide range indicates lack of supporting evidence
- No published studies have identified pressure reliefs as factors in preventing ulcers
  - Based upon self-report
  - Functional movements aren't considered
- Controlled studies suggests >60 secs for perfusion to return
  - Coggrave & Rose 2003



Consortium for Spinal Cord Medicine; PVA 2000  
O'Connor & Salcido, in *Spinal Cord Medicine*, 2002

# Each of these tasks are equally feasible

- Holding a push-up pressure relief for 60 secs
- Juggling a chain saw, M&M and bottle of beer
- Getting 3 children  $\leq$  5yo to share 1 toy.

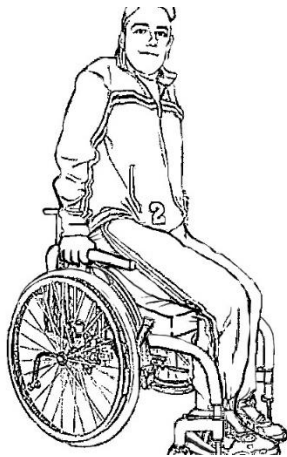




# Pressure Reliefs and Weight Shifts

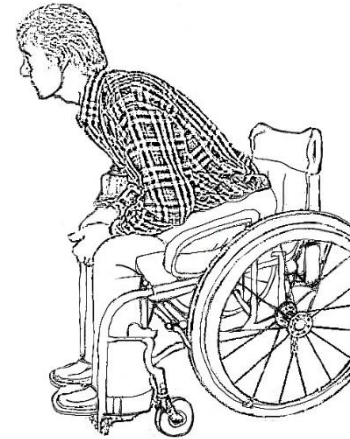
## Pressure Reliefs

- Functional constraints limit options for independent pressure reliefs



## Weight Shifts

- In-seat activity (e.g., shifting the center of mass) redistributes loading on the buttocks

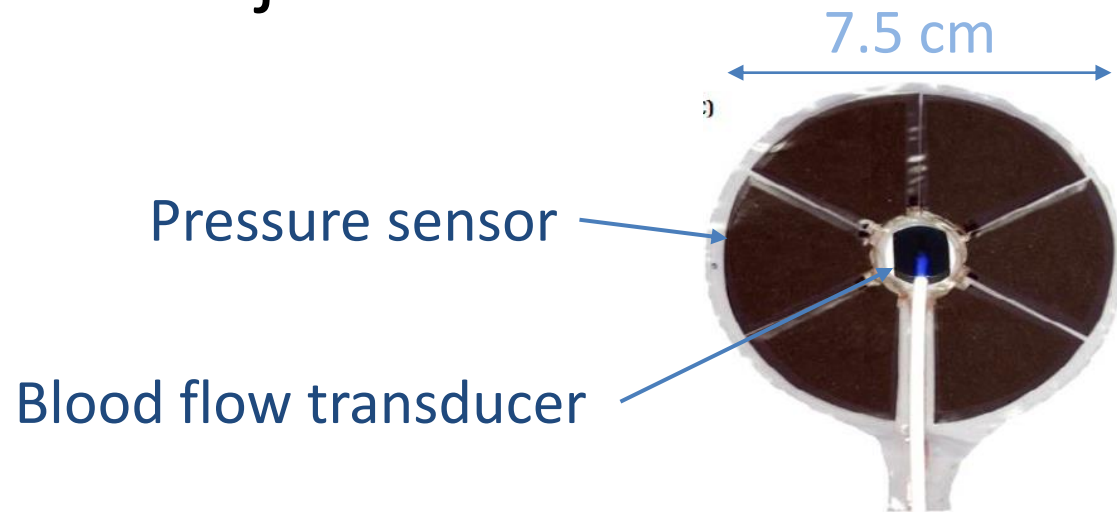


# Study 1: Effect of weight shifting maneuvers

- Hypothesis:
  - Weight-shifts, other than full push-ups, significantly alter ischial pressure and blood flow
- Weight-shifts include
  - Reaching- leaning- and other functional activities
- Approach:
  - measure interface pressure and blood flow during weight shifts
  - Compare cushion's influence

# Effects of wheelchair cushions and pressure relief maneuvers on ischial interface pressure and blood flow

- 6 seated postures
- 3 cushions
- 19 persons with spinal cord injuries



# Changes in ischial *pressure* and *bloodflow* compared to upright sitting

Decrease in pressure

-7%

-29%

-80%

-46%

-72%

Increase in Blood flow

30%

95%

320%

330%

450%

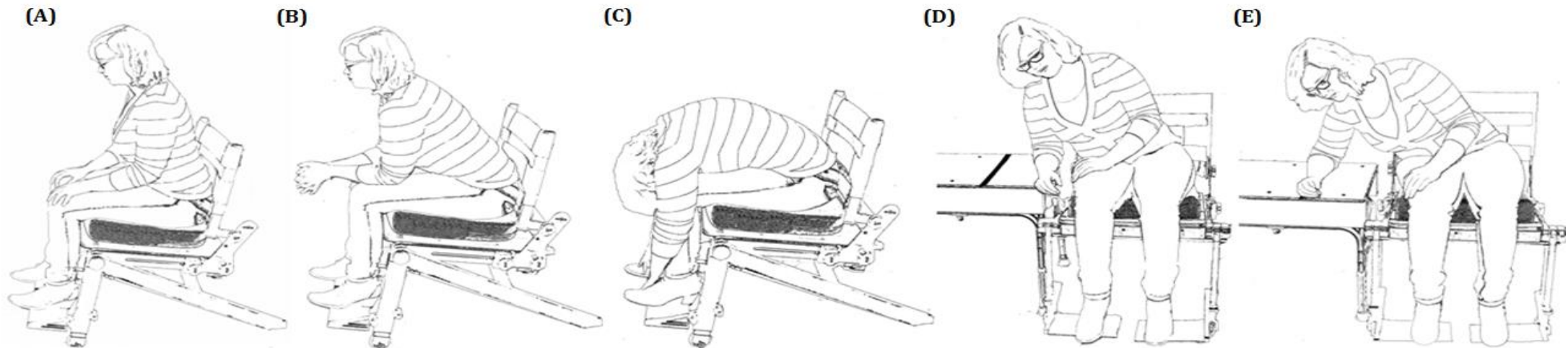
**Small frontward lean**

**Intermediate frontward lean**

**Full frontward lean**

**Intermediate sideward lean**

**Full sideward lean**

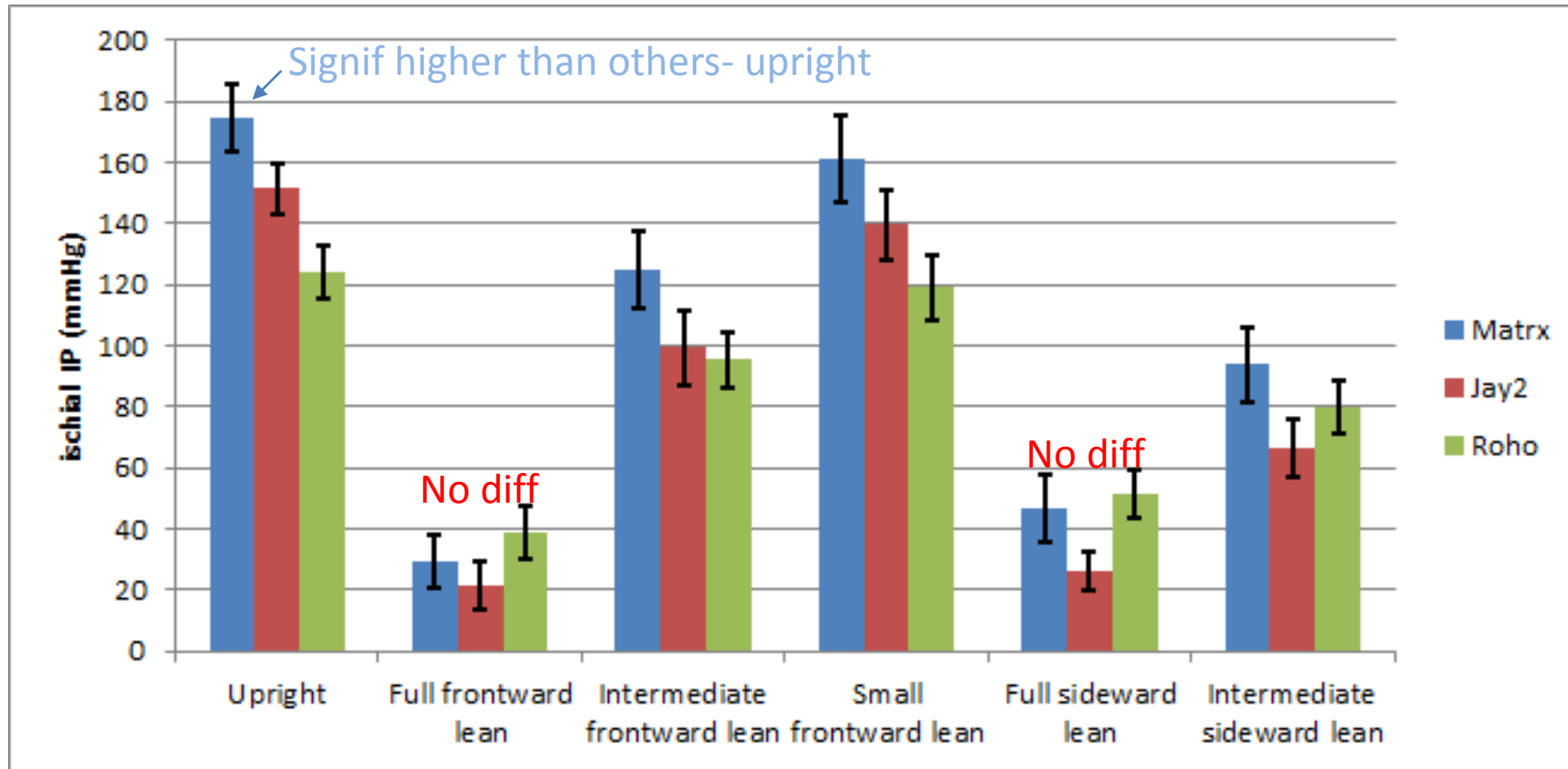


Sonenblum, et al, (2014), Arch Phys Med Rehabil

Positions in **red** were significantly different from upright posture

# Ischial Pressures across cushions

Matrx Vi   Jay2   Roho



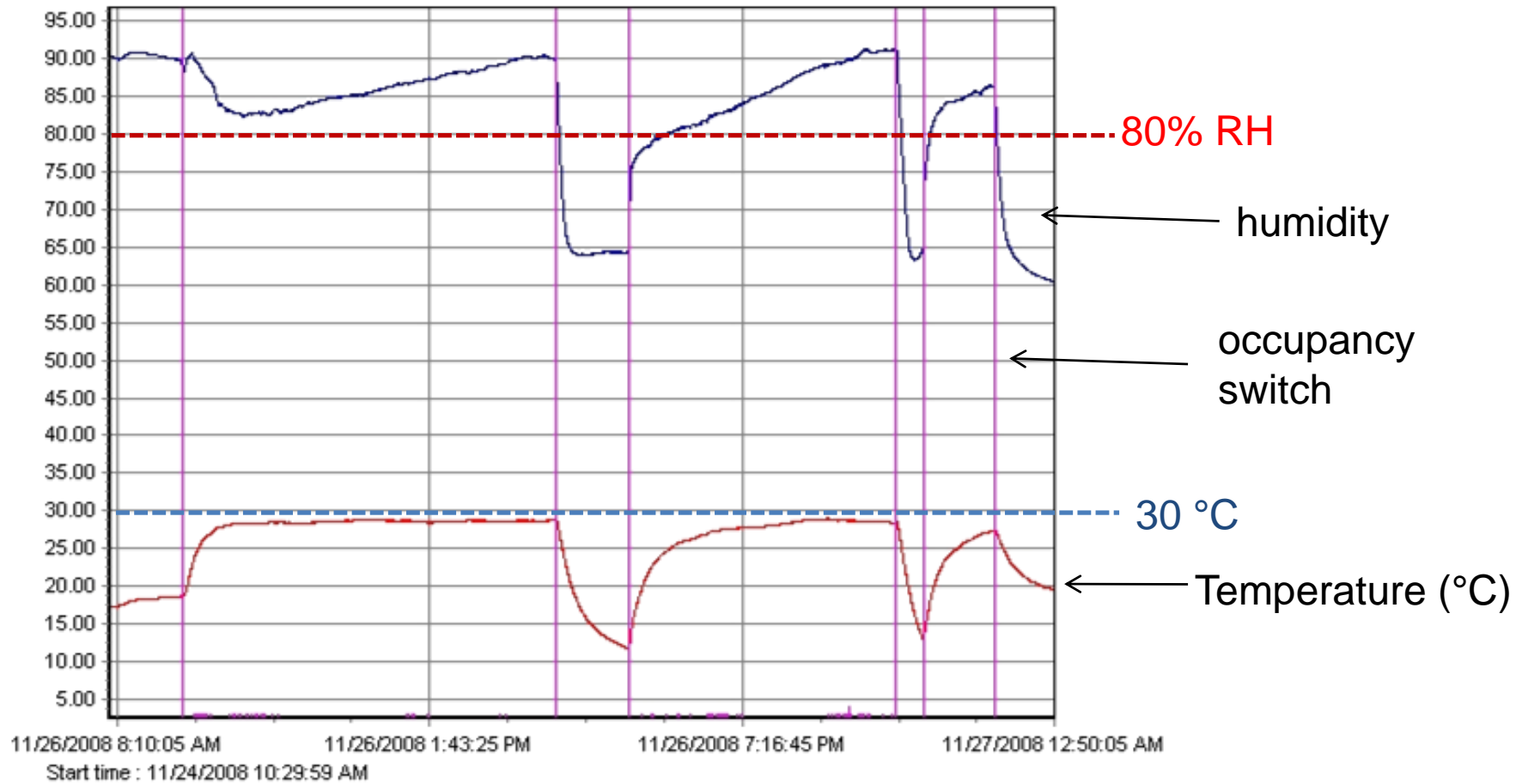
# Clinical Implications

- Leaning can reduce loading and increase blood flow at the buttocks
  - Only ‘hands-on-knees’ did not have impact
- Interaction between posture and cushion
  - How cushion responds to weight shift differs across cushion
- During full weight shifts- cushions act similarly

## Study 2: Does in-seat movement affect microclimate: heat and moisture

- Clear evidence that microclimate is important
  - Especially in populations with poor regulation
- Movement dissipates heat and humidity

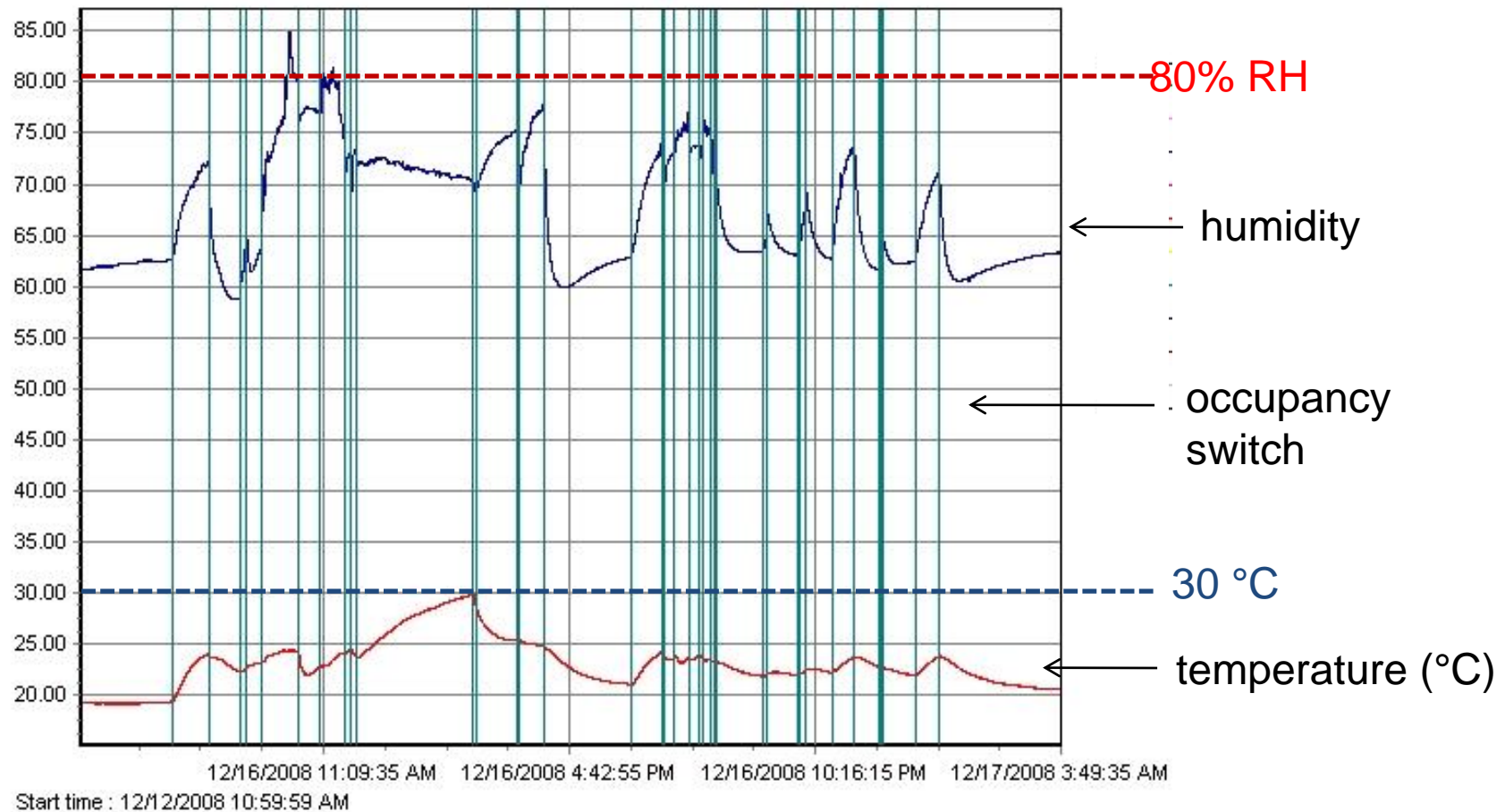
# Monitoring temperature and humidity over a day



Long bouts of sitting



# Monitoring temperature and humidity over a day



Frequent weight shifting activity

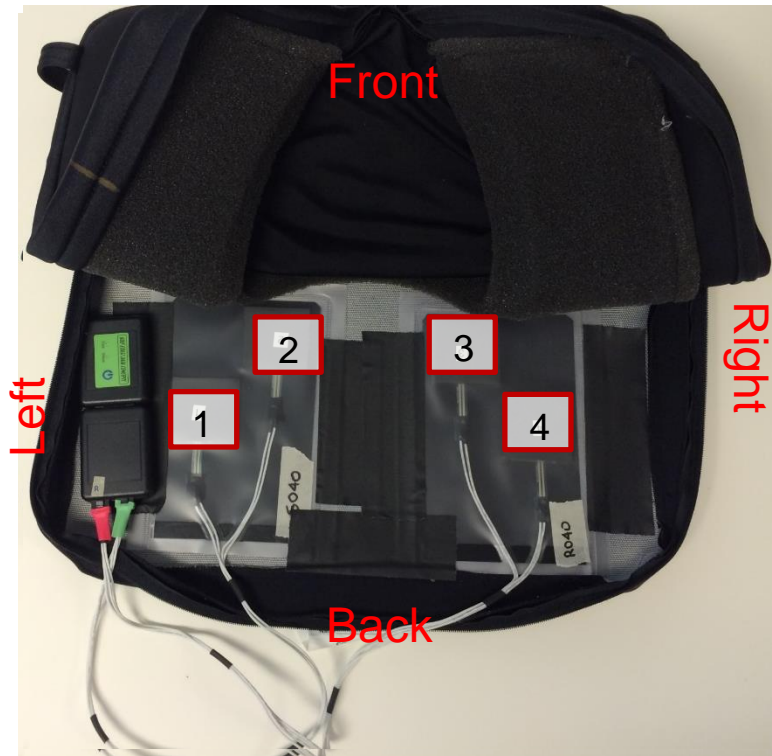
# Clinical Implications: Microclimate

- Movement dissipates heat and humidity
  - Put people in a system that permits activity
  - Educate people to *move*
- Judicious approach: if someone commonly sweats on a cushion- *change it*

# Studies 3 & 4: Monitoring Weight-shifting activities during everyday life

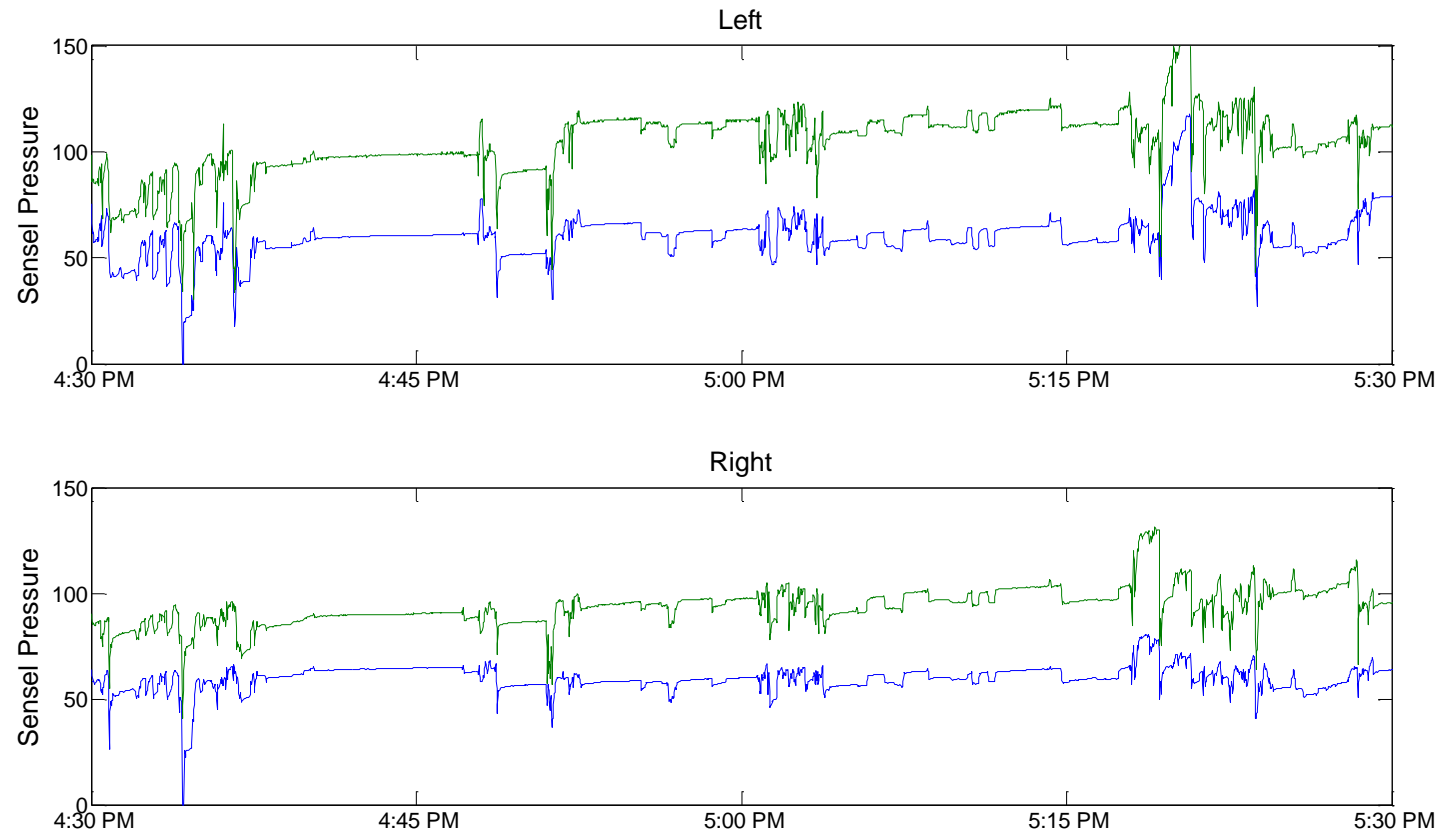
- Research questions:
  - How do wheelchair users move in their seats?
  - How does in-seat movement differ across wheelchair users?
    - Monitor new wheelchair users in their first months following discharge
    - Monitor people who have been using a wheelchair for more than 2 years
      - Compare *behaviors* across groups of people with and without a history of recurrent pressure ulcers

# Seat monitor and data logger



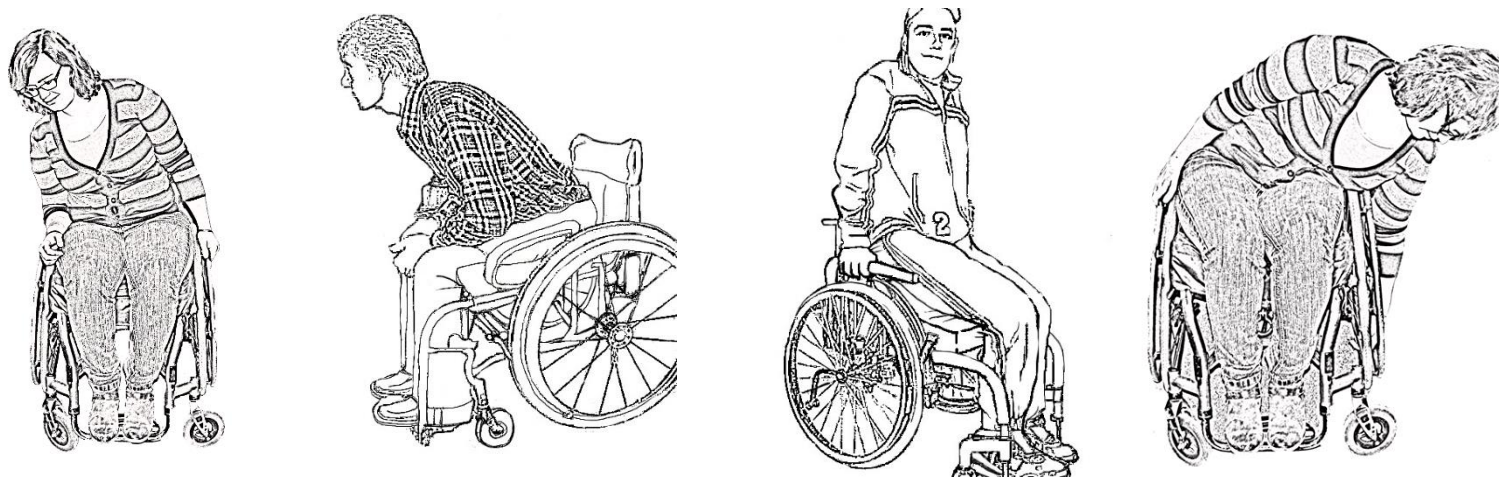
- 4 force-sensing resistors located under wheelchair cushion
- Data-logger captures forces at 1 Hz

# Raw data is a continuous signal of forces that are run through a classifier



# Definitions

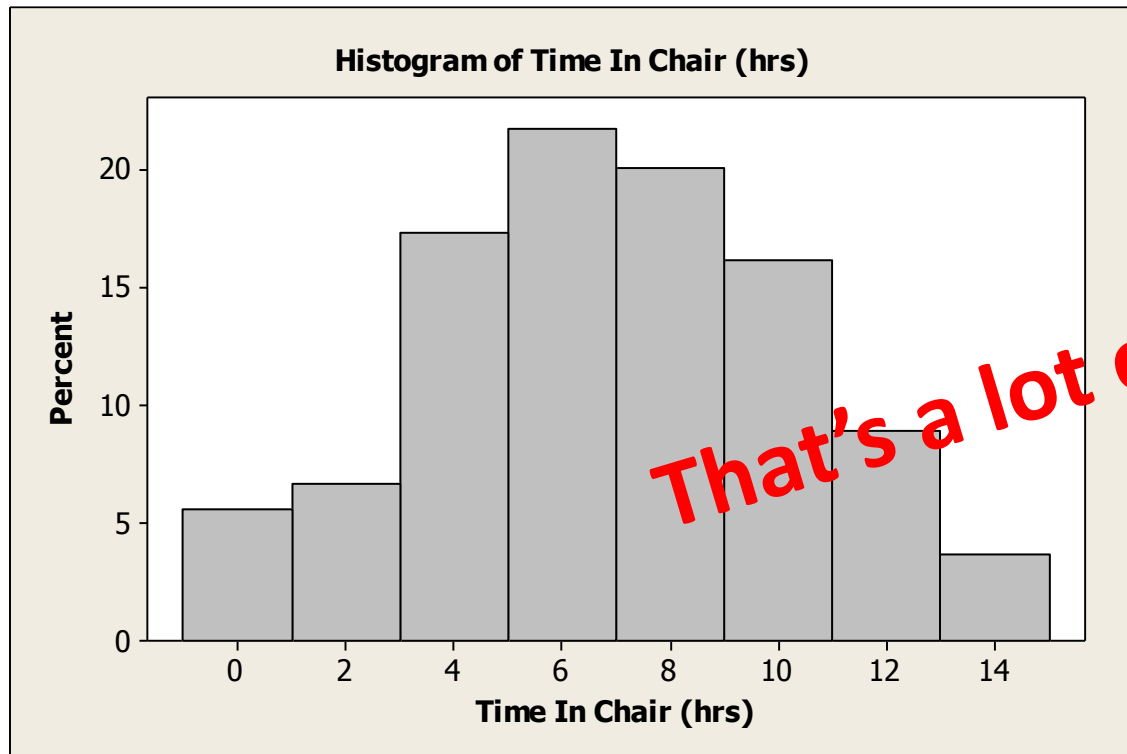
- Out of Chair – fully unloaded for > 2 minutes
- Full Pressure Relief (PR) – left and right sides fully unloaded for > 15 seconds and < 2 minutes
- Weight Shift (WS) – either side or both sides are partially unloaded (>30% pressure reduction) for > 15 seconds



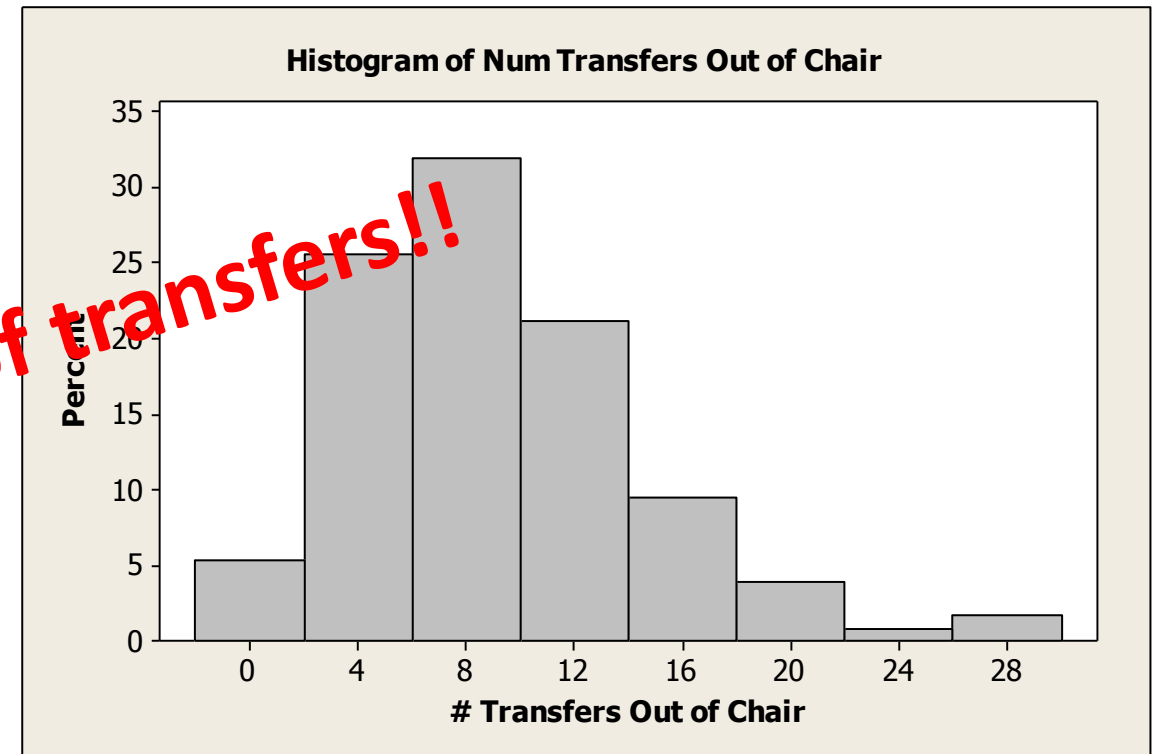
# Recent SCI

- 31 manual wheelchair users
- 359 complete days of data
- Recruited through Shepherd Center and Kessler Foundation
- Characteristics
  - Ages 19-63 (Average 32 yo)
  - 25-215 days post injury (Average 97 days)
  - 22 men, 9 women
  - LOI split: 8 cervical, 10 upper thoracic, 13 lower thoracic or lumbar

# In and Out of the Chair



7.0 (3.4) hours



8.6 (5.4) Transfers OUT

**That's a lot of transfers!!**



# Pressure Relief Training

## Shepherd

- Every 30 minutes
- Hold for 1 minute
- Depression lift is possible, side leans to each side if not
- Timer

## Kessler

- Every 20 – 30 minutes
- Hold for 3-5 minutes
- Forward lean for all manual users
- Sometimes iPhone timer or on the hour and half hour

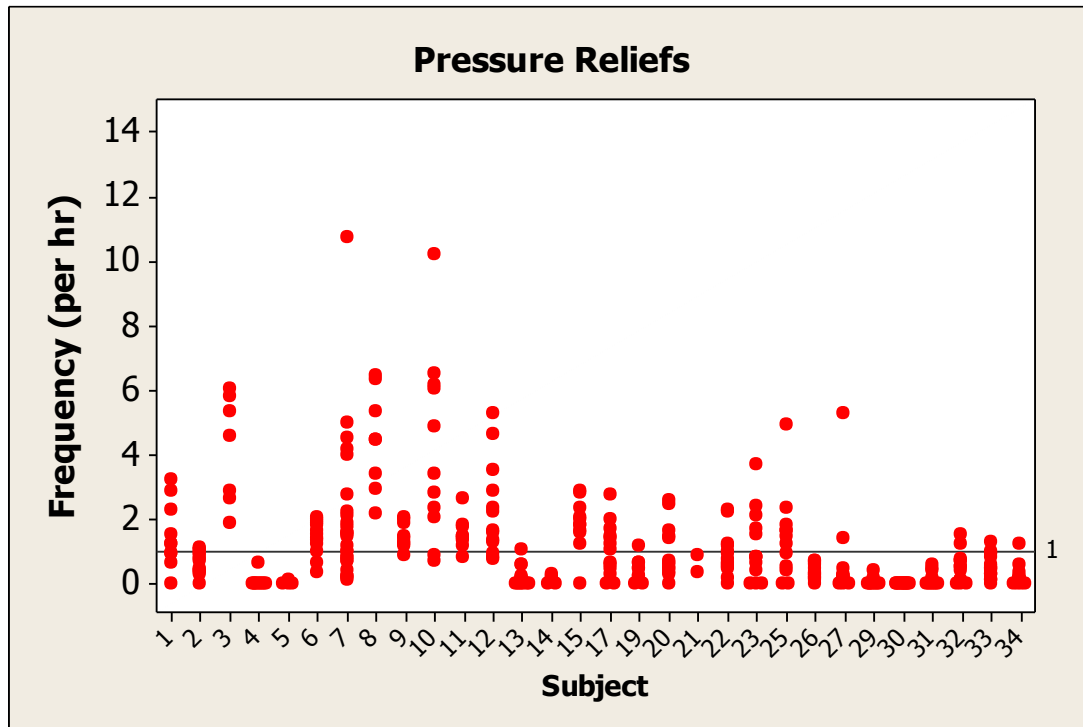
# Reality Poll:

How often do you think individuals do pressure reliefs when they go home from rehab?

- A. They are over-achievers (1 PR every 15 minutes)
- B. They are rule followers (1 PR every 30 minutes)
- C. At least they are trying (1 PR per 60 minutes)
- D. What's a Pressure Relief? (1 PR every 2 hours, or less)

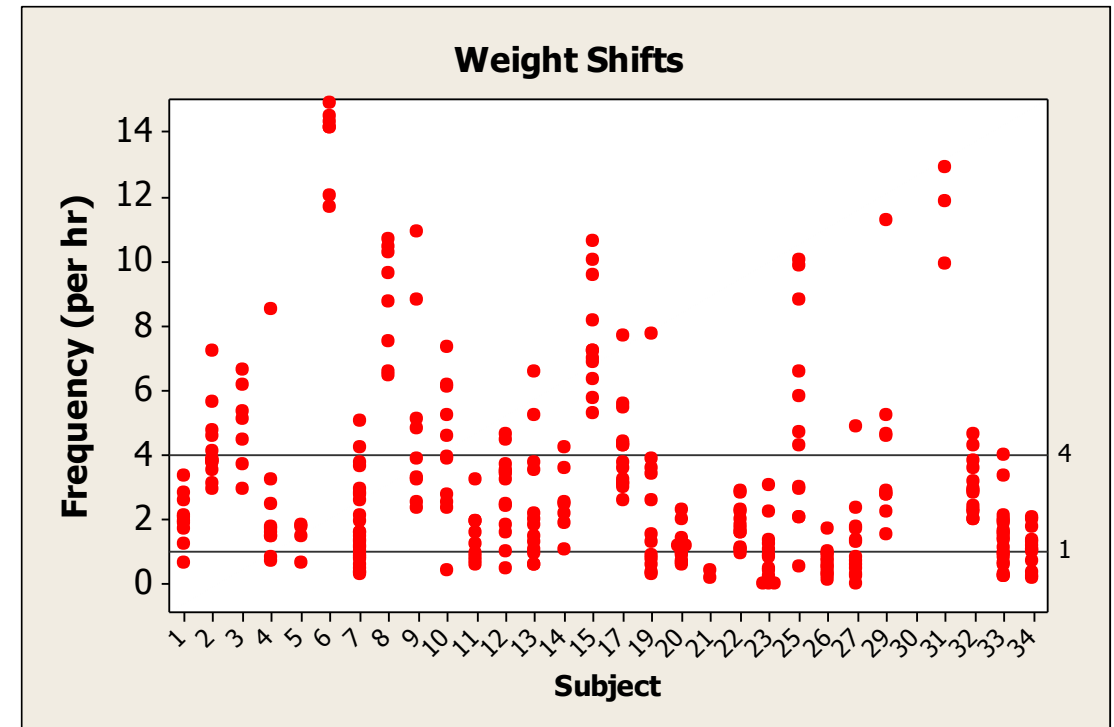
# Actual In-Seat Movement

## Pressure Reliefs (Full Unloading)



1.2 (1.7) Pressure Reliefs  
~1 every 50 minutes

## Weight Shifts (Partial Unloading)



3.8 (4.2) Weight Shifts  
~1 every 16 minutes

# Overview of In-Seat Behavior After Discharge

- 7 hours per day in wheelchair
  - 17 hours per day NOT in wheelchair
    - Where are they sitting?
    - Are the ischium still taking a beating?
    - What about the poor sacrum?
- 17 transfers daily
- Hourly pressure reliefs and more frequent weight shifts.

# Chronic SCI Population

- 29 manual wheelchair users
- 225 complete days of data
- Recruited through Shepherd Center and Duke University / Durham VA
- Characteristics
  - Ages 21-66 (Average 41 yo)
  - 2-33 years post injury (Average 15 years)
  - 23 men, 6 women
  - LOI: mostly lower thoracic or lumbar (18), 7 upper thoracic and 3 cervical
  - 12 had a history of recurrent pressure ulcers

# How long do full time users sit in their wheelchairs?

This study:

29 Manual WC users	10.1 hrs	3.8 (St Dev)
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Prior studies

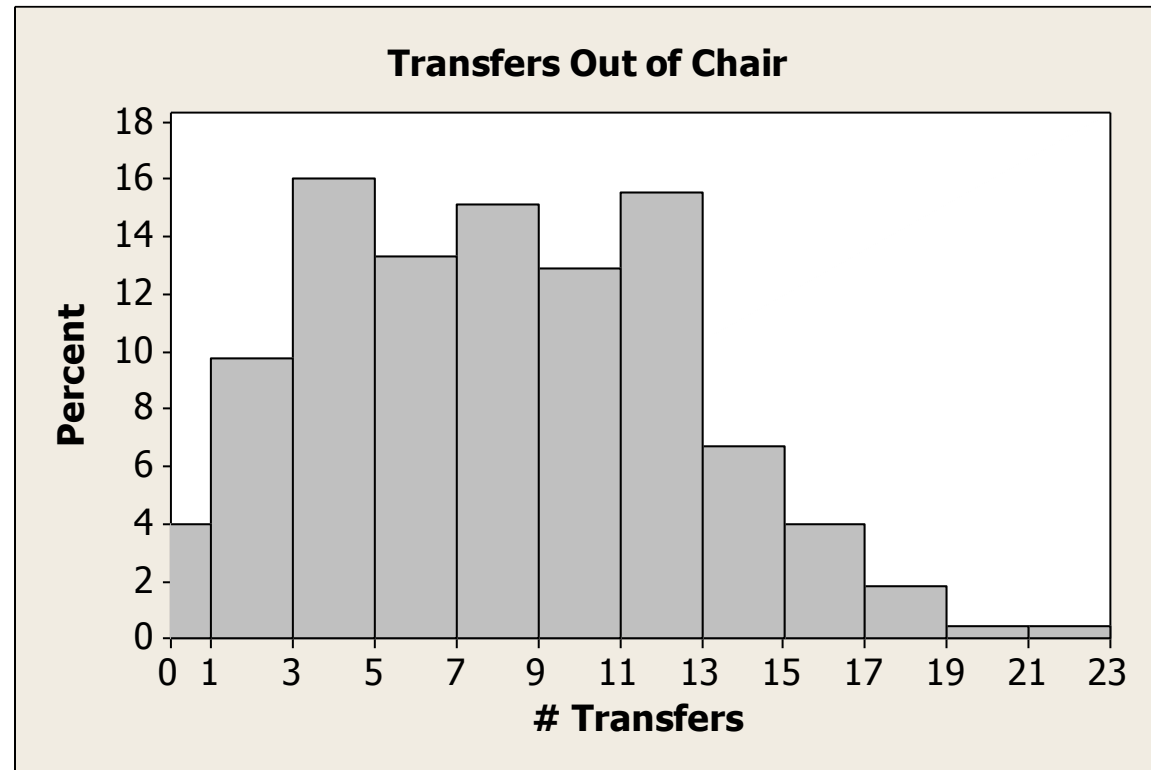
	Mean	St Dev
28 Chronic Manual WC users	10.5 hrs	5.2
20 Chronic Power WC users	10.8 hrs	2.9

For full time users, the wheelchair is not merely a means of conveyance, it is an extension of their functional being.

Sonenblum, et al. *J Rehabil Res Dev, In Press.*; Sonenblum, et al. *Rehabil Res Pract*, 2012.

Sonenblum, et al., *Arch Phys Med Rehabil*, 2008. **89(3)**.

# Many full time wheelchair users transfer a lot



**Median = 8 xfers**

# Reality Poll:

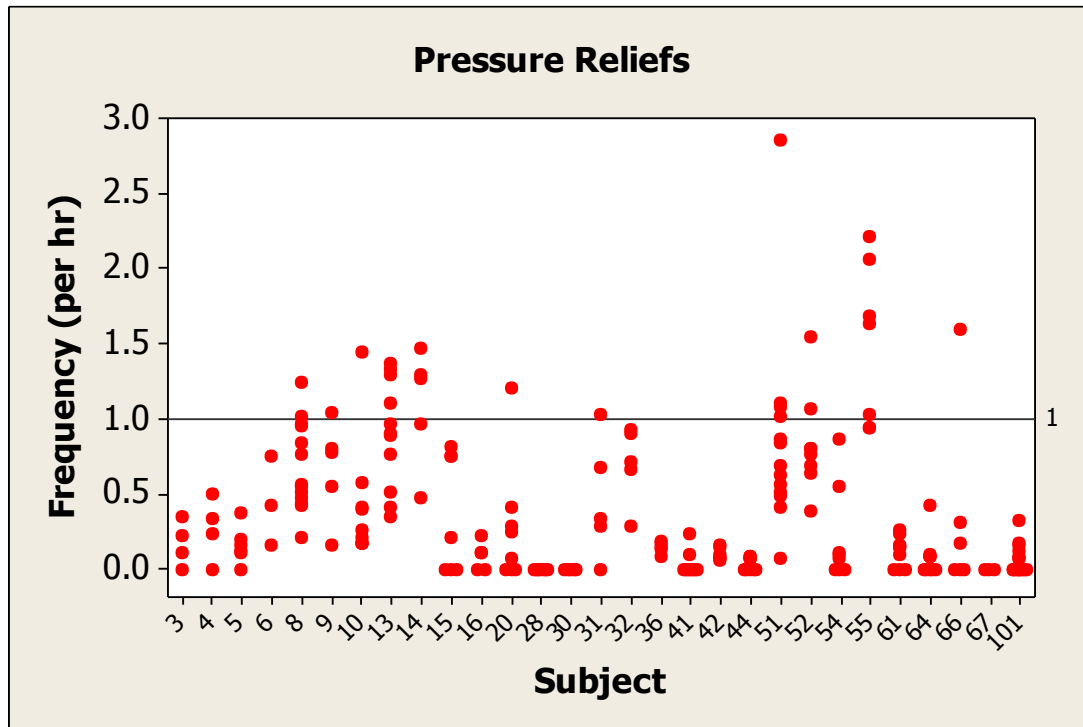
How often do you think individuals do pressure reliefs when they are years out from rehab?

- A. They are over-achievers (1 PR every 15 minutes)
- B. They are rule followers (1 PR every 30 minutes)
- C. At least they are trying (1 PR per 60 minutes)
- D. What's a Pressure Relief? (1 PR every 2 hours, or less)



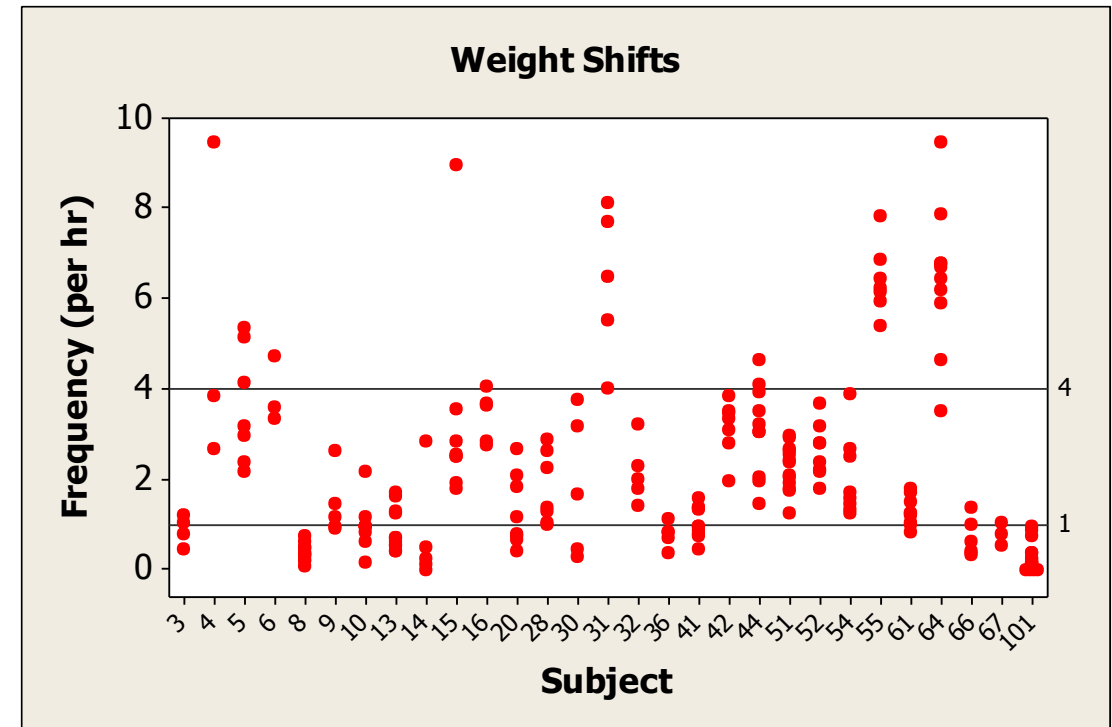
# Full Pressure Reliefs and Weight Shifts Daily Frequencies per Occupancy-hour

## Pressure Reliefs (Full Unloading)



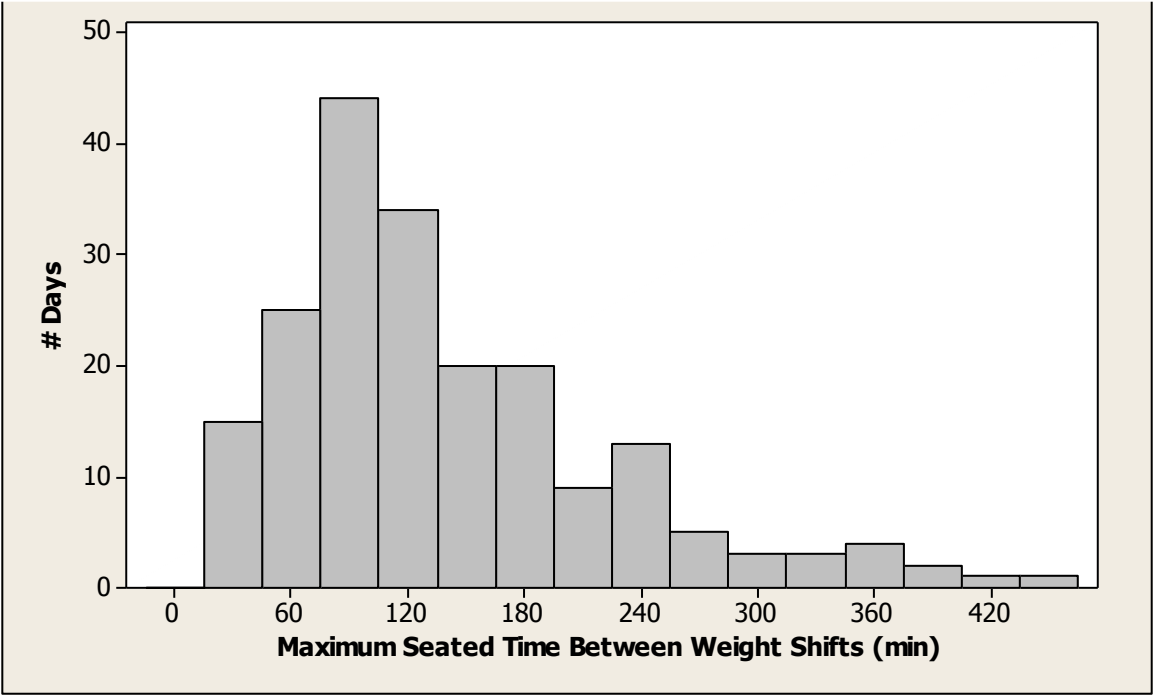
0.5 (0.8) Pressure Reliefs / hour  
~ 1 PR every 2 hours

## Weight Shifts (Partial Unloading)

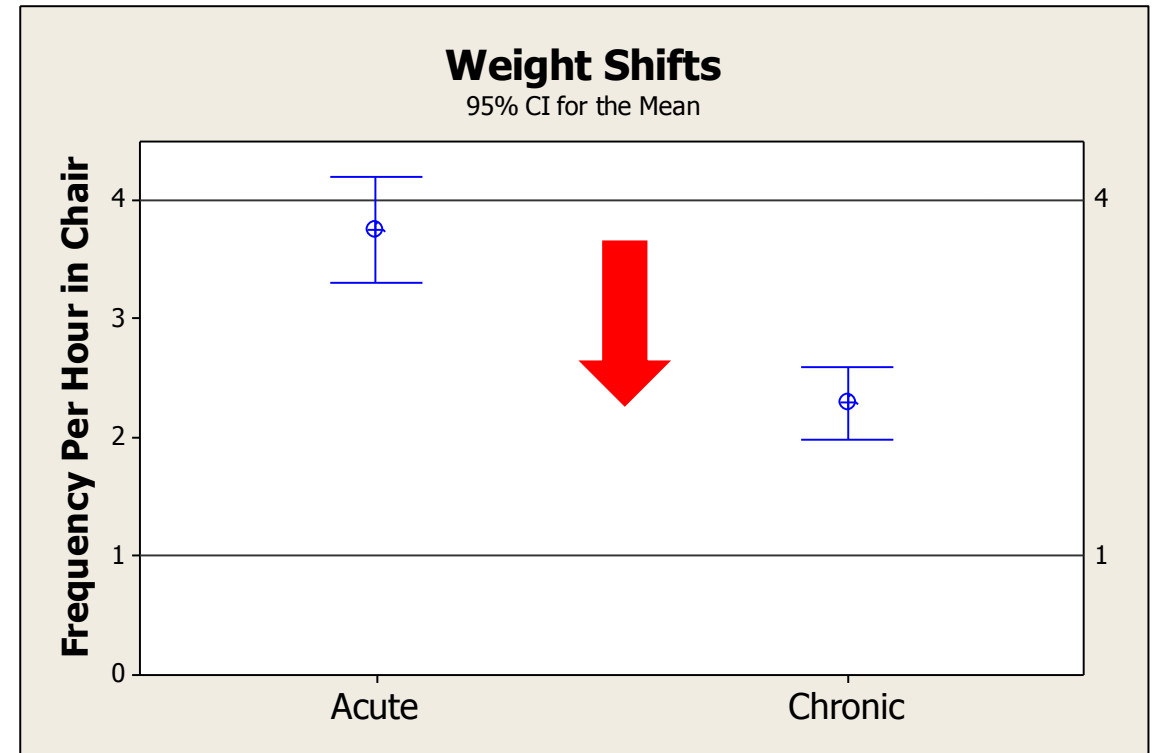
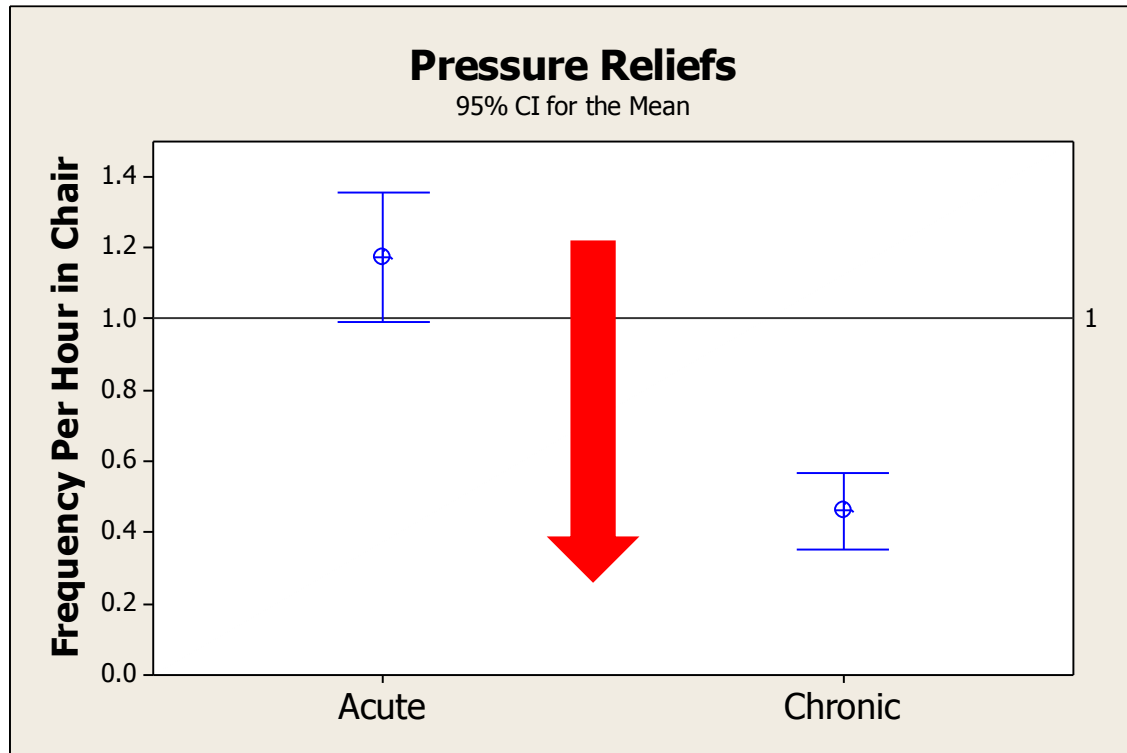


2.3 (2.3) Weight Shifts / hour  
~ 1 WS every 26 minutes

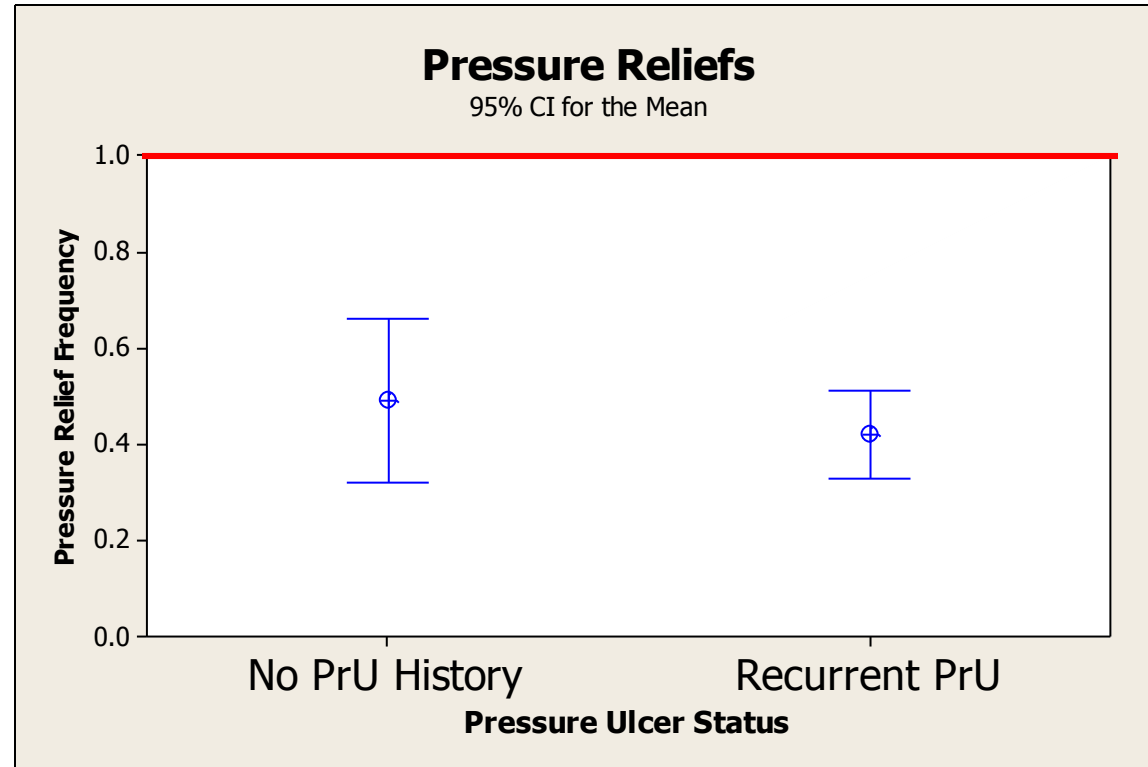
# Maximum Time Between Weight Shifts Daily



# So what happens over time?

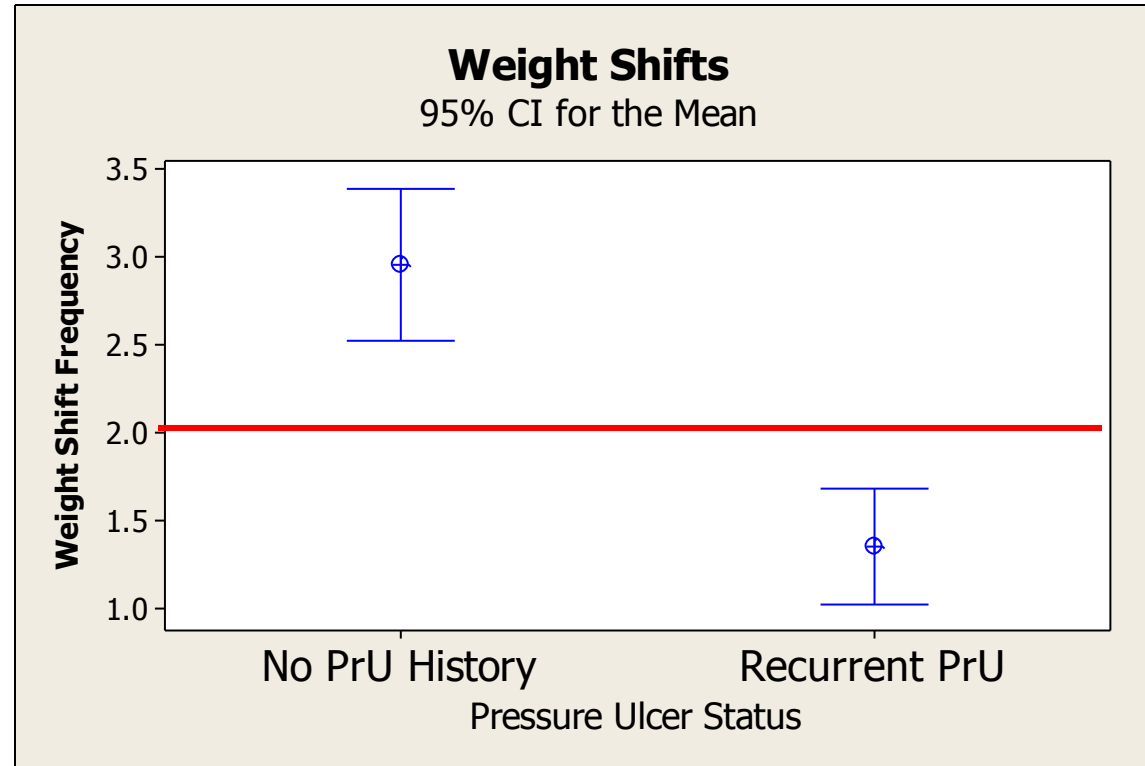


# What about Pressure Ulcers?



**Nobody does them regularly!**

# What about Pressure Ulcers?



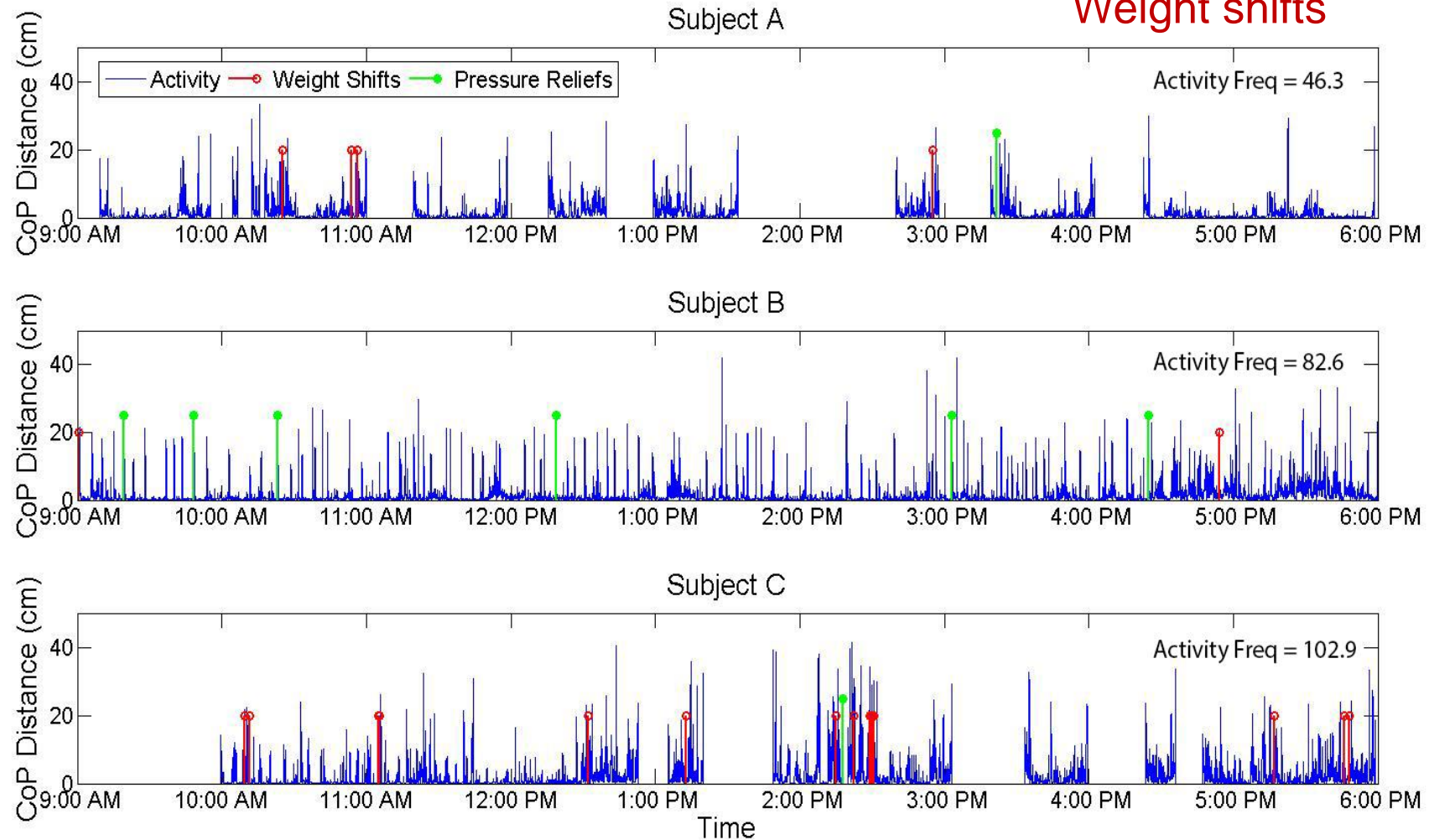
**Weight shifting behavior IS different!**

# Vastly different in-seat movement of 3 persons

COP of in-seat movement

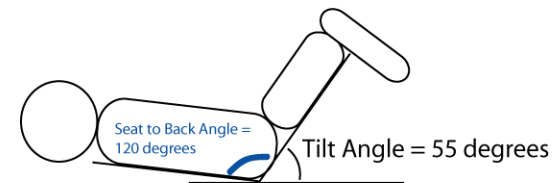
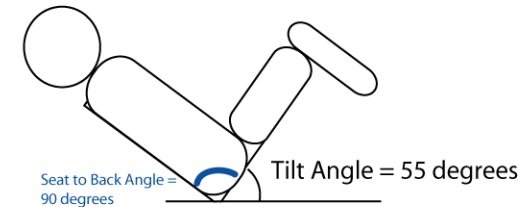
Pressure reliefs

Weight shifts



# Studies 5 & 6: Everyday Use and Biomechanical Effects of Power Tilt

For people at high risk, powered tilt and tilt/recline systems are available



# The impact of tilting on blood flow

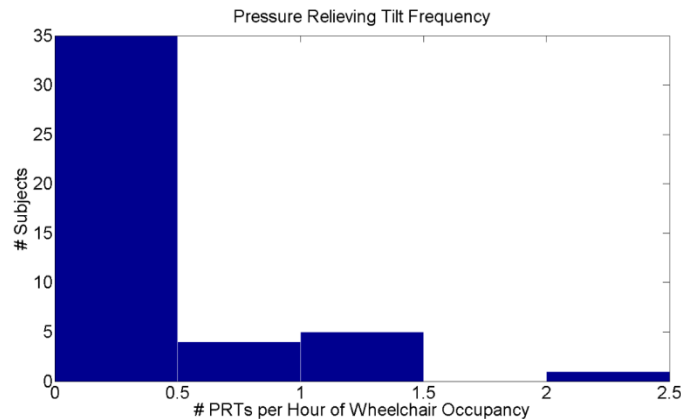
Tilt Position	Increase in Mean Blood Flow Compared with Upright (SD)	P-value
15°	8% (19%)	0.016
30°	24% (48%)	0.003
45°	84% (84%)	0.007

Sonenblum SE, Sprigle SH. The impact of tilting on blood flow and localized tissue loading; J Tissue Viability. 2011 Feb;20(1):3-13.

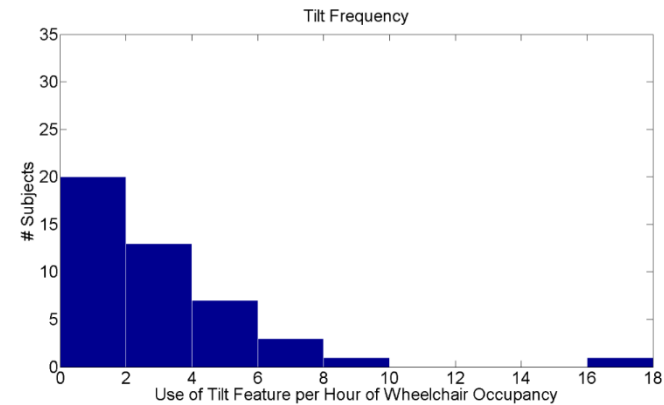


# Challenge lies in getting users to fully engage the functionality

**“Pressure Relieving Tilts”**  
(Tilts > 30° lasting > 1 minute)



**Use of tilt feature**  
(Angle change of 5° lasting > 20 sec)



## Use of tilt feature per hour

Sonenblum SE, Sprigle S, Maurer CL. Use of power tilt systems in everyday life. *Disabil Rehabil Assist Technol* 2009; 4(1):24-30.

# Putting It Together

	Power Tilt		Manual Weight Shifts	
	Position	Mean (SD)	Position	Mean (SD)
Small Movements	Angle change of 5° lasting > 20 sec	3.0 (2.9)	Weight Shift: Pressure Reduction > 30%	2.4 (2.2)
Intermediate / Large Movements	Tilts > 30° lasting > 1 minute	0.3 (0.5)	Pressure Relief: Complete unloading of both buttocks lasting > 15 seconds	0.4 (0.5)

# If there's time...

- Wheelchair use – bouts of mobility.

How much people move in wheelchairs

is a different question than

How people move in wheelchairs

We are concentrating on the latter

# How people move in manual wheelchairs

## *Distance, time moving & bouts of mobility*

- Distance & Time moving are commonly described
  - Distance and time are very highly correlated
    - Therefore, do not offer unique information
  - Bouts of movement
    - Represent transitions between activities
- | <u>START</u>  | <u>STOP</u>   |
|---|---|
| <ul style="list-style-type: none"><li>• Travel at 0.12 m/s (0.27 mph) for at least 5 seconds</li><li>• Traverse at least 0.61 m</li></ul> | <ul style="list-style-type: none"><li>• Travel less than 0.76 m over 15 seconds</li></ul> |

# Manual Wheelchair Use

Wheelchair Movement			
	Acute	Chronic	P value
Distance Wheeled (km)	1.2 (1.1)	1.5 (1.2)	0.010

# Manual Wheelchair Use

Wheelchair Movement			
	Acute	Chronic	P value
Distance Wheeled (km)	1.2 (1.1)	1.5 (1.2)	0.010
# Bouts	55 (32)	84 (41)	<0.01

# Manual Wheelchair Use

Wheelchair Movement			
	Acute	Chronic	P value
Distance Wheeled (km)	1.2 (1.1)	1.5 (1.2)	0.010
# Bouts	55 (32)	84 (41)	<0.01
% Mobile	9.7 (8.5)	8.5 (5.8)	0.122



# Manual Wheelchair Bouts of Mobility

69 Full time manual wheelchair users  
All K0005 wheelchairs  
59,027 bouts of activity  
566 subject-days

Characteristic	Median	Min	Max
<b>Bout Distance (m)</b>	8.3	0.8	3,891
<b>Bout Duration (sec)</b>	20	5	2,419
<b>Bout Speed (m/s)</b>	0.44	0.09	2.65

# Other tidbits of manual wheelchair use

- **Long bouts > 5 minutes?**
  - 344 bouts out of 59,151 bouts (<1% bouts)
  - 2/3 of the subjects had at least 1 long bout
  - 15 subjects had > 5 long bouts
    - representing > 80% of bouts longer than 5 minutes
- **Fast bouts > 1 m/s?**
  - 1870 bouts out of 59,151 (3%)
  - Every subject has at least 1 fast bout
  - 41 subjects had at least 10 fast bouts

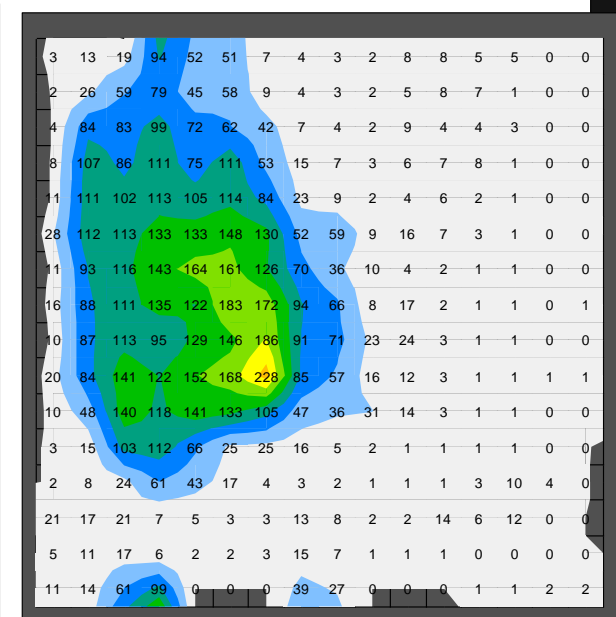
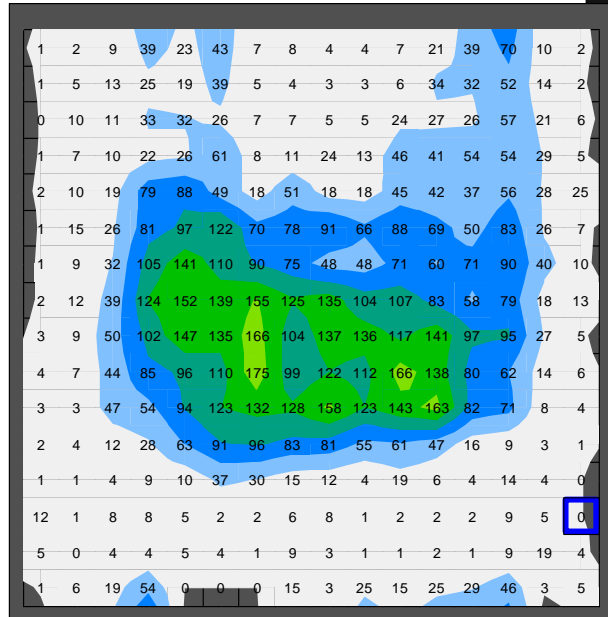
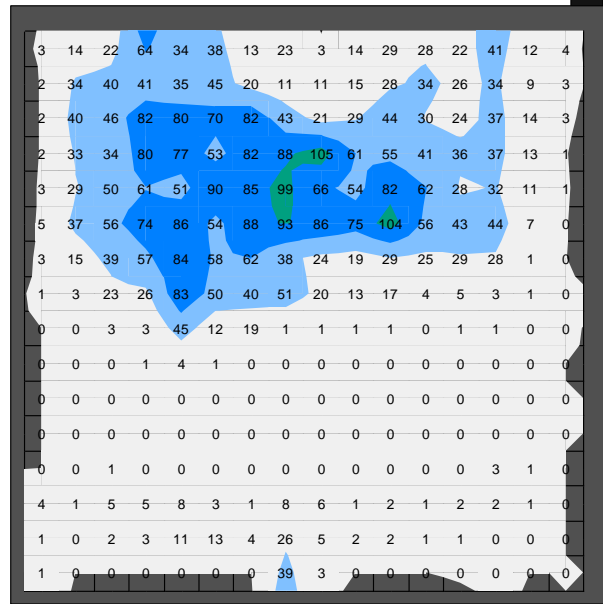
# Clinical Implications

- Transfers
  - Training
  - Possible (likely?) culprit in shoulder pain
- Change with time
  - After discharge, time in chair increases and propulsion increases, but protective behaviors decrease.
  - What does this mean about the AT prescribed to them while in inpatient? Does it still fit their needs?

# Clinical implications

- Wheelchair users do not demonstrate routine
  - All were trained in PRs and to target a frequency
  - We cannot assume dedicated PRs are routine
- Weight shifts are much more common, for tilt and manual
  - Intermediate forward and side leans qualify
  - In-seat movement can have an impact so
    - Education should address these activities
    - IPM as an education tool, especially because amount of pressure relief for a weight shift might differ by cushion
    - Position people so they can move

# Interface pressure mapping is useful when teaching pressure reliefs and weight shifts



Upright posture



# In summary

- Weight- shifts are based upon PU models linking time@pressure to necrosis
- Activity is good
  - put people in a position that they can do stuff
  - Seating systems and training to facilitate transfers
  - encourage activity-
    - leaning and reaching has positive tissue benefits
    - Weight shifts impact microclimate
- Most persons do not have a weight shift routine
- Behavior changes over time

# Acknowledgements

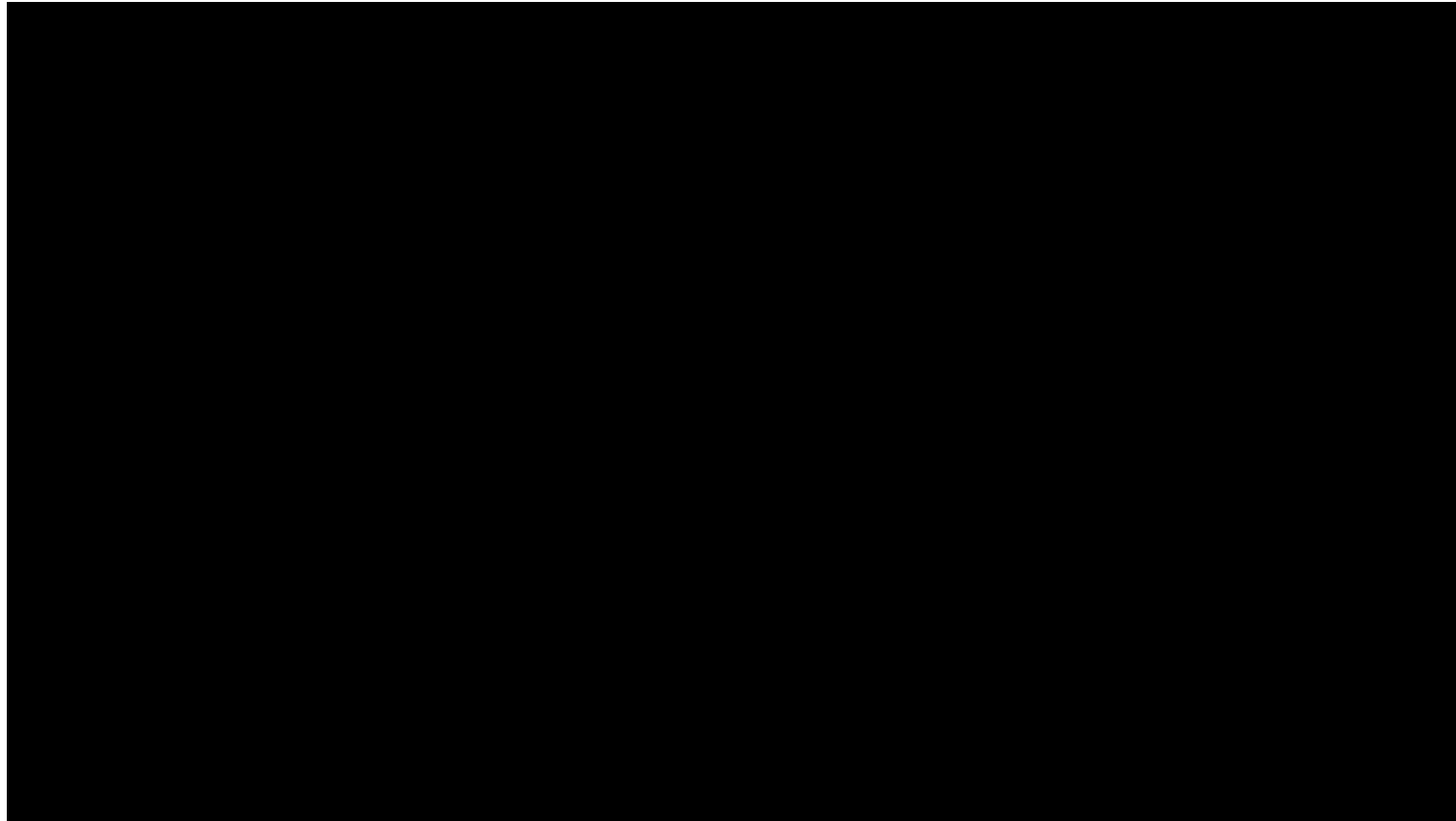
- Georgia Tech
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- Kessler Foundation
  - William Weber
- Shepherd Center
  - Chris Maurer
  - David Kreutz
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# Questions



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HD  
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