Is the Sliding Sheet Good Enough? Guidelines for Practice Based on Biomechanical Evaluation of Repositioning Technology

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Disclosures

• Neal Wiggermann and Victor Zhou are employees of Hill-Rom
• Nany McGann participates on the Hill-Rom/Liko SPHM Advisory Council
Patient Handling Injury

On average, in the previous 12 months, (Davis, 2015)
- 55% of caregivers reported experiencing back pain or injury
- 44% experienced shoulder pain/injury
- 36% experienced lower extremity pain/injury

82% of patient handling injuries occurred when lift equipment was not used (Gomaa, 2015)

Each year, an estimated 12% of nurses leave the profession due to chronic back pain

Background

Repositioning patients in bed is most common patient handling activity (Poole-Wilson, 2015; Vailiadou, 1995)

Manual repositioning is associated with risk of musculoskeletal injury (Marras, 1999)

Assistive devices have been studied, but often:
- One or few devices
- A single patient weight
- No biomechanical modeling or estimation of injury risk

Objective
- Evaluate risk of caregiver injury when repositioning patients in bed for several combinations of 1) repositioning activity, 2) patient weight and 3) repositioning aid
Guidelines for Physical Loading – A Quick Overview

**Lifting:** risk of back injury increases when spine compression exceeds **3400 N** [764 lbs]
- NIOSH lifting equation (Waters, 1993)
- 35 lbs lift limit for patient handling (Waters, 2007)

**Pushing and Pulling:** Psychophysical tables from Liberty Mutual Tables (aka “Snook Tables”) (Ciriello, 1993)
- Exceeding psychophysical limits associated with injury (Herrin, 1986)
- Example: Pull force of 55 lbs every 30 minutes is acceptable to 75% of females

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Translating Guidelines to Healthcare

Compared to the study populations used to develop the manual material handling guidelines, the nursing population is older, heavier, and more deconditioned:

- **Median age of workforce:**
  - 1996: 38.3 years
  - 2016: 42.0 years

- **US Population with Obesity:**
  - 1975: 12%
  - 1995: 22%
  - 2014: 34%

Conclusion – guidelines might not be sufficiently conservative to protect workers

Sources:
Methods

Participants

◦ Caregivers
  ◦ N = 10
  ◦ Height: 170 cm (SD 7.6 cm)
  ◦ Weight: 80.4 kg (SD 16.6 kg)
  ◦ Experience 7.5 years (SD 3.7 years). All >1 year experience, regularly reposition patients

◦ “Patients”
  ◦ 50 kg [110 lbs]
  ◦ 77 kg [170 lbs]
  ◦ 141 kg [311 lbs]
Methods

Equipment
- Motion Capture
- Ground Reaction Force
- Pull Force

Procedure
- 90 Trials per subject
- Order of test conditions partially randomized
Methods

Repositioning Activities Studied

A. Pull up in Bed
B. Lateral Transfer
C. Lateral Reposition
D. Turning
Methods

Repositioning Aids
- Draw sheet (control)
- Friction reducing sheets (used as a pair)
- Turn and position system
- Air assisted lateral transfer device
Methods – Outcome Variables

Hand Forces

Biomechanical model
- L5/S1 Spine compression
- Muscle activity estimates
Methods – Biomechanical Model


Methods – Biomechanical Model

L5/S1 Spinal compressive force (N)

NIOSH recommended injury threshold: 3400 N
Muscle Activation and Injury

• A strong association between overexertion and musculoskeletal injury has been demonstrated in a large number of epidemiological studies in various regions of human body (Kumar 2001).

• High muscle exertion should be avoided to reduce the risk of musculoskeletal injury.

• When performing occupational tasks, a muscle activity of over 60% MVC is generally considered high exertion (Jakobsen et al., 2014).

References:
Pull up in bed – L5/S1 Compression

Spine Compression (N)

- Draw
- Draw + Trendelenburg
- Sage TAP
- Friction Reducing
- AirPal

Error Bars = Range

- 110-lbs
- 170-lbs
- 311-lbs
Pull up in bed – Pull Force

- Error Bars = Range

- 75% female
- 90% female

<table>
<thead>
<tr>
<th></th>
<th>Draw</th>
<th>Draw+Trend</th>
<th>Sage</th>
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Pull up in bed – Spine Compression vs. Pull Force

- **Spine Compression** (N):
  - Draw
  - Draw+Trend
  - Sage
  - Friction
  - AirPal

- **Pull Force** (lbs):
  - 110-lbs
  - 170-lbs
  - 311-lbs

- **Devices**:
  - Draw
  - Draw+Trend
  - Sage
  - Friction
  - AirPal

- **Pull up in bed** – Spine Compression vs. Pull Force
Lateral Transfer – L5/S1 Compression

Spine Compression (N)

Error Bars = Range

- Draw Sheet
- Friction Reducing
- AirPal

110-lbs

170-lbs
Lateral Transfer – Pull Force

Draw Sheet
Friction Reducing
AirPal

Error Bars = Range

75% of females accommodated
90% of females accommodated
Lateral Reposition – L5/S1 Compression

- **Spine Compression (N)**
- **Draw**
  - 110-lbs: REFUSED
  - 170-lbs: REFUSED
  - 311-lbs: REFUSED
- **Sage**
  - 110-lbs: REFUSED
  - 170-lbs: REFUSED
  - 311-lbs: REFUSED
- **Friction**
  - 110-lbs: REFUSED
  - 170-lbs: REFUSED
  - 311-lbs: REFUSED
- **AirPal**
  - 110-lbs: REFUSED
  - 170-lbs: REFUSED
  - 311-lbs: REFUSED

**Error Bars = Range**
**Lateral Reposition – Pull Force**

- **Draw**: REFUSED
- **Sage**: REFUSED
- **Friction**: REFUSED
- **AirPal**: REFUSED

Legend:
- 110-lbs
- 170-lbs
- 311-lbs

Error Bars = Range

- 75% of females accommodated
- 90% of females accommodated

Notes:
- Pull Force (lbs)
- Graph shows the pull force required for different devices (Draw, Sage, Friction, AirPal) with error bars indicating the range of values.
Lateral Reposition – Spine Compression vs. Pull Force

Spine Compression (N)

- 110-lbs
- 170-lbs
- 311-lbs

Draw
- Sage
- Friction
- AirPal

Pull Force (lbs)

- 0
- 100
- 200
- 300
- 400
- 500
- 600
- 700
- 800
- 900
- 1000
- 1100
- 1200
Turning – Spine Compression vs. Pull Force

- **Manual Turn Assist**
- **Turn Assist**

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Pull up in bed – Biceps Muscle Activation vs. Pull Force

% of Max Strength

- Draw
- Draw+Trend
- Sage
- Friction
- AirPal

Pull Force (lbs)

REFUSED

- 110-lbs
- 170-lbs
- 311-lbs
# Recommendations

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Implications for Care
(for most healthy caregivers)

**Turning**
- May be acceptable to perform manually for average patients when taking into account disc compression and pull forces.
- However, healthcare worker injury data and patient safety risk factors must be considered.
- Turn assist reduces physical stress, especially recommended for heavy patients
Implications for Care
(for most healthy caregivers)

Lateral Repositioning, Pull up in bed, Lateral Transfer
- Unacceptable to perform manually (with draw sheet) for any size patient
- Friction Reducing Sheets acceptable for lighter patients
- Lift equipment required for patients with average to above average weight
- Air Assisted Transfer devices suitable alternative, at least up to 311 lbs
- Ceiling lifts with reposition slings will remain the lowest risk as air assisted devices require manual handling to roll under and off of each patient. Reposition slings may remain under the patient.
Compensatory Strategies

How do we perform tasks that our muscles do not have the strength to perform?
Staff Education: “What NOT to do”

Pressure

Strain

Friction & Shear to Patient

Pressure
Staff Education: Proper Repositioning of a Patient

NO Friction & Shear to Patient
Conclusions

• For repositioning, pull force appears to drive injuries more than spinal compression due to high muscle activation and therefore compensation.

• Repositioning aids reduce physical stress on caregivers. However, these aids are only appropriate for lighter patients.

• Lift equipment or air assisted transfer devices are needed to safely reposition most patients.

• Due to the need to turn patients on and off of most air-assisted devices, a reposition sling and ceiling lift are most ideal.

• Most patients can be safely turned to place slings when considering disc compression forces and hand forces. However, caution should remain due to patient risk factors and employee injury data.