Inclined Surfaces: Impact on Postural Stability and Spine Loading

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Presented by Kermit Davis

Low Back Biomechanics and Workplace Stress Laboratory

Challenges of Inclined Manual Material Handling

- **Challenges multiple systems**
  - Balance and base of support
  - Low back and trunk musculature
- **Frequent lifting on inclined surfaces**
  - Roofers, warehouse item selectors, construction workers

Potential Negative Outcomes

- **Slippery inclined surfaces increases rates of falling**
  - **Challenges the proprioceptive input system by changing the length of the ankle muscles** (Mezzarane and Kohn, 2007)

Potential Negative Outcomes

- **Increased loading on the spine resulting in back injuries**
  - **Changes in the trunk muscle coactivation due to unstable base of support may increase low back injuries**

Gap in Knowledge

- **Lack of understanding of the link between postural stability (at the base of support) and spine loads (biomechanical loading)**
  - **Linkage between feet, legs, and trunk is a muscular activation chain**

Specific Aims and Hypotheses

- **Aim 1: Determine spine loads when lifting from flat and incline surface (14^{o} and 26^{o})**
  - **Hypothesis 1: Surface inclination angles (14^{o} and 26^{o}) will increase muscle coactivation resulting in higher spine loads during MMH tasks.**

Specific Aims and Hypotheses

- **Aim 2: Measure displacements of the body's COP associated with different inclined surfaces (flat, inclined at 14° and 26°)**
  - **Hypothesis 2: Greater inclination angles will increase postural instability: larger COP sway area and path length during lifting**

Specific Aims and Hypotheses

- **Aim 3: Determine the correlation between postural stability and spine loads**
  - **Hypothesis 3: A strong correlation between postural sway area and length and spine loads**
  - Not Presented Today

METHODS

Study Design

- **Repeated measures within subjects laboratory study**
- **Participants were 10 healthy males (19 – 45 years old)**

Independent Variables

- **Surface Inclination Angle**
  - Flat (0°) and Sloped (14° and 26°)
- **Task Asymmetry**
  - Sagittally symmetric, 90° right, and 90° left
- **Number of Hands**
  - Two hands, Right hand, and Left hand

Dependent Variables

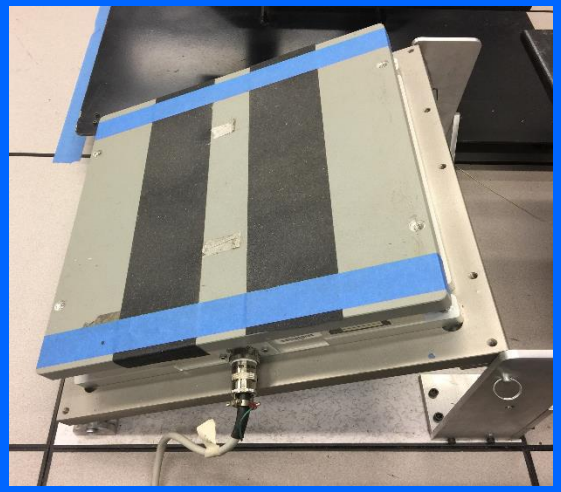
- **Peak Spine Loads**
  - Compression, Lateral shear, and A-P shear
- **Postural Stability Indices**
  - COP Sway Area and Path Length
- **Rating of Perceived Exertion**
  - Borg's RPE (6 -20) whole body scale

Apparatus

- **EMG Acquisition System**
  - 16-Channels GrassTM Model 12 Neurodata EMG Acquisition System
  - Bipolar Ag/AgCl surface electrodes over 10 trunk muscles and 6 leg muscles

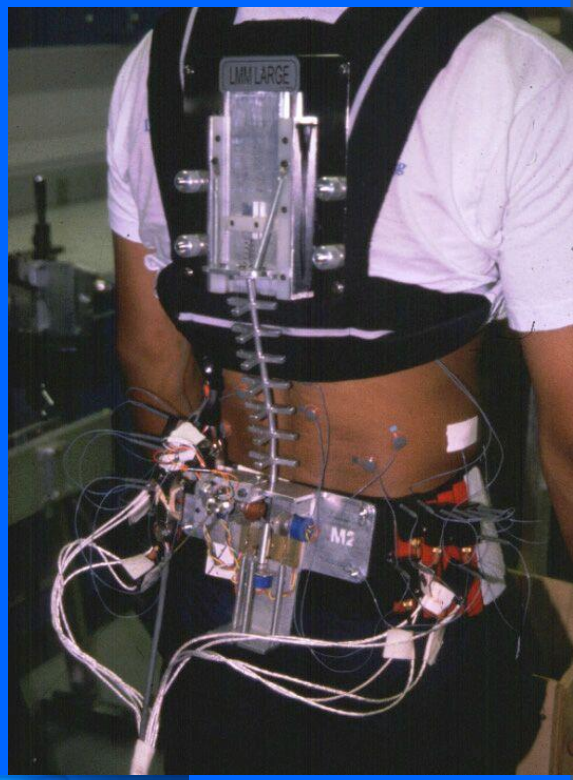
Apparatus

- **COP Acquisition System**
  - Force plate mounted on the adjustable platform connected to an amplifier and data collection computer
  - Synchronized with the EMG acquisition system via an external trigger



Apparatus

- **Lumbar Motion Monitor**
  - Tri-axial electrogoniometric system
  - Measures instantaneous 3D position and velocity of the trunk



Apparatus

- **Calibration System**
  - Force plate and electrogoniometric system
    - Pelvic Angle Monitor and Moment Arm Monitor
  - Set of lifts to calibrate EMG-assisted spine load model

Apparatus

- **Three shelf units**
  - Positioned directly in front, right, and left
  - Wood platform marked for placement of box with three inclines corresponding to flat, 14°, and 26°

Apparatus

- **Standard Box**
  - Single handle through the center at same height as two handles on outside
  - Weighed: 8 kg
  - Size: 25.5 cm X 25.5 cm X 23.5 cm

Procedures

- Screened, briefed on study protocol and signed approved informed consent
- Each participant donned a standard athletic shoe and t-shirt
- Application of EMG and completion of MVC exertions

Procedures

- LMM was placed on the back
- Completion of calibration lifts
- Completion of 81 lifts
  - Blocked on inclination angle (counterbalanced)
  - Randomized lifts within block
  - 3 repeats of each lifting condition
    - Completion of perceived rating after set completed

Procedures

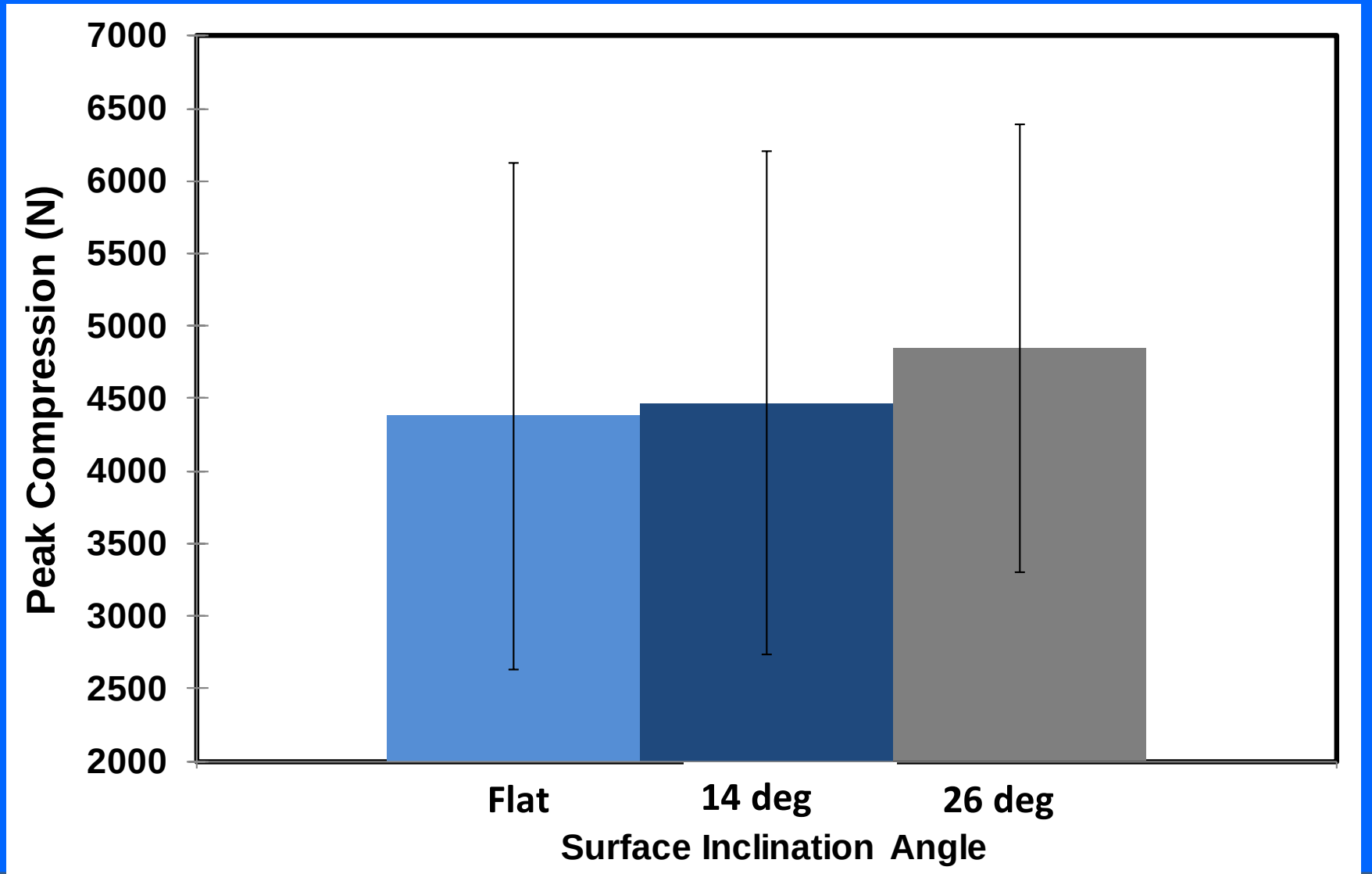
- **30 sec rest break after each set of 3 lifts**
- **Used time marker to mark start of lift and end of lift**
  - Signal set out to both EMG and COP data collection systems

Data and Statistical Analyses

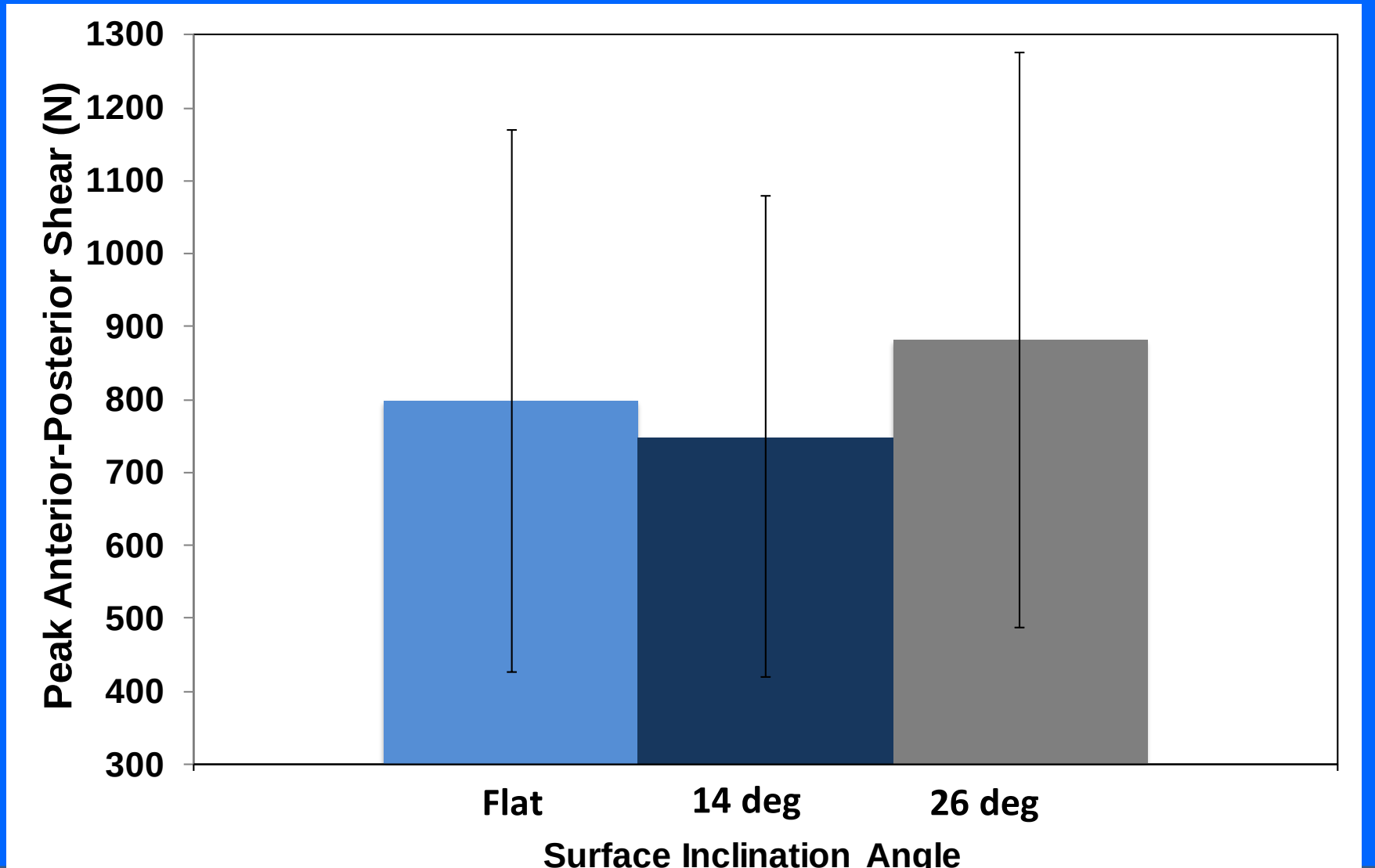
- **Means and standard deviations as a function of the independent variables**
- **Repeated measures ANOVA**
  - **Effects of the experimental conditions on the dependent variables**
- **Tukey studentized t-tests**
  - **Identified source of the significant effects**

RESULTS

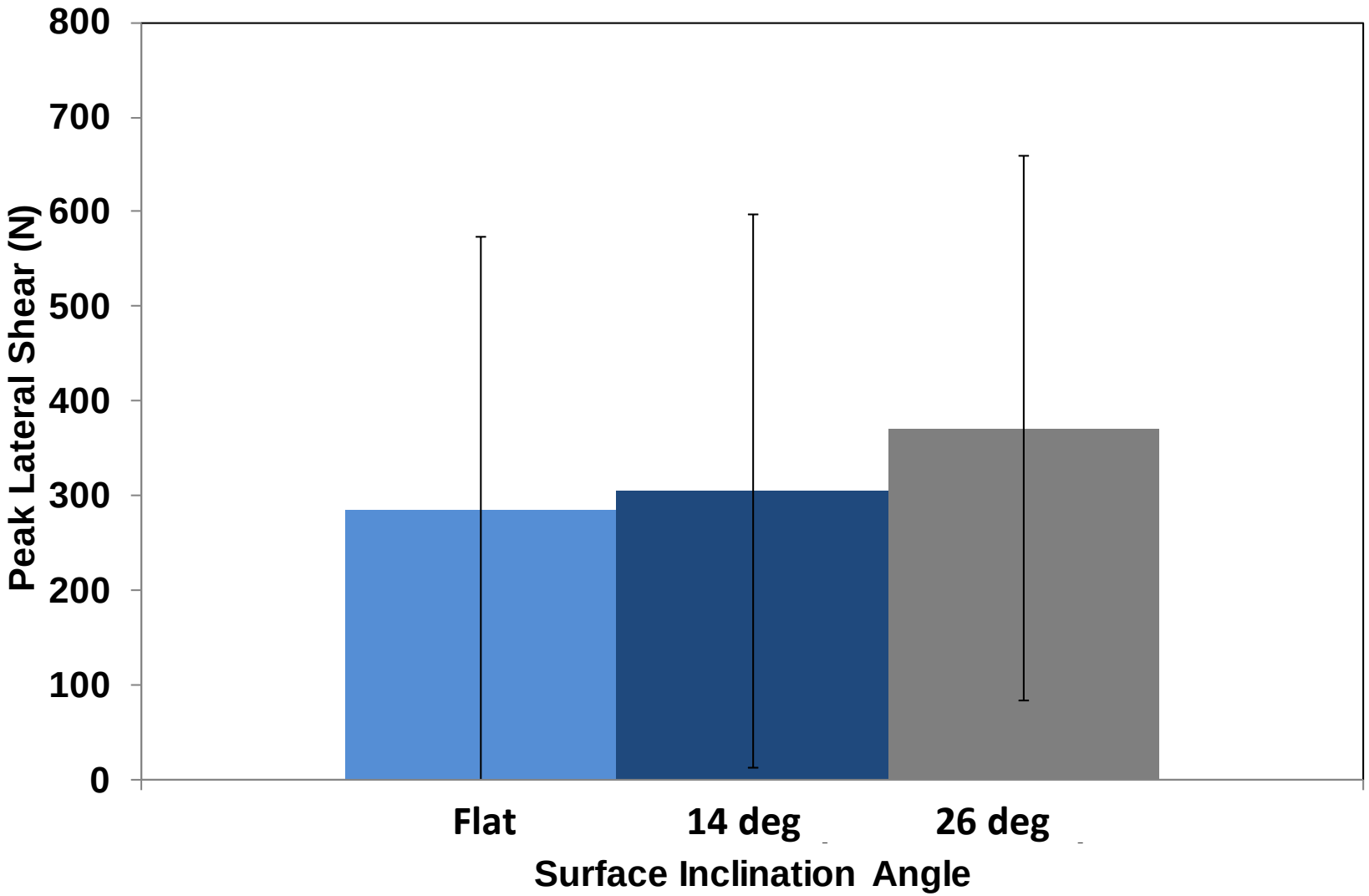
Compression



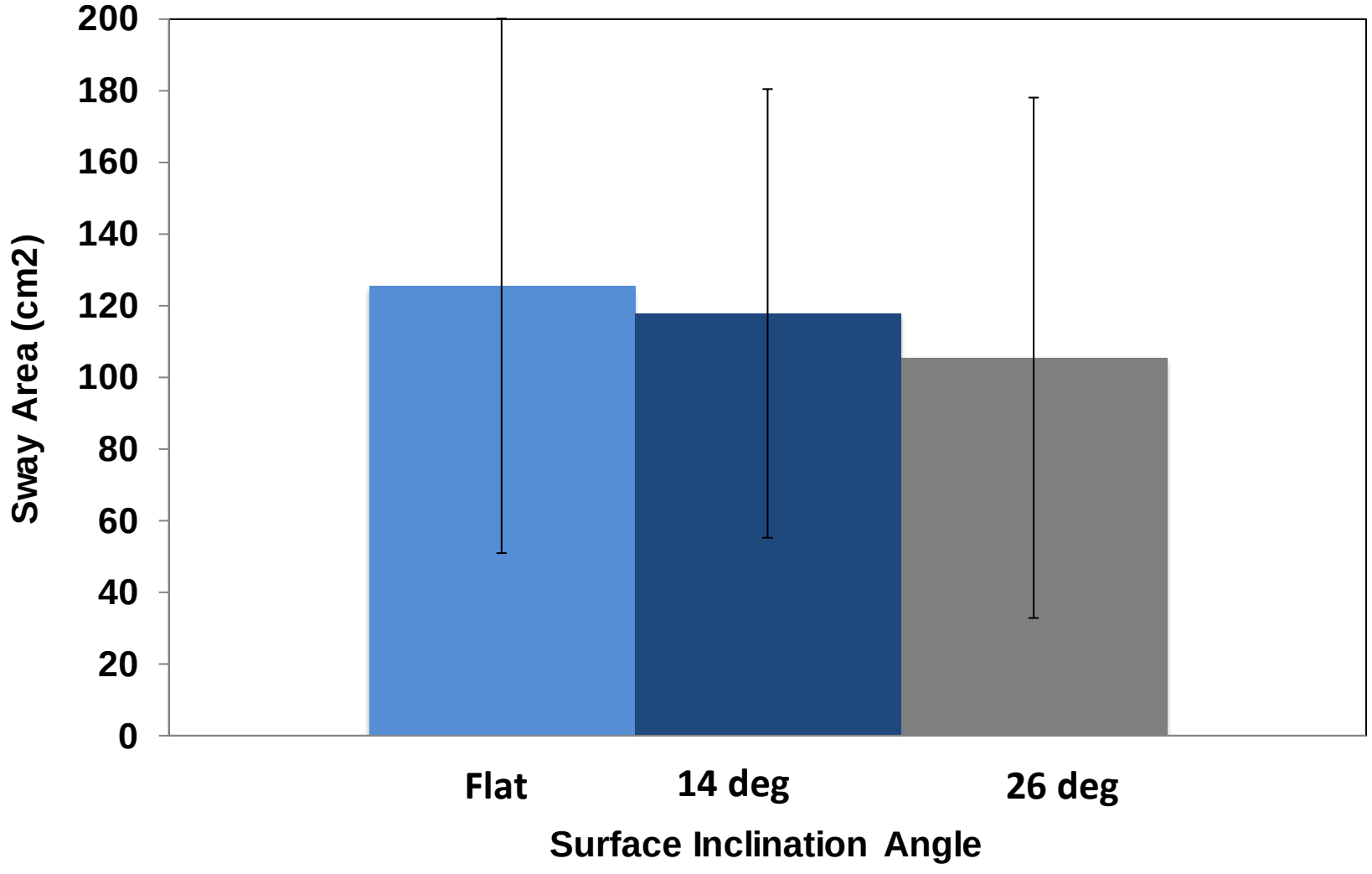
A-P Shear


Peak Anterior-Posterior Shear (N)
1300
1200
1100
1000
900
800
700
600
500
400
300
Flat
14 deg
26 deg
Surface Inclination Angle

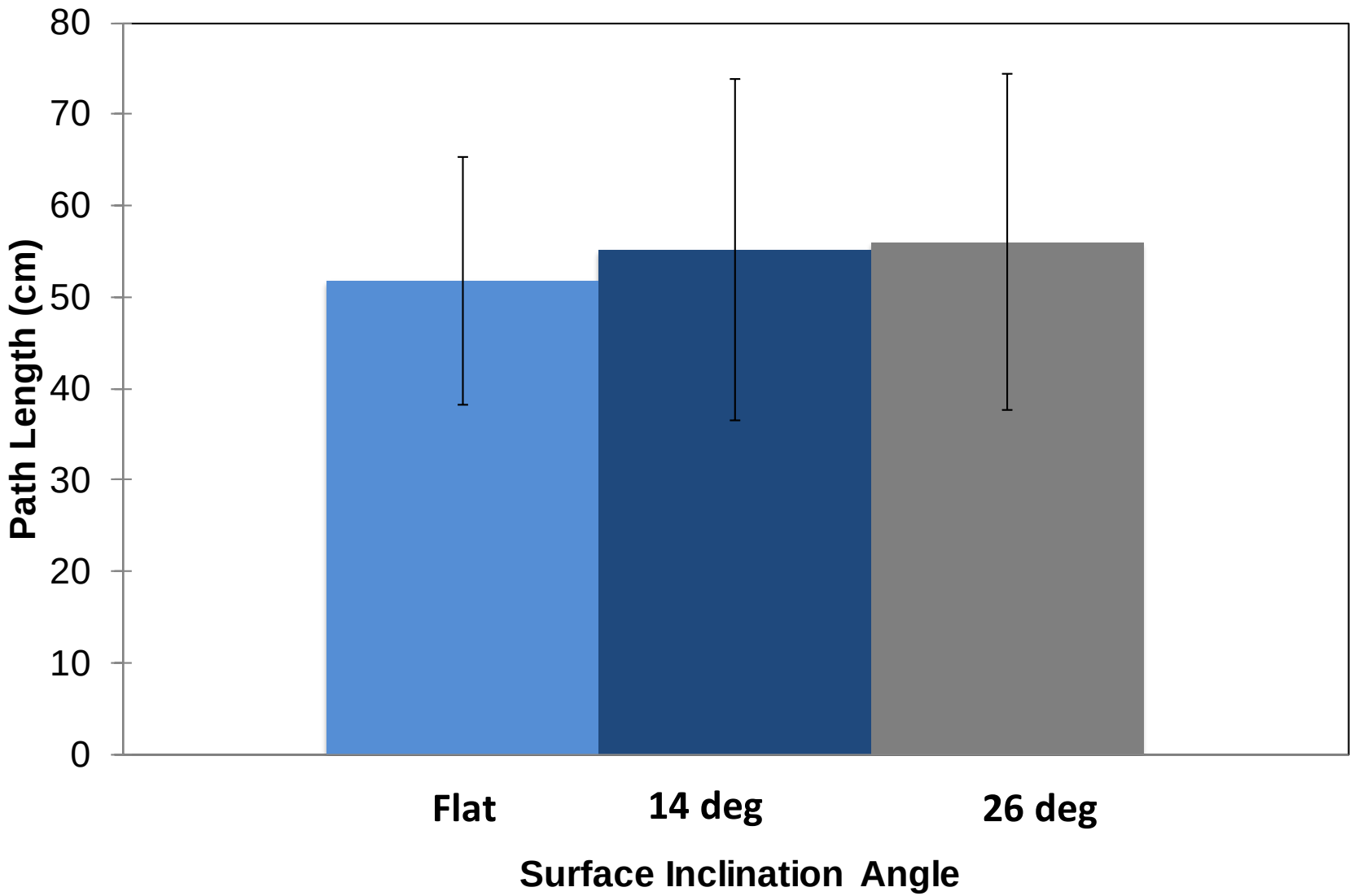
Lateral Shear



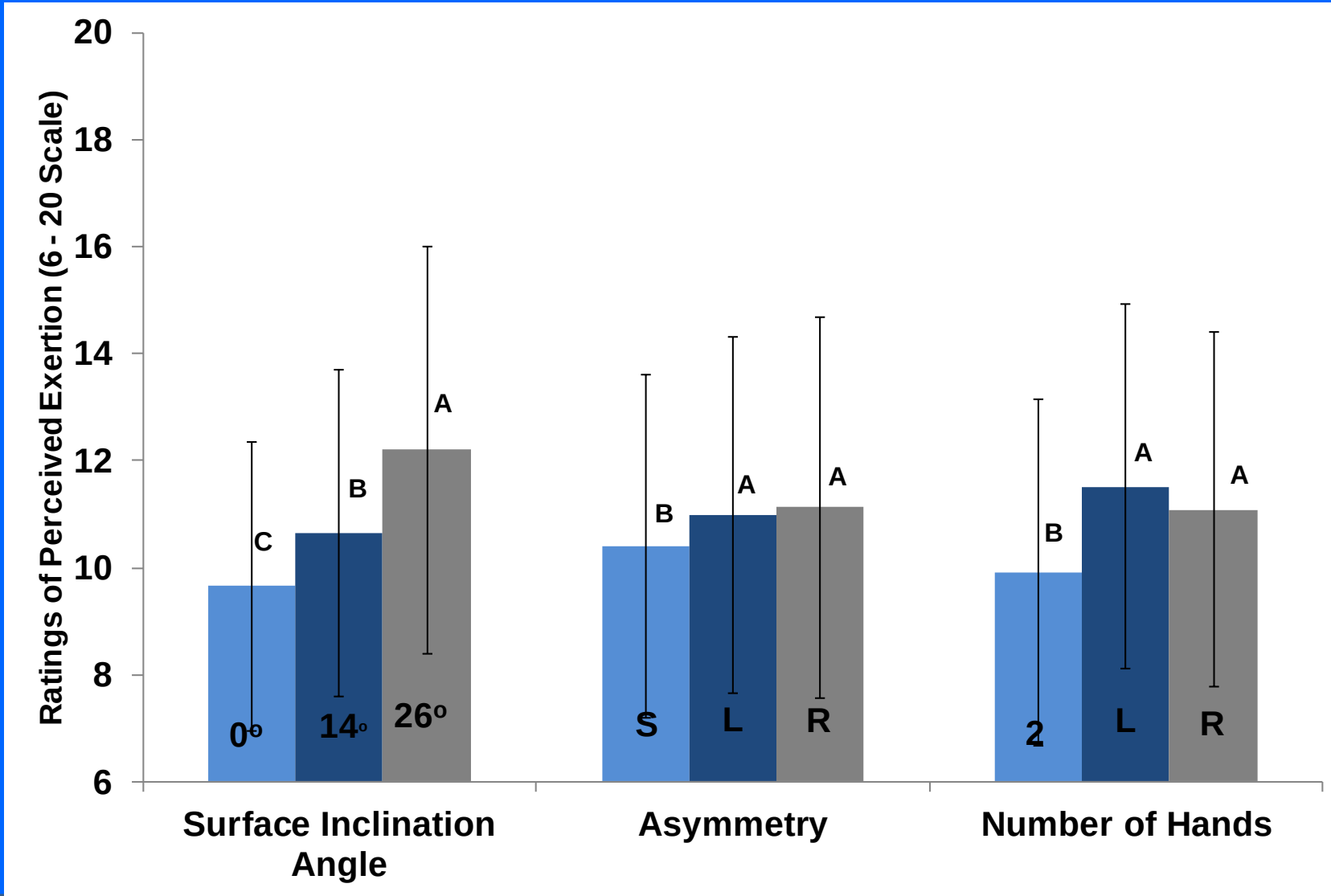
Postural Sway Area



Postural Sway Length



Rating of Perceived Exertion



WHAT DOES IT ALL MEAN?

Adverse Impact of Inclined Surface

- **More inclined floor resulted in greater three-dimensional spine loads**
  - Resulted in greater trunk sagittal and lateral flexion but slower trunk motions
  - Greater coactivation of trunk muscles: Latissimus Dorsi, Left Erector Spinae, Rectus Abdominus, Right External Oblique, and Left Internal Oblique
- **Supports Hypothesis 1**

Adverse Impact of Inclined Surface

- **Mixed results for postural sway**
  - Postural sway area decreased with increased incline
  - Postural sway length increased with increased incline
- **Partially Supports Hypothesis 2**

Biomechanical System

- **Some evidence that postural stability is linked to changes in leg muscle activity, transferring to changes in trunk muscles and ultimately increasing the spine loads**
  - Further analyses are underway to explore these phenomena

Limitations

- **Limited to young healthy males**
  - Unknown how females and older workers would respond to inclined surface
- **Small number of participants**
  - Limited ability to identify significant differences
  - Repeated measures study reduces impact of small study population

Limitations

- **Lab study in a controlled environment**
  - Single level of weight being lifted
  - Limited number of levels for independent variables
  - Environmental factors were controlled
- **Experimental setup required participants to maintain static foot postures**
  - Feet stationary, not allowing stepping

Take Home Message

- **Inclined surfaces cause adverse responses within the body**
  - Increased spine loads
  - Increased postural sway length
- **Need to better understand the inter-relationship between postural stability and spine loading**

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QUESTIONS?