What We Do

To Reduce Work-related Musculoskeletal Disorders and Injuries at Occupational Ergonomics and Biomechanics (OEB) Laboratory

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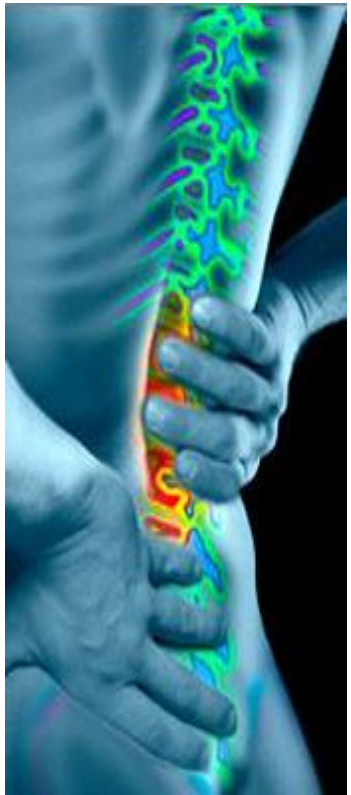
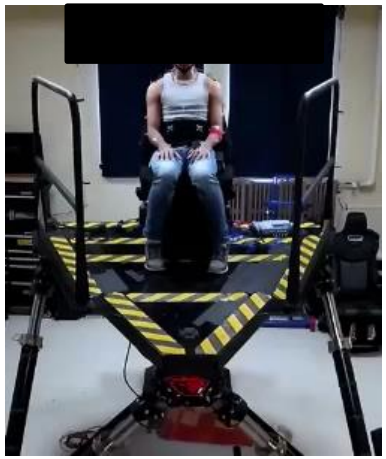
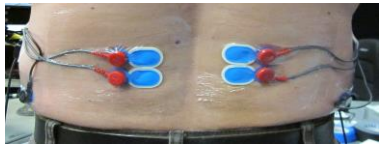


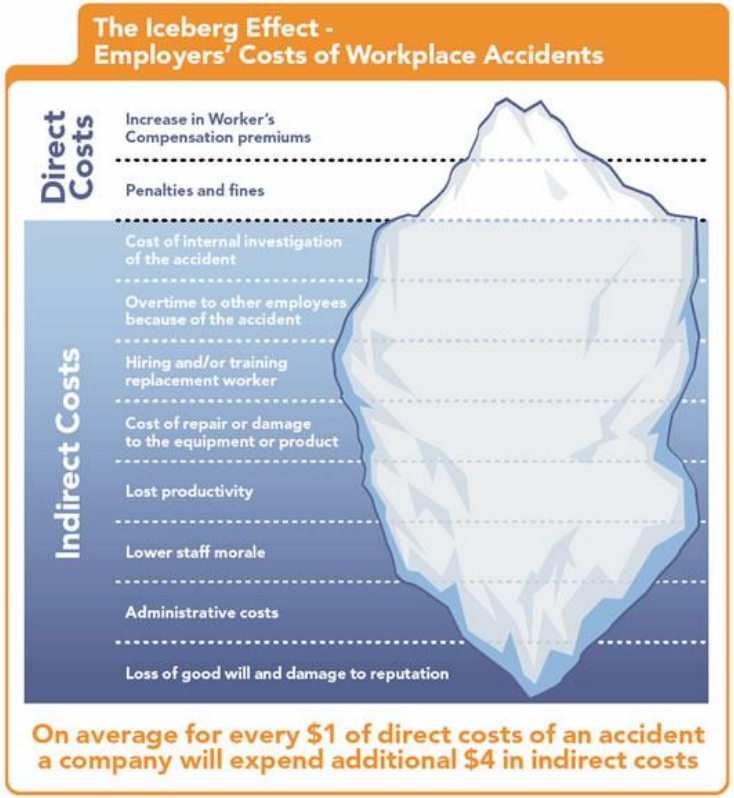




The Burden of Occupational Injuries and illnesses

- ~3 million workplace injuries and illnesses in the US (BLS 2016).
  - 3.0 case per 100 equivalent full-time workers.

- Annual injury cost: $171 billion in the US (NIOSH 2000)
  - Direct cost: ~ $88 billion in 2006



That’ not all….

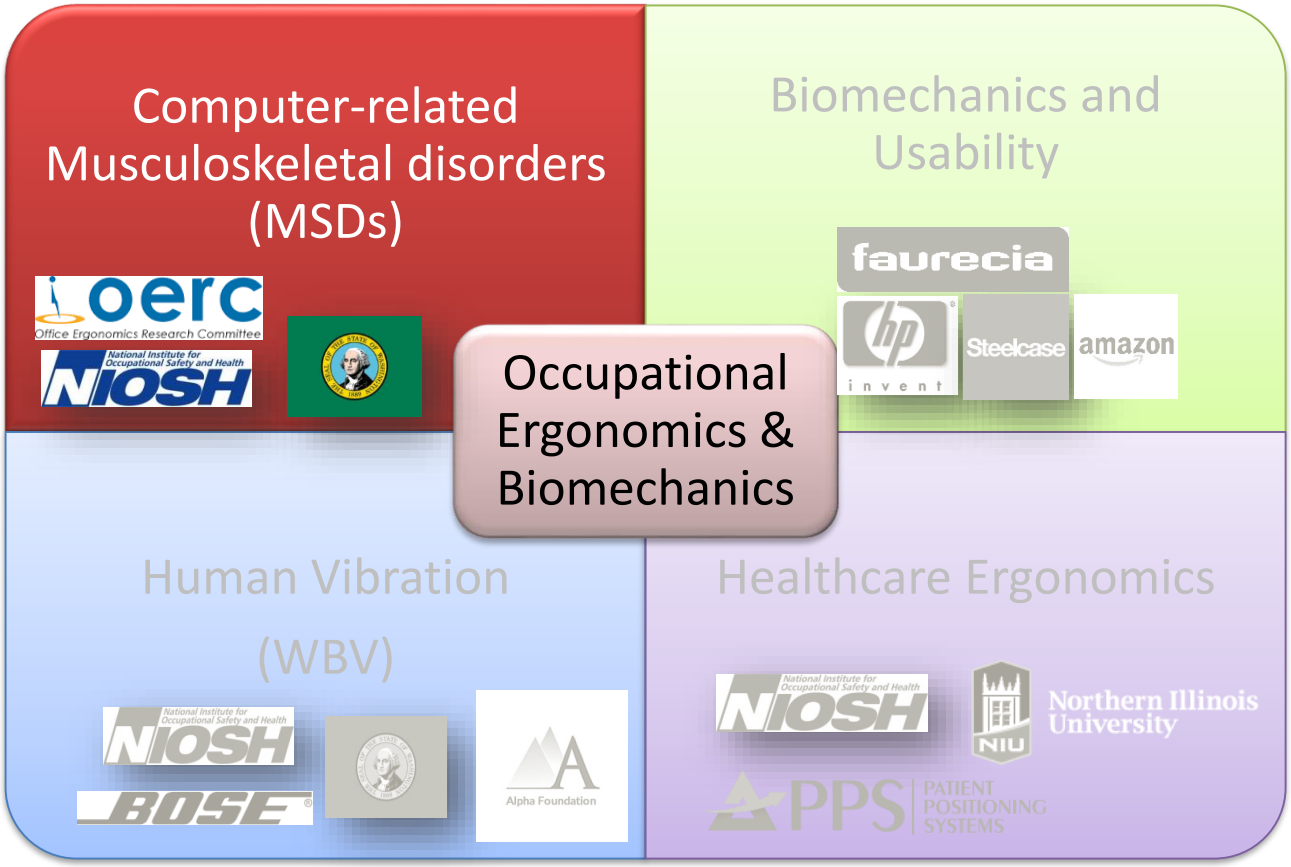
- These numbers are underestimated as many problems are not recorded due to:
  - Vague between occupational and non-occupational
  - Long latent periods -> difficult to make causal-and-effect inference.
  - Less strict reporting requirement when health problems are related to both work and outside of work.

Major Occupational Injuries and Illnesses

This is all about ergonomics research!

1. Musculoskeletal injuries and disorders
2. Respiratory disorders
3. Neurologic and psychiatric disorders such hearing loss
4. Skin disorders
5. Reproductive and developmental disorders
6. Cardiovascular disorders
7. Hematologic disorders
8. Hepatic disorders
9. Renal and urinary tract disorders

Occupational Ergonomics and Biomechanics Research Areas



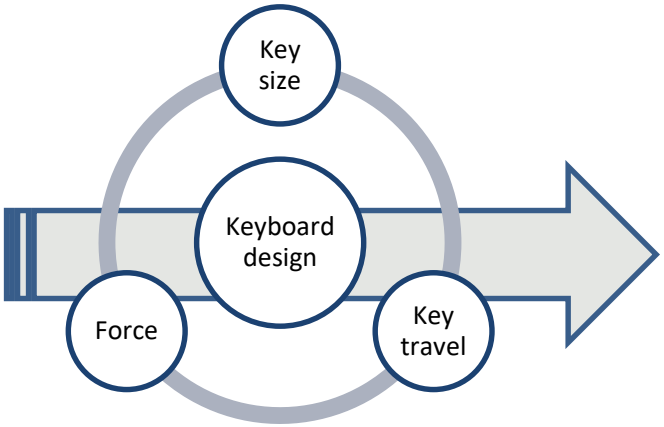
EFFECTS OF KEY TRAVEL DISTANCES ON BIOMECHANICAL EXPOSURES AND TYPING PERFORMANCE DURING ULTRA-LOW KEY TRAVEL KEYBOARD USE

Oregon State University

UNIVERSITY of WASHINGTON

Background: Keyboard Design

- Computer use have been associated with musculoskeletal disorders (MSDs) in the upper extremities.
- Risks for MSDs have known to be affected by various key characteristics.



- Despite prevalent use of ultra-low travel keyboards (< 2.0 mm), little research has studied the effect of such low key travel on biomechanical risks for computer-related musculoskeletal discomfort and disorders.

Objectives

- Determine whether there are differences between **conventional (key travel ≥ 2.0 mm)** and **ultra-low travel keyboards (key travel < 2.0 mm)** in:
  - Muscle activity (finger, shoulder, and neck)
  - Typing force
  - Wrist posture
  - Typing performance: Speed (WPM) and Accuracy (%)
  - Self-reported fatigue (Borg CR-10)
  - Subjective comfort and usability (7 pt. Likert Scales)

Subjects

- 20 adults subjects
  - 10 males and 10 females
  - No current pain or history of upper extremity MSDs
  - Experienced touch typists: > 40 WPM
  - Mean age: 29.45 (range 19 to 47) years old

5 keyboards tested

0.5mm

- Macbook
- Apple

0.7mm

- Thin Touch
- Synaptics

1.2mm

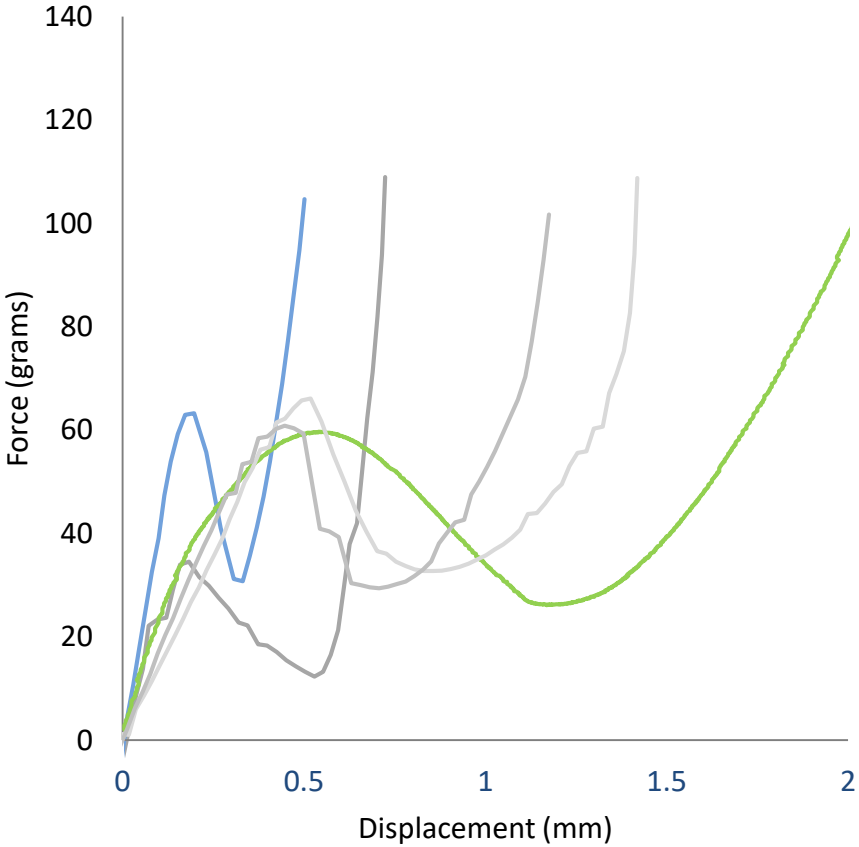
- Magic Keyboard
- Apple

1.6mm

- Surface Typecover
- Microsoft

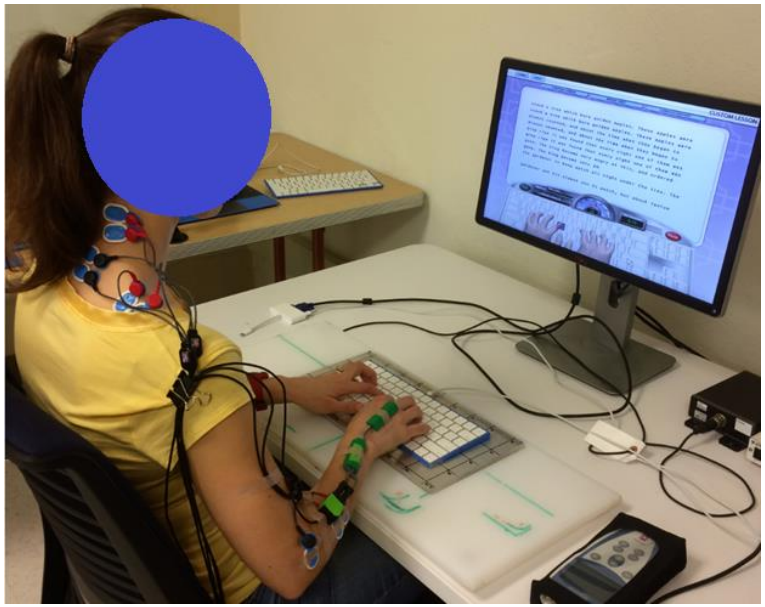
2.0mm

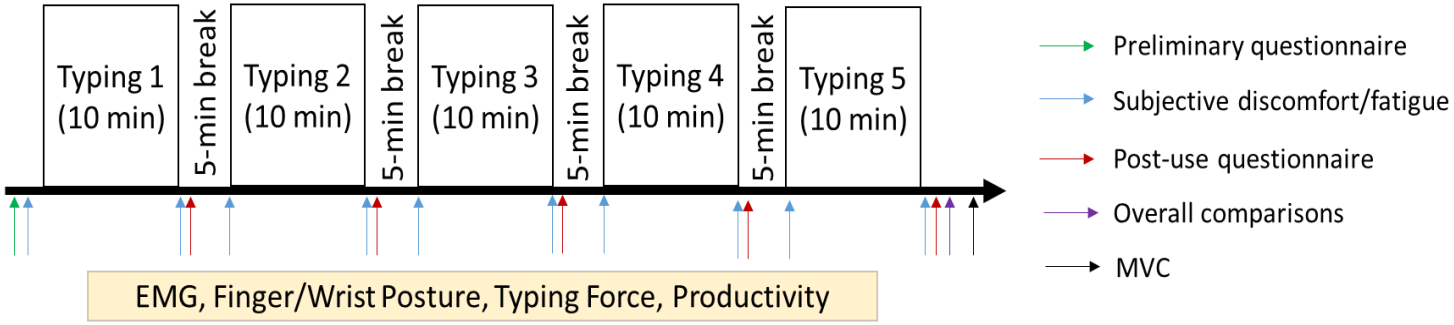
- A1234 Keyboard
- Apple



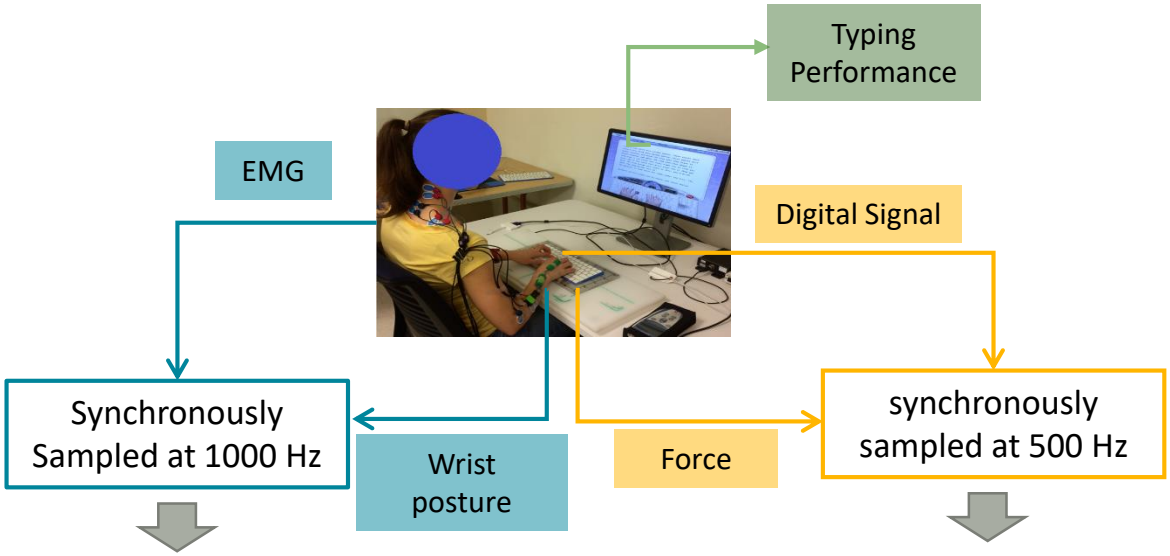
Experimental setup

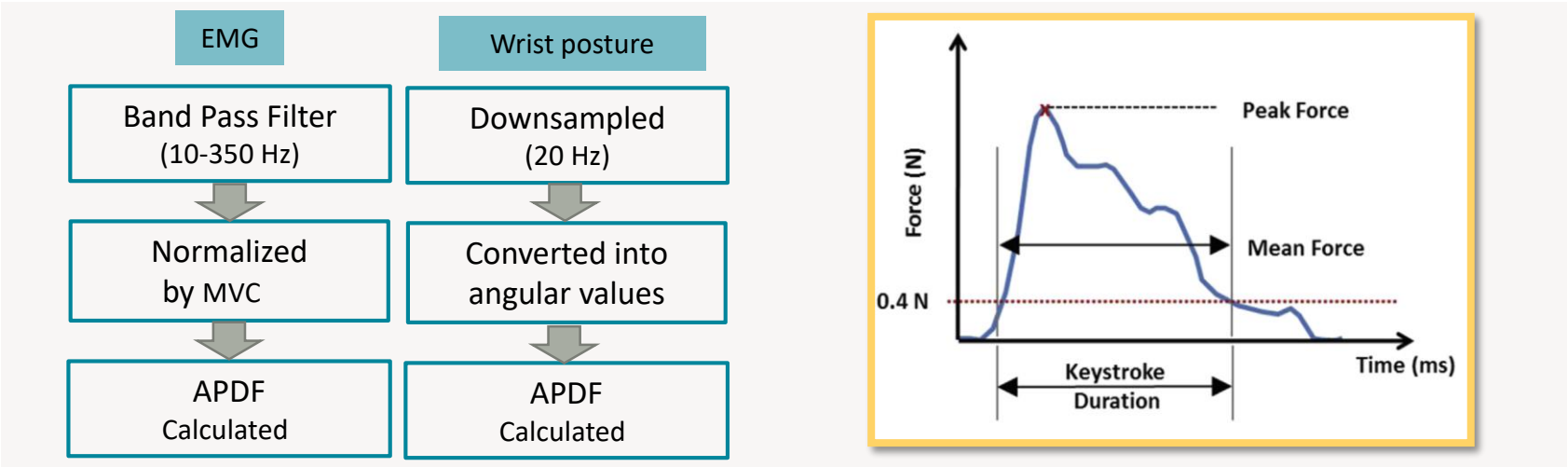
- 10-minute typing on each keyboard
- Keyboard order was randomized.





Data Collection





Summary

- **Finger Muscle activities** showed limited differences (< 2%) across the keyboards despite statistical differences in some measures.
- **Typing force** showed small differences across keyboards (< 0.3 newton).
- **Wrist posture** data showed that typing on ultra-low travel keyboard resulted in more wrist ulnar deviation, but less wrist extension.

Summary

- **Typing performance** showed small differences across keyboard despite statistical significant.
- **Self-reported fatigue** showed limited differences between the keyboards while **subjective comfort and usability** showed the conventional keyboard was preferred to ultra-low travel keyboards.
- In conclusion, ultra-low key travel keyboards may not have additional effects on physical exposures and typing performance measures as compared to a conventional keyboard.

BIOMECHANICAL EVALUATION OF AUGMENTED REALITY INTERACTIONS

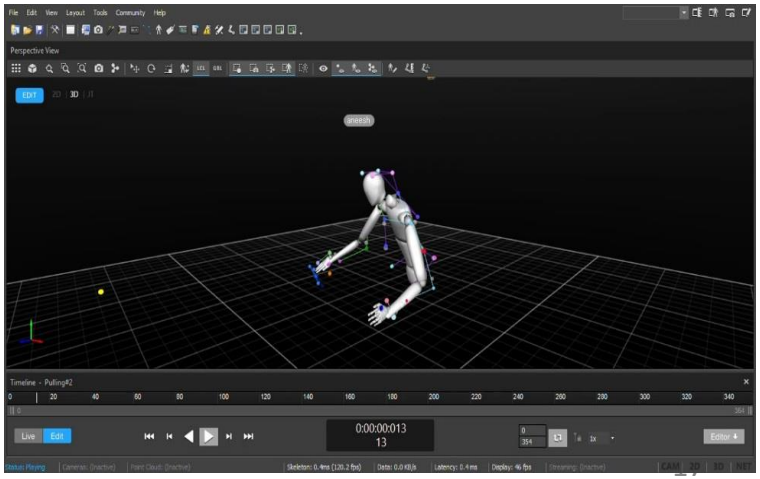
Oregon State University

Background

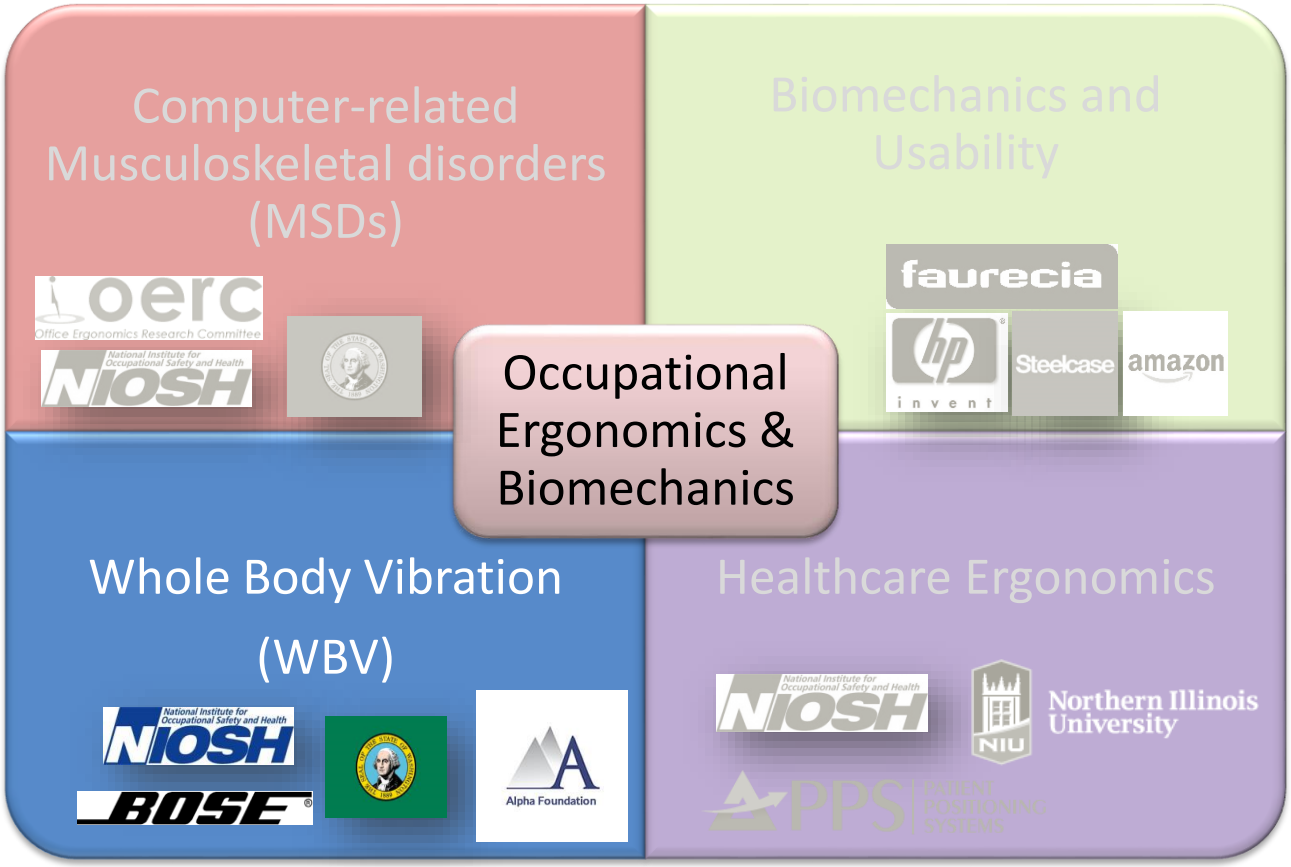
- Augment reality (AR) technology has recently gained public attention for its intuitive user interface.
- AR requires larger movements with lack of support (e.g. armrest) than conventional computer interface.
  - Therefore, they may increase risks for musculoskeletal fatigue/discomfort.
- There is a lack of information on:
  - Biomechanical exposures associated with AR interactions;
  - Ergonomic gestures and reach envelop for AR interactions.

Objectives

- Characterize the biomechanical stresses in the neck and the shoulder, subjective comfort, and usability during AR interactions, using:
  - Electromyography (EMG)
  - 3-D Optical Motion Capture System

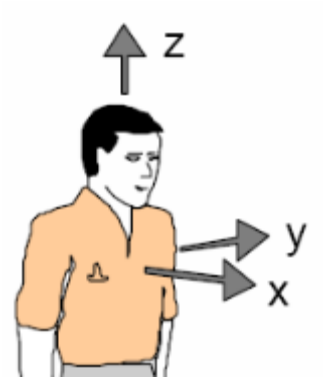


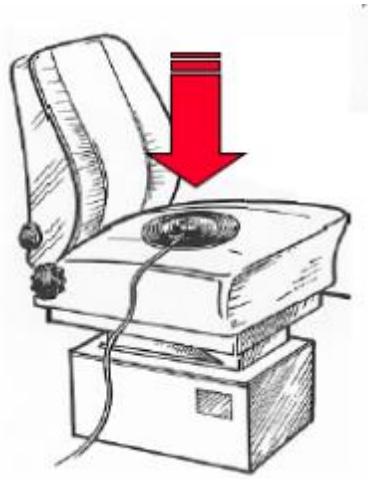
Occupational Ergonomics and Biomechanics Research Areas

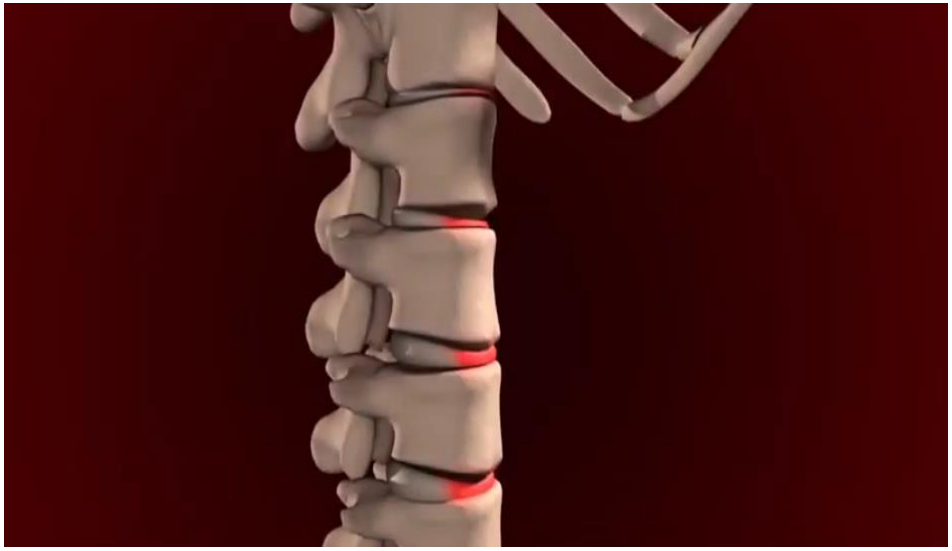


What Is Whole-Body Vibration?

- Objective measure to describe operator motion







https://www.youtube.com/watch?v=fFiBoIlHLKA

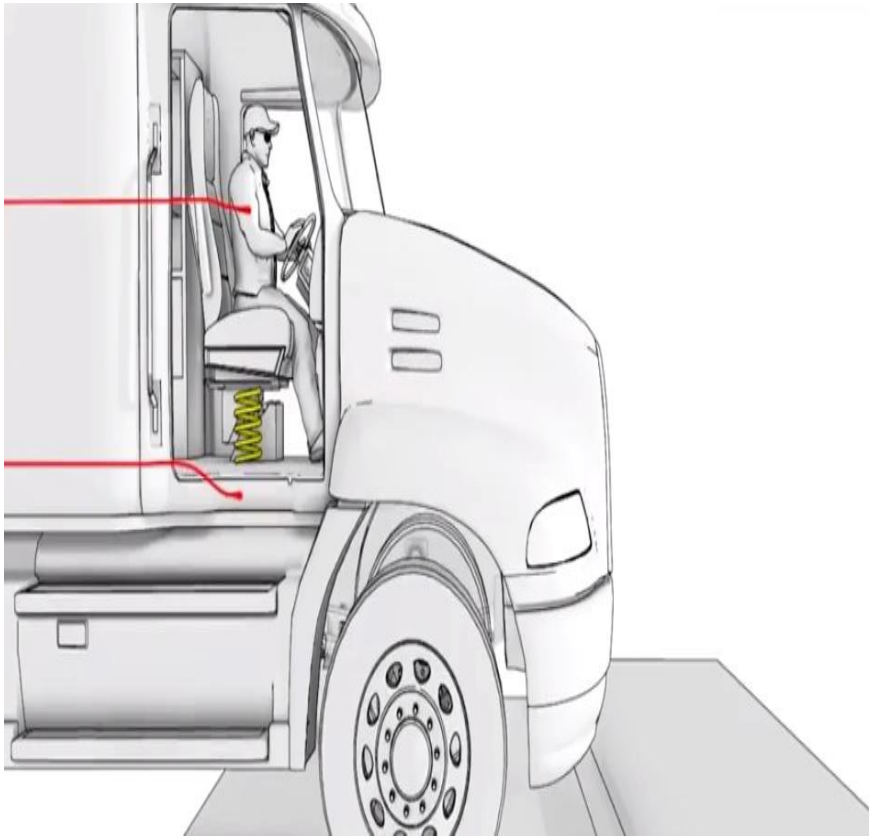
WBV and Low Back Pain Development

- High prevalence of back pain and injuries among professional drivers.
- Epidemiological studies have consistently demonstrated association between WBV exposures and musculoskeletal disorders in occupational drivers.

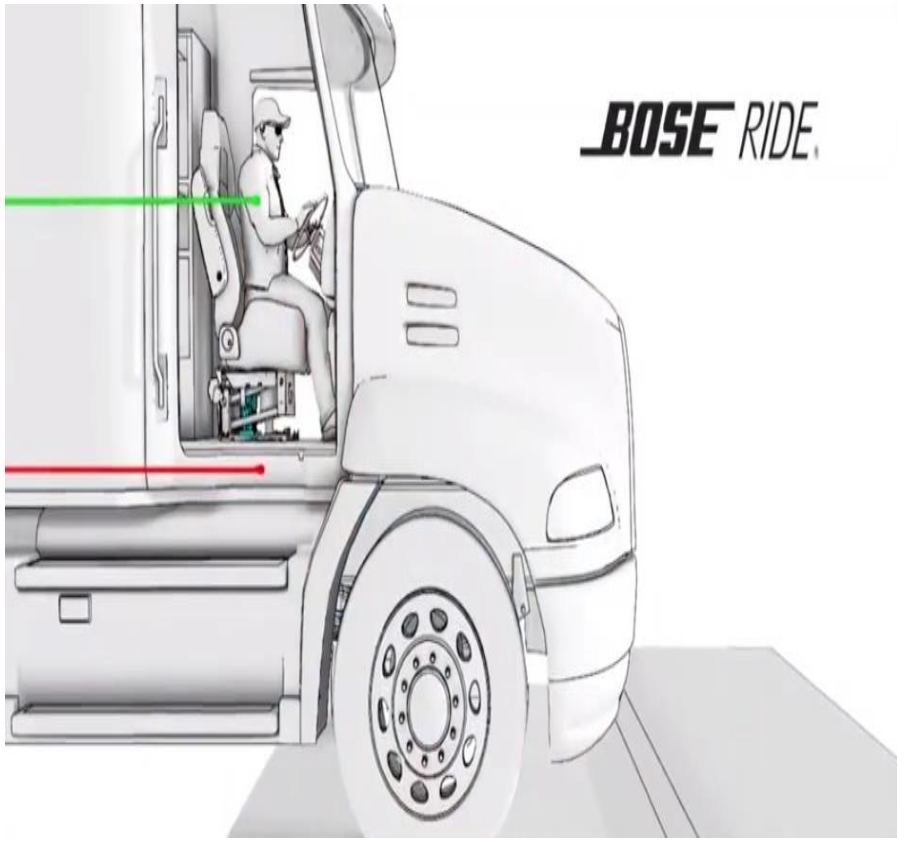
A RANDOMIZED CONTROLLED TRIAL OF WHOLE BODY VIBRATION INTERVENTION IN TRUCK DRIVERS

Oregon State University
University of Washington
Harvard University
Northestern University

Engineering Interventions

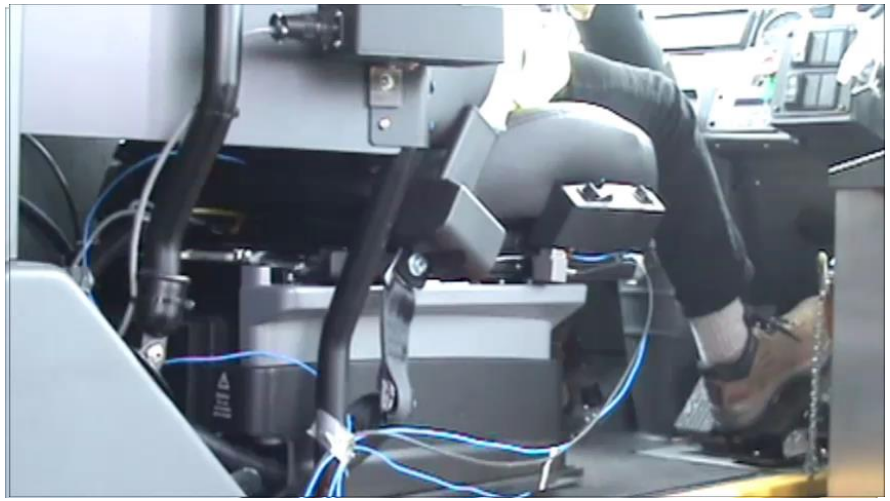


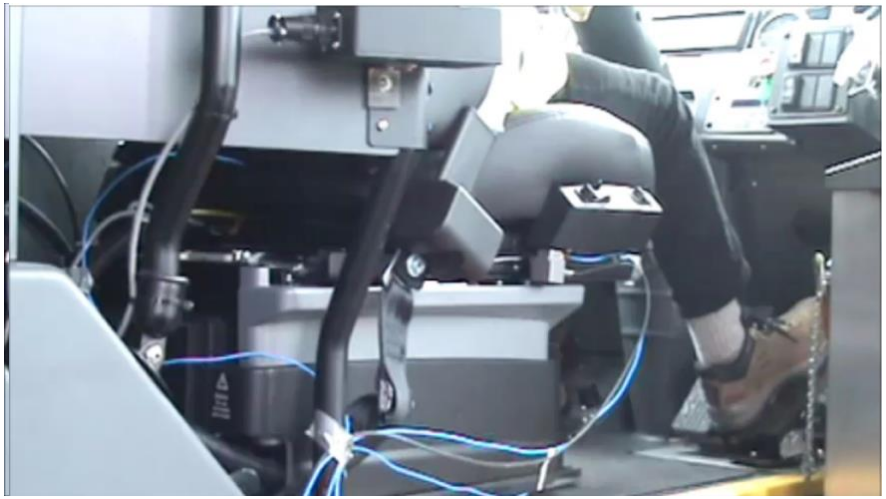
Air Suspension Seat



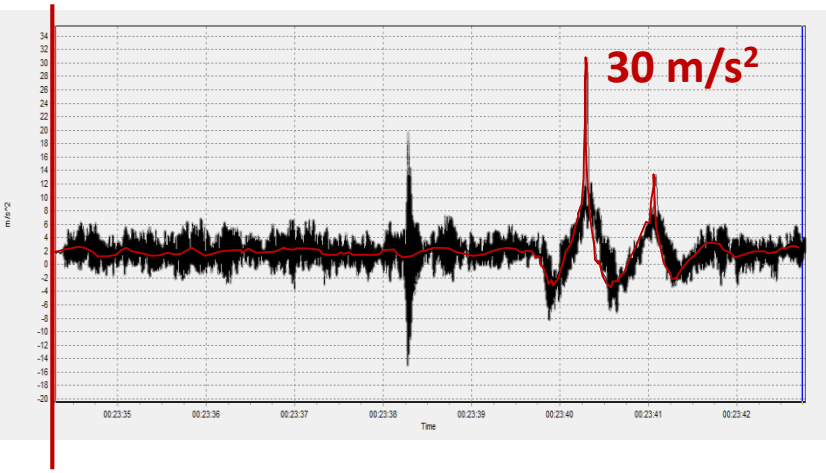
Active Suspension Seat

Engineering Interventions

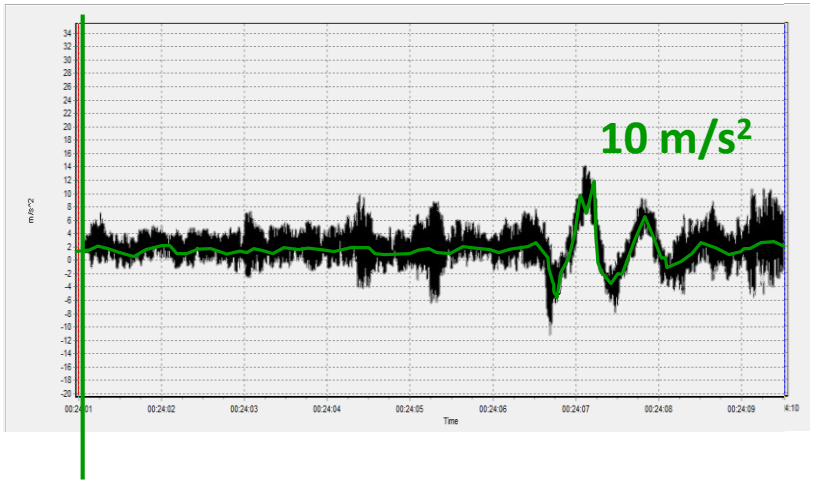




Air Suspension Seat



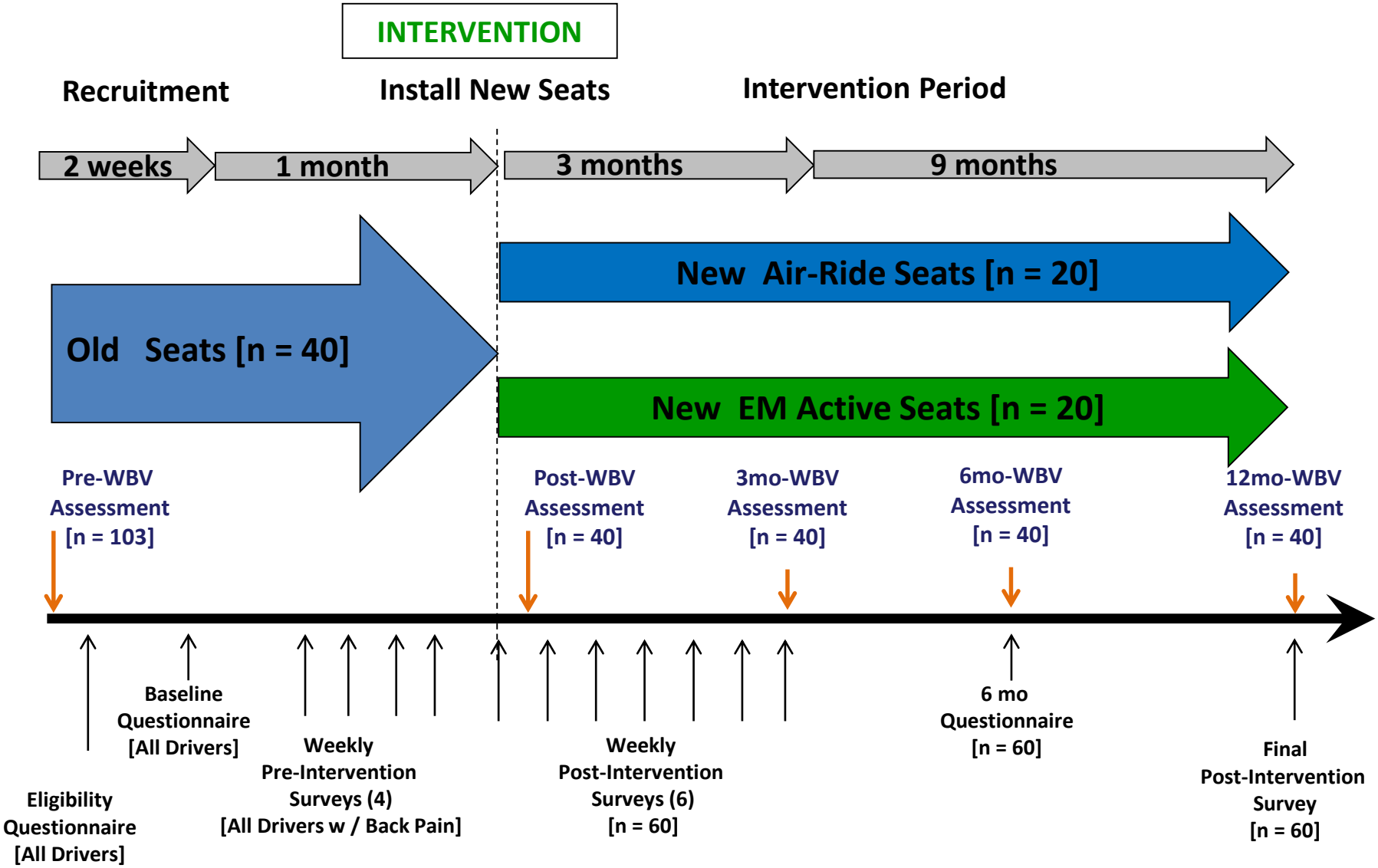
Active Suspension Seat



Objectives

- Evaluate and characterize occupational vibration exposure.
- Investigate the efficacy of the engineering intervention in reducing low back pain.

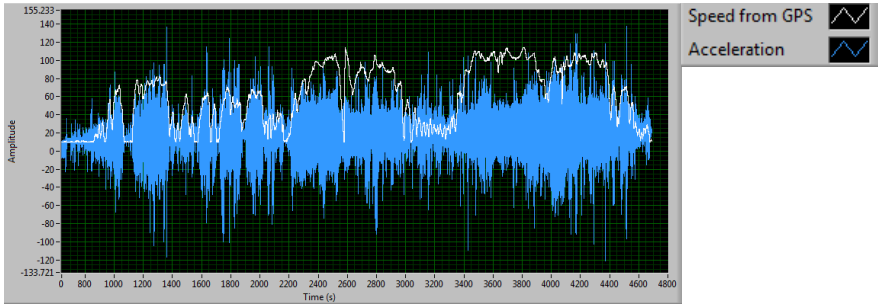
Study Overview



Methods

- **One-year Randomized Controlled Trial (RCT) with three study arms**
  - *20 drivers used industry standard, air-suspension seats (Placebo)*
  - *20 drivers used active suspension seats (Intervention)*
- **Collected back pain (last month and week) using a 10 point scale**
- **Collected 256 full day (6-24 hr) WBV exposures from truck seat and floor**
  - *7 WBV systems*
  - *Measured at seat and floor*
  - *WBV collected at 1280 Hz*
  - *GPS collected at 1 sample/sec*

- **Synchronized WBV exposures and GPS data using LabVIEW program floor**
  - *A(8), VDV(8), SEAT*



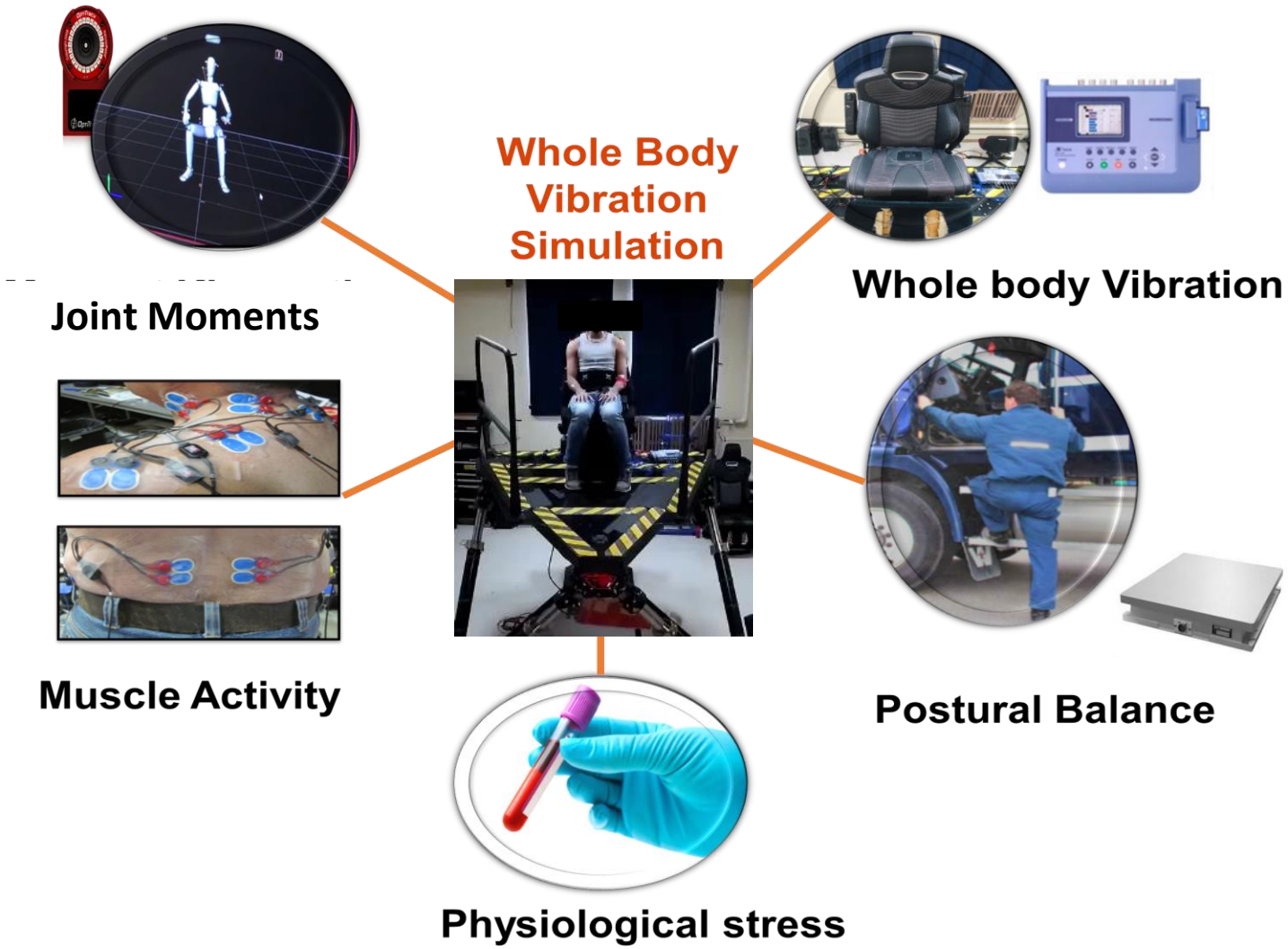
Summary

- New seats reduced WBV exposures.
- Active-suspension truck seat was more effective in reducing LBP.

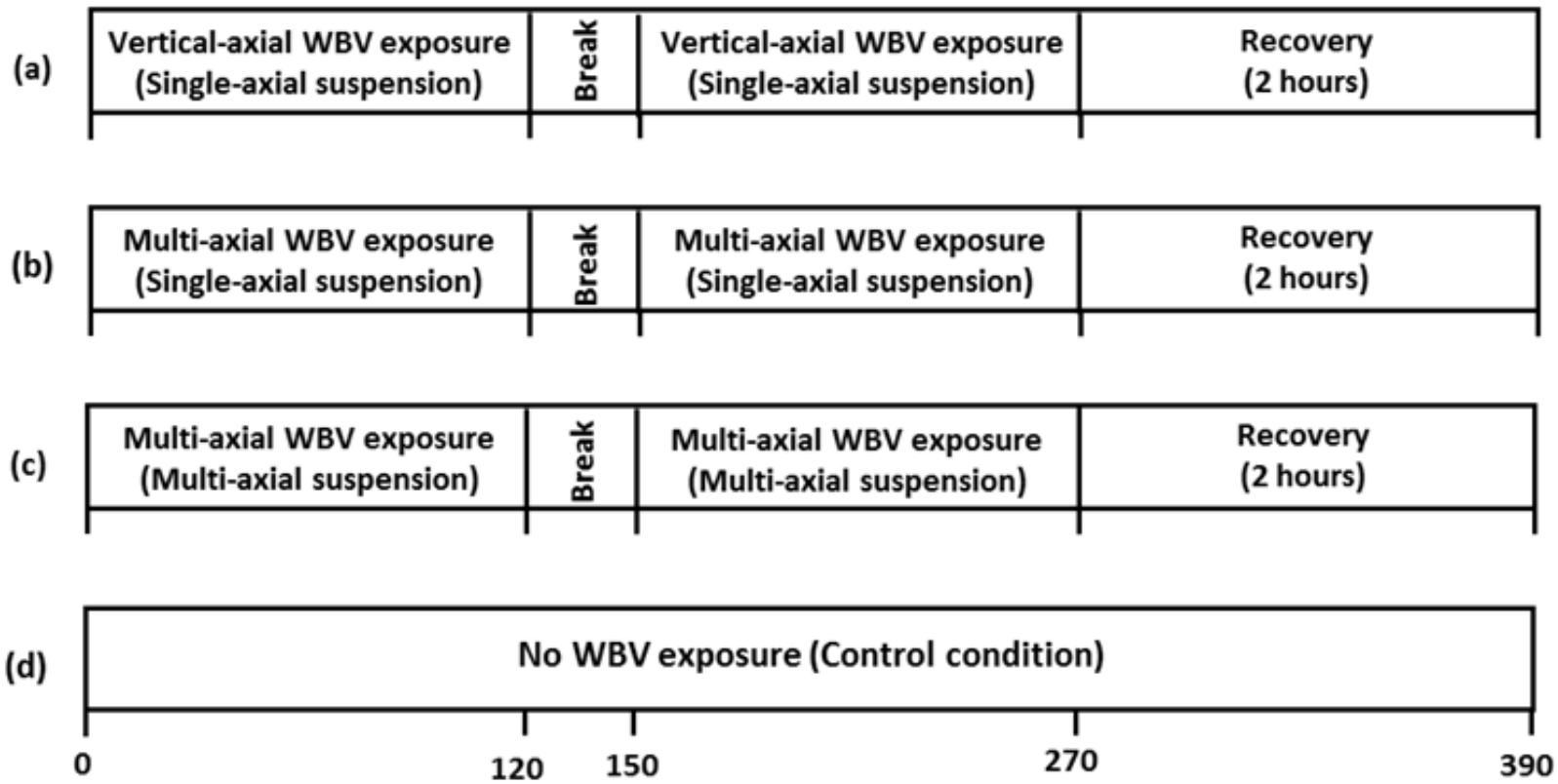
Field-Based Studies

- Great for showing association between exposure and response.
- But….
  - Causality
  - Underlying injury mechanisms

Lab-Based Studies



Experimental setup



EVALUATING BIOMECHANICAL MEASURES AND NON-DRIVING TASK PERFORMANCE WITH THREE DIFFERENT CAR SEAT SUSPENSION:
EVALUATION FOR AN AUTONOMOUS CAR APPLICATION

Oregon State University

UNIVERSITY of WASHINGTON

Motivation

- Whole body vibration (WBV) is an important physical exposure associated with various adverse health outcomes.
- The BoseRide® active suspension seat has been shown to effectively reduce WBV exposures.
- Autonomous vehicles will allow drivers to perform non-driving activities such as computer work; as a result, there may be even greater demands for enhanced ride quality.

Objectives

- Test three seat suspensions for use in autonomous cars
  - Vertical Active Suspension Seat
  - Multi-Axial Active Suspension
  - No suspension (no air in suspension - to simulate a conventional car seat)

- Determine whether there are differences between different suspension settings in terms of:
  - WBV exposures
  - Muscle activities in neck, shoulder, and low back regions
  - Performance of standardized non-driving tasks
    - Omni-directional pointing task
    - Typing task
    - Web-browsing task
    - Reading task
  - Subjective fatigue/discomfort
  - Usability/Subjective Performance

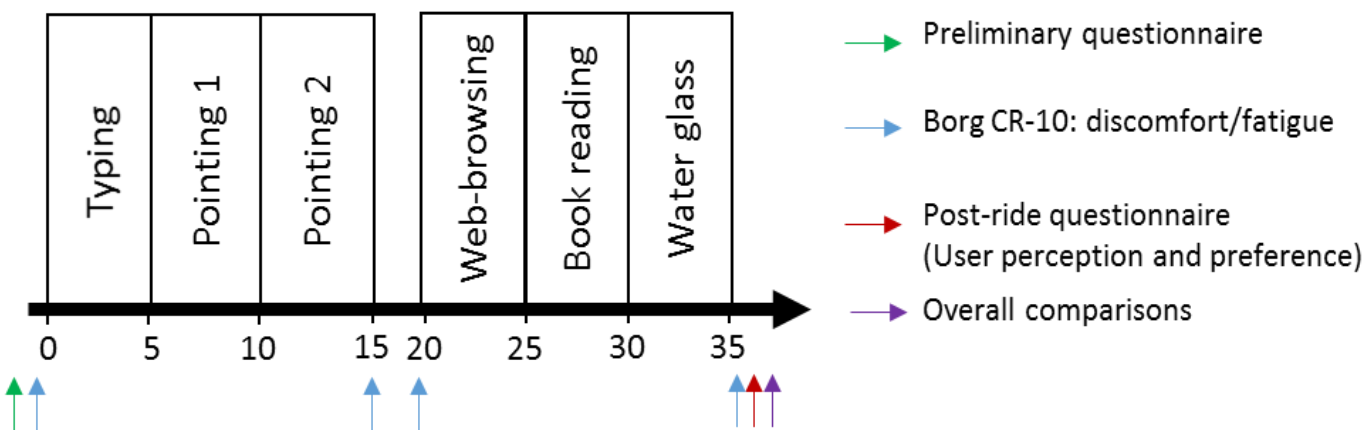
Experimental Methods

- Subjects
  - 18 adult subjects (9 females and 9 males)
  - Age (Mean ± SD): 27.5 ± 7.6 years old
  - Driving experience (Mean ± SD): 10.4 ± 8.2 years

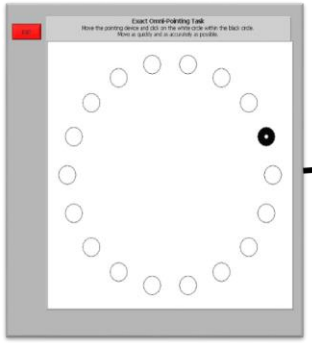
- Variables
  - WBV exposure measures [A(8) , VDV(8)]
  - Muscle activity (Electromyography - EMG)
  - Non-driving task performance
  - Subjective discomfort and preference

Study Design

- Repeated Measures Design
- Three different suspension settings
  - Vertical Active (BoseRide)
  - Multi-axial Active (Cradle 2.0)
  - No suspension
- Seat order randomized



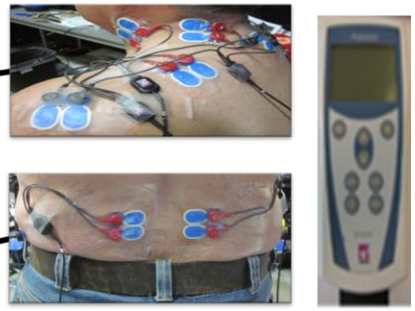
Experiment Setup



Omni-directional Pointing

Typing

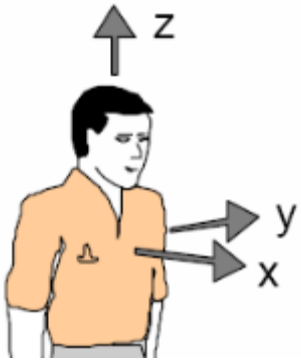
6 DOF Motion Platform



Muscle Activity

Whole Body Vibration

Summary



- WBV
  - The active suspension seats reduced Z-axis A(8) average continuous and VDV(8) impulsive exposures compared the no suspension seat.
  - The multi-axial active seat reduced Y-axis VDV(8) impulsive exposures relative to the two other seats.
- Muscle Activity (EMG)
  - No substantial differences in muscle activity were found across the three seats.
  - Muscle activity with the Multi-axial Active seat was lower in neck on the left side and peak muscle activity was lower on the right side of the low back.

Summary

- Performance of non-driving tasks
  - Tablet pointing task performance was better with the multi-axial active seat.
  - However, in general, no significant differences in performance measures were found across the seats.
- Subjective measures
  - Perceived performance measures of computer work were higher on the multi-axial active seat than the other seats.
  - Limited between-seat differences were found in perceived comfort ratings.
    - However, the comfort ratings tended to be slightly higher on two active seats compared to no suspension seat.

Thank You!

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