TRANSMISSION OF ACCELERATION FROM VIBRATING EXERCISE PLATFORMS TO THE LUMBAR SPINE AND HEAD

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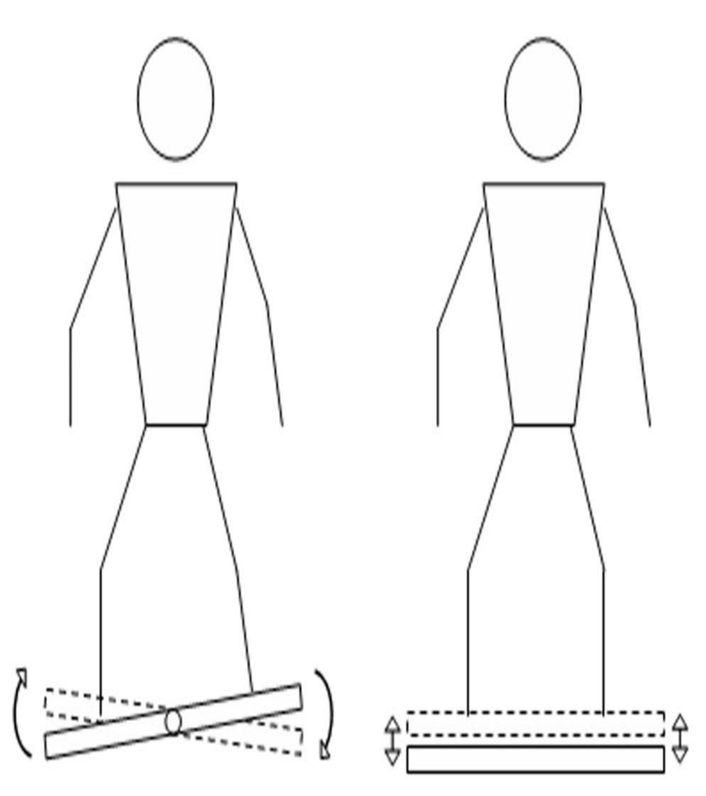
Occupational Exposure to Whole Body Vibration

- People experience various types of whole body vibration in daily life including…
- Vehicles (trucks, helicopters, subways)
- Machinery (industry and agriculture)
- Industrial (mining, forestry,)

Vibrating Platforms



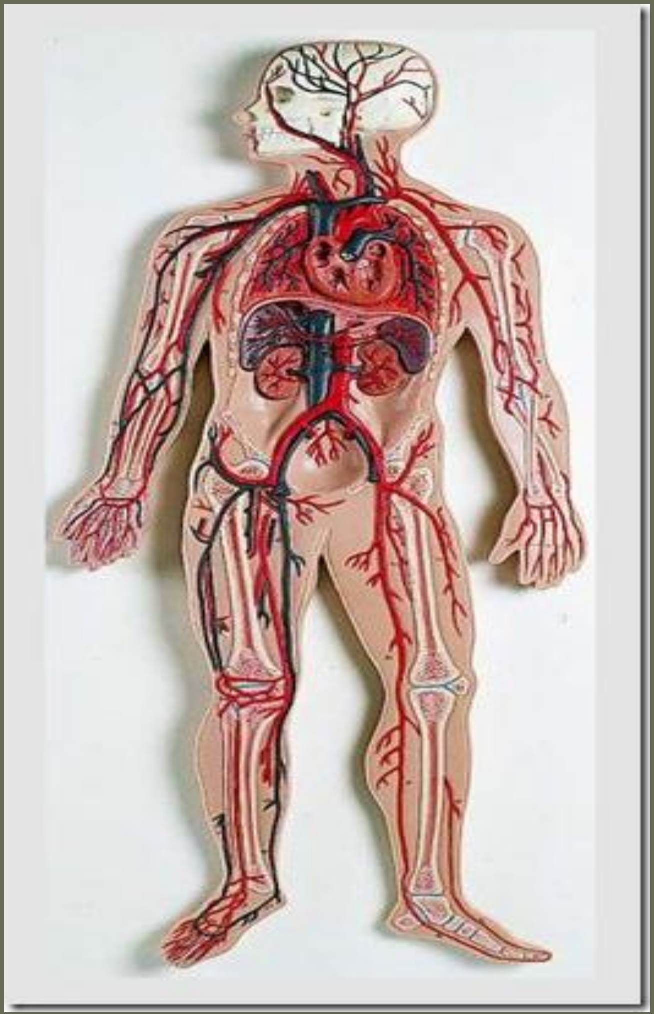
a)Reciprocating b) Vertical

- **The intensity of a vibration intervention is determined by manipulating…**
  - **Amplitude (0.5 – 10mm)**
  - **Frequency (15 – 50Hz)**
  - **Duration of Exposure vs. Rest Time**

Acceleration magnitudes range from 0.5 to 15 g

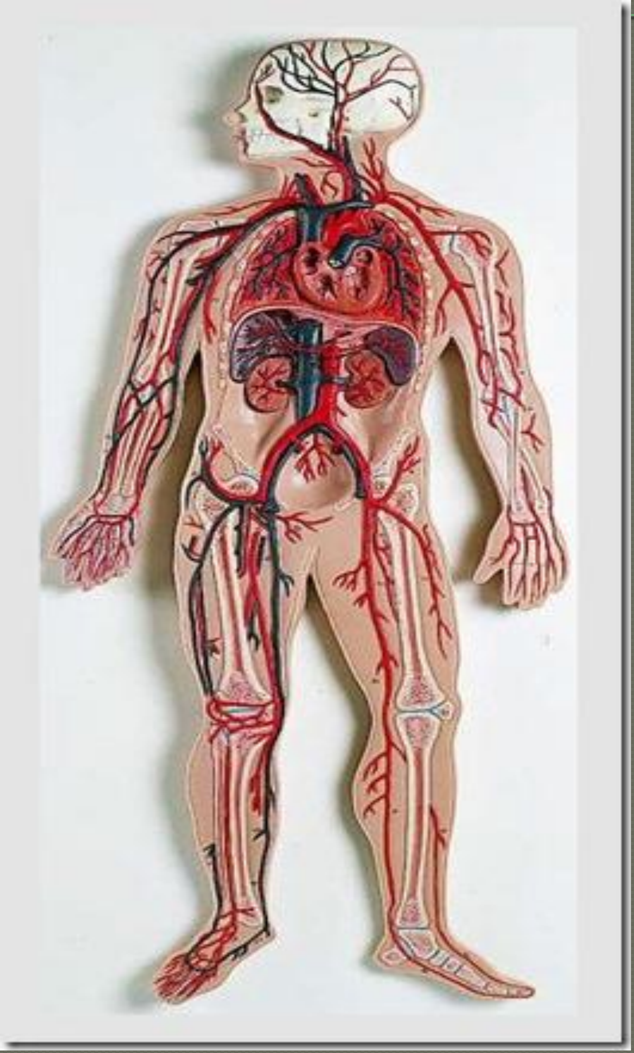
(Cardinale, M., Bosco, C. 2003)

Whole Body Vibration as an Exercise Intervention



- **Improvements in muscular strength and power** (Delecluse, C. et al. 2003. Roelants, M. et al. 2004)
- **Increased Neuromuscular Recruitment** (Abercromby A.F.J. et al. 2007)
- **Increased bone density in animal subjects** (Rubin C. et al. 2001)
- **Decreased risk of falls in the elderly** (Bruyere, O. et al. 2005)

WBV Exposure and Health Effects

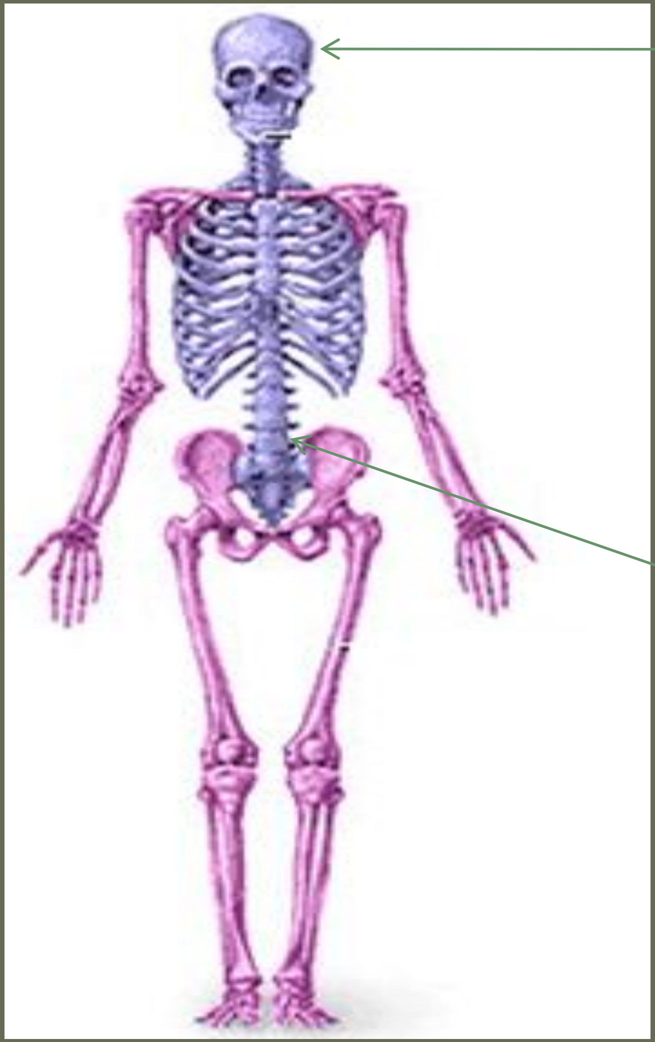


WBV exposure can have negative side effects…

- Musculoskeletal system
- Digestive system
- Reproductive system
- Vestibular system
- Visual system

(Seidel, H. 2001)

WBV Exposure and Health Effects



- **Head**
  - hearing loss
  - headaches
  - visual impairment
  - vestibular damage

(Griffin 1990, Seidel H 2001)

- **Lumbar spine**
  - Increases disc compression
  - Accelerates osteoarthritis and disc degeneration

(Magid et al. 1960 Dupuis and Zerlett, 1987, Pope et al. 1994)

Variation in transmissibility of acceleration could be caused by postural changes

(Griffin 1990)

Muscles' Role in Vibration Energy Dissipation

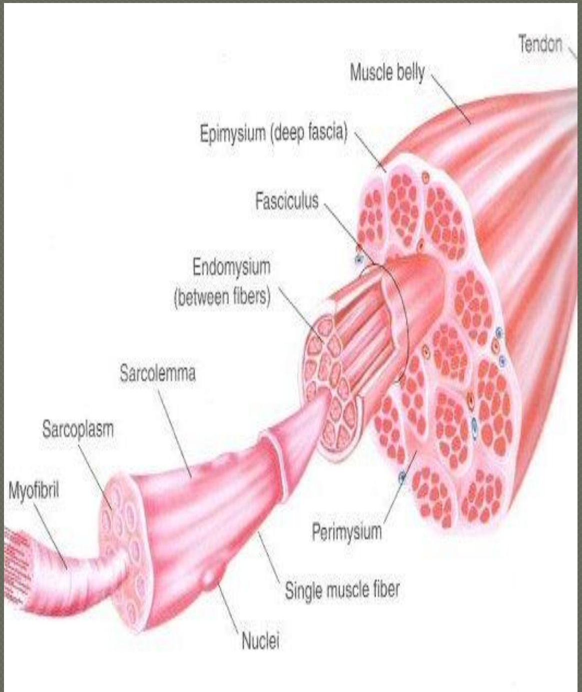


Figure 1: Muscle belly split into various component parts (from Essentials of Strength Training & Conditioning, National Strength & Conditioning Association)

Muscles have great potential to absorb and attenuate energy

- Increased muscle activation during continuous vibration stimulus (Abercromby A.F.J 2007)
- Increased knee angle at impact is highly effective at shock attenuation in the 5-60Hz frequency bandwidth. (Lafortune M.A. et al 1996)

Study Objectives

1) Quantify the accelerations experienced by the axial skeleton during standing vibration between 20 – 50Hz

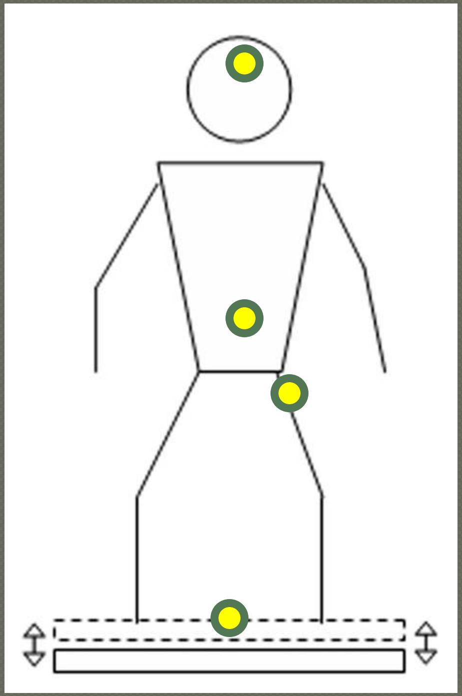
2) Investigate which knee angles effectively dampen vibration to the upper body

3) Evaluate whether ISO standards for evaluating WBV are appropriate when measuring standing vibration.

WAVE Whole Body Vibration

Instrumentation

- **Four triaxial accelerometers**
  - Forehead
  - 5th Lumbar Vertebrae
  - Greater Trochanter
  - Platform



- **Electrogoniometer**
  - Right tibiofemoral joint

- **All data sampled at 1024Hz**

Study Design

Recreationally Active Male and Female Subjects

↓

<u>Static or Dynamic Squat</u>
30 second trials

↓

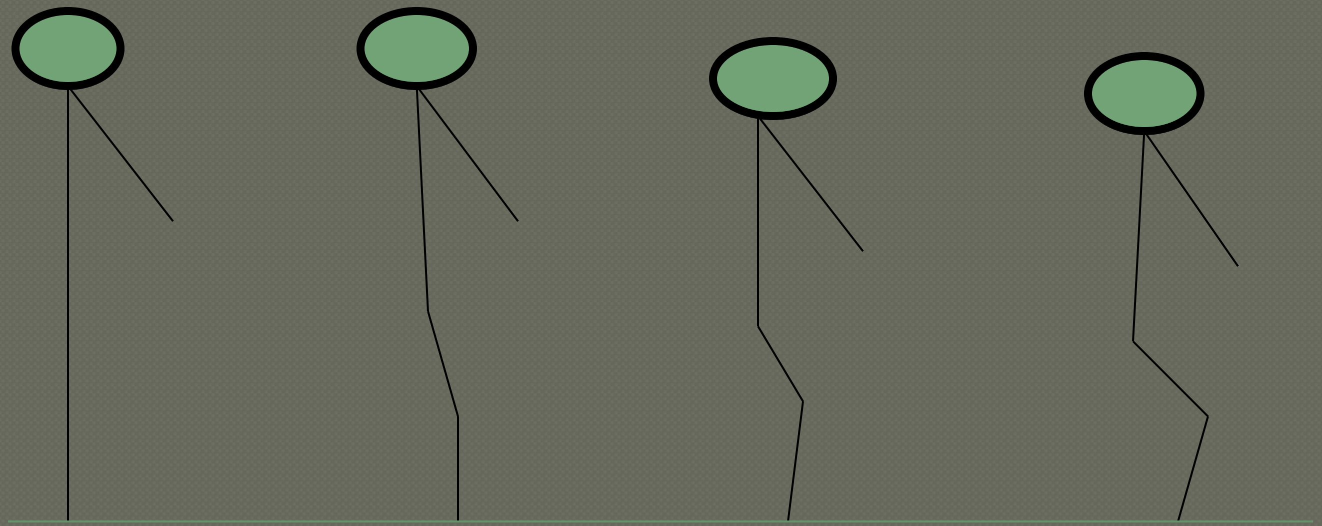
<u>RMS Acceleration (m/s/s)</u>
4.90, 8.80, 13.70, 25.0, 32.0

↓

<u>Posture Conditions</u>
0, 20, 40, 60 degrees

- Trials were randomized to account for confounding factors such as fatigue and subject adaptation
- Each subject completed a trial of either static or dynamic squats
- Dynamic trials completed 3 repetitions controlled with a metronome

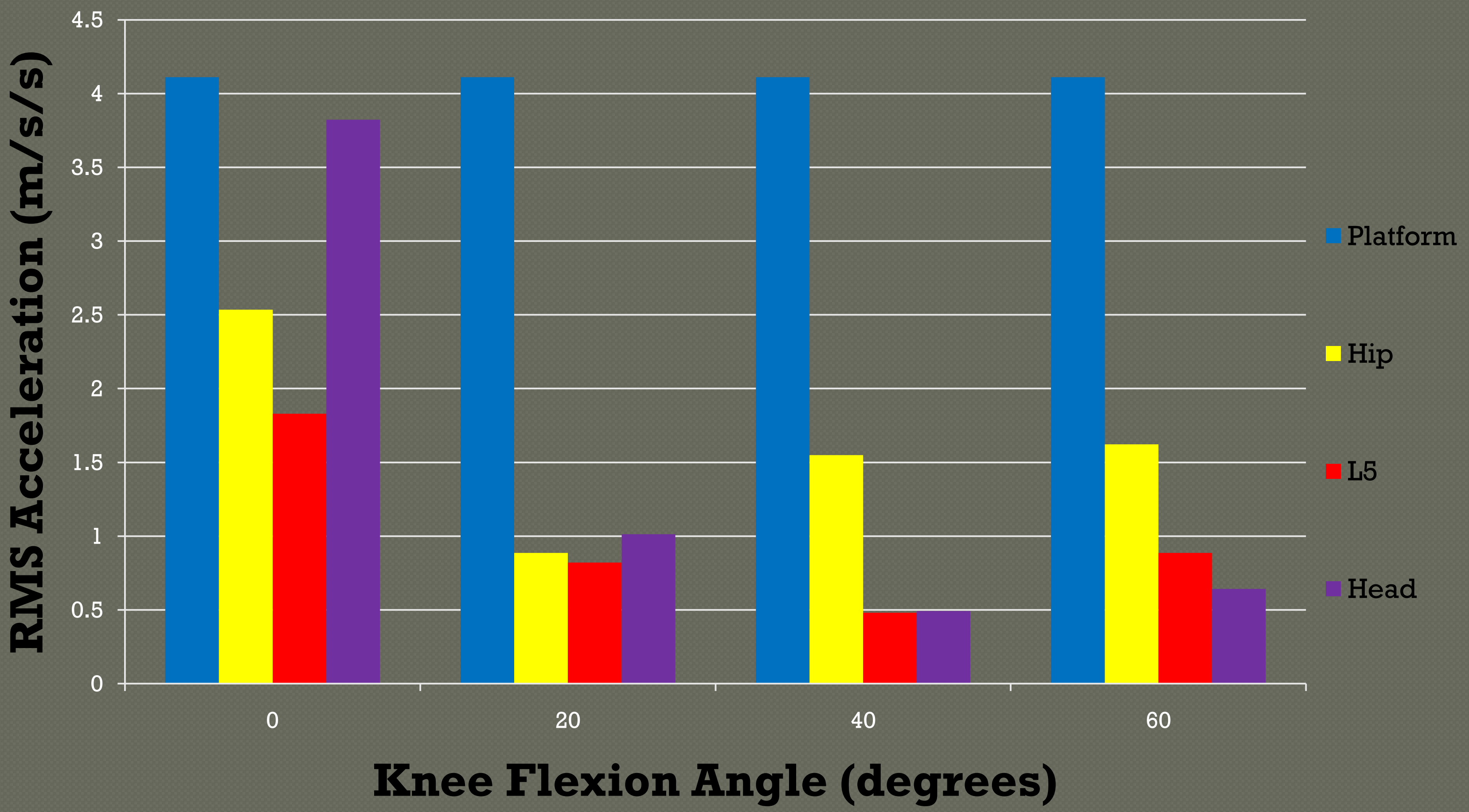
Posture Conditions



0^0 20^0 40^0 60^0

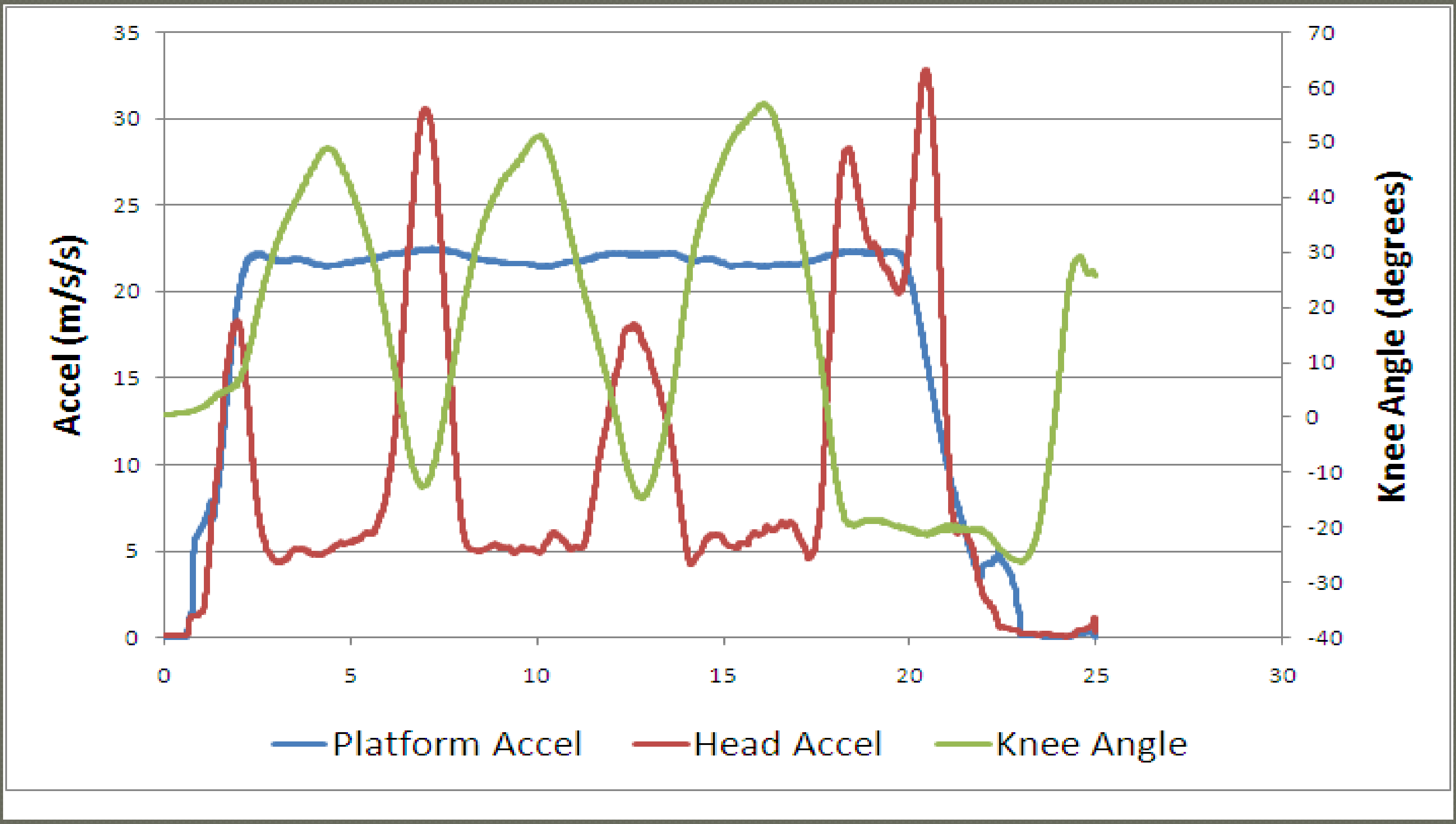
Knee Flexion Angle (degrees)

Preliminary Results

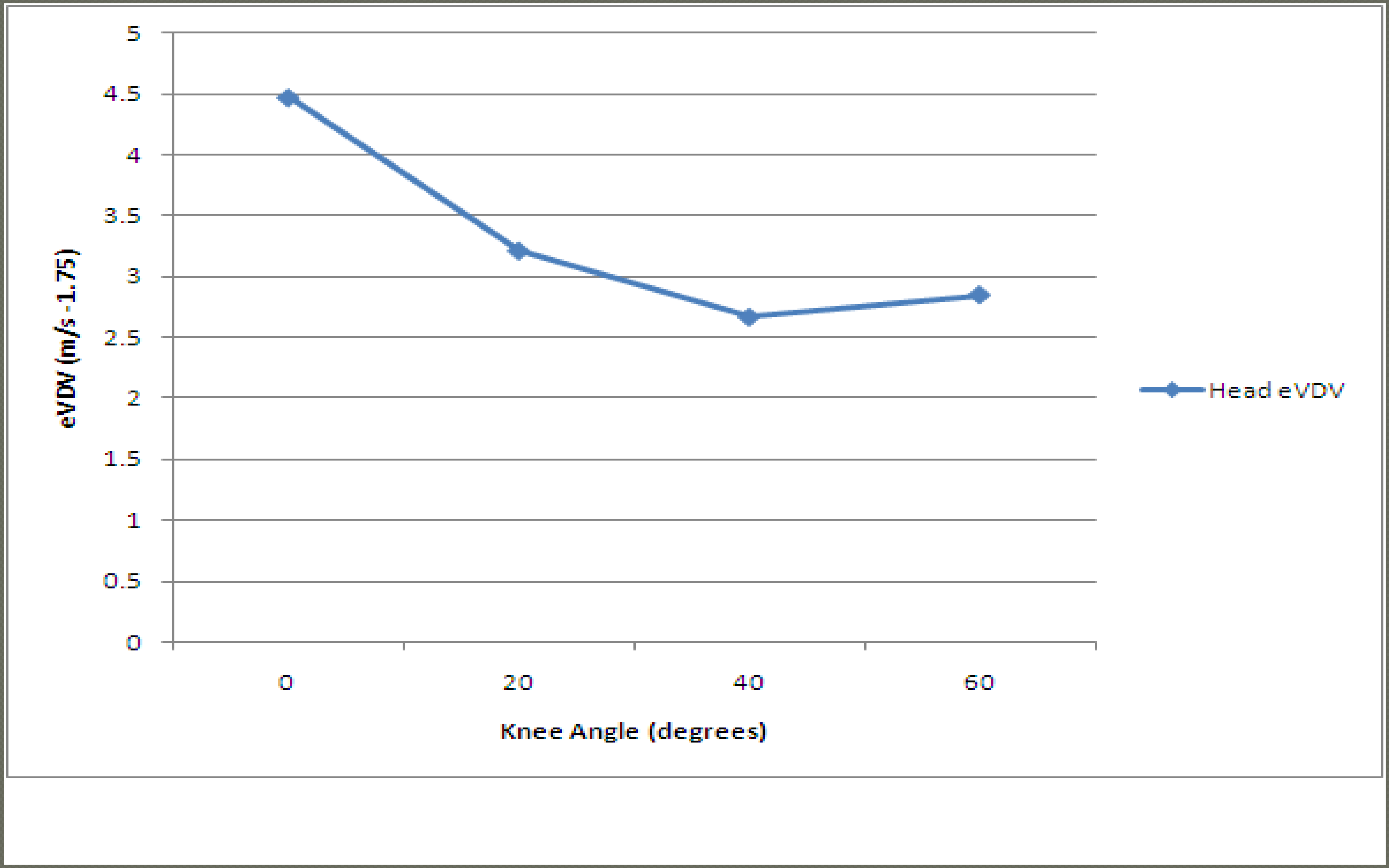


Data shown for one subject

Preliminary Results



Preliminary Results



Preliminary Conclusions

- Joint actions (knee flexion) serve to absorb shock wave energy
- In an extended position the knee extensor muscles cannot absorb energy; vibration is left unattenuated to pass onto the trunk and head
- ISO standards do not appear to be an appropriate tool for evaluating foot to head WBV exposure.

Future Directions

- Acceleration measurements taken on the skin may not accurately represent those at the bone. Currently we are investigating methods to correct this.

Acknowledgments

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