From Research to Practice: Evidence-backed Insights For Implementing Markerless Motion Capture Technology for Ergonomics Assessments

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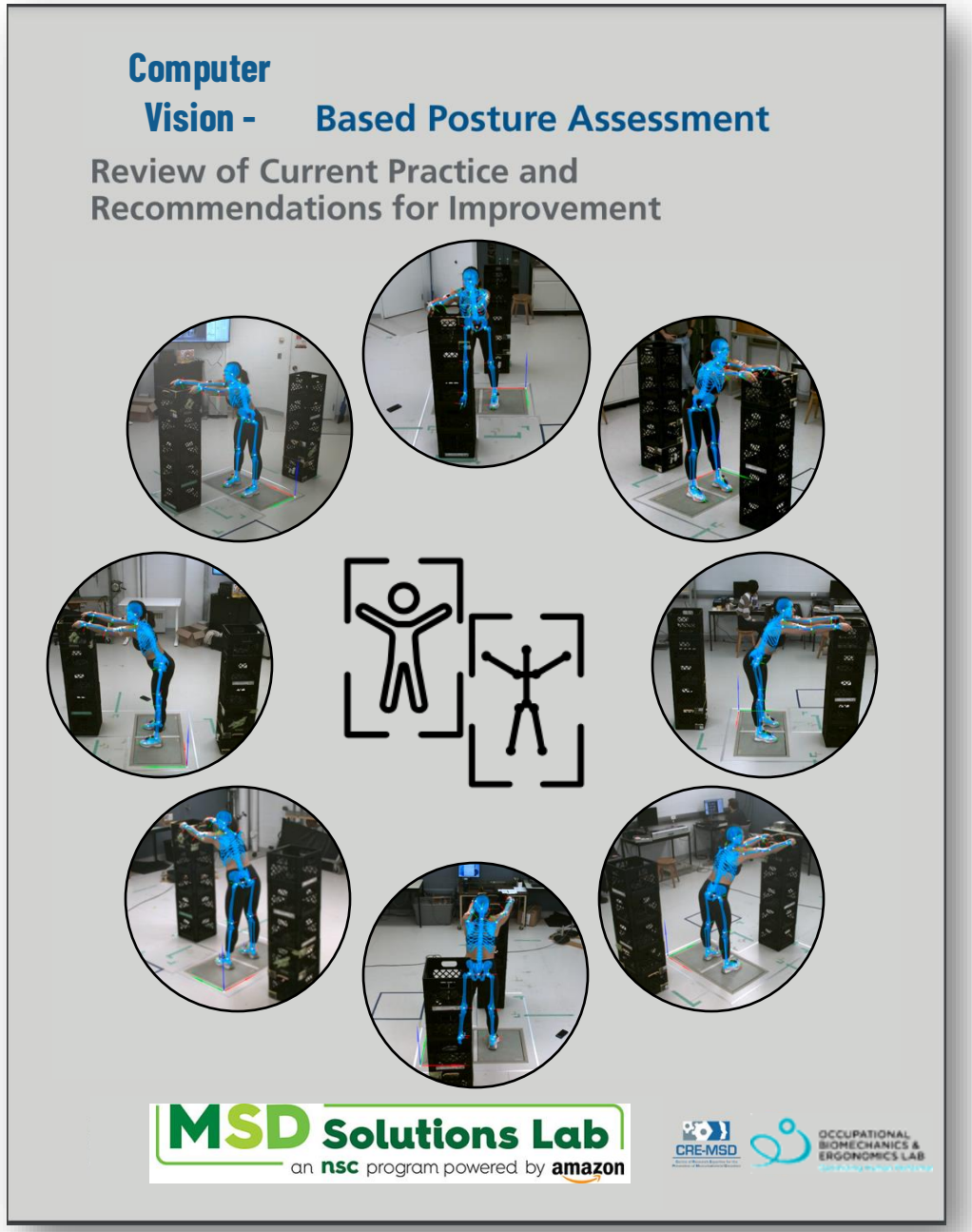

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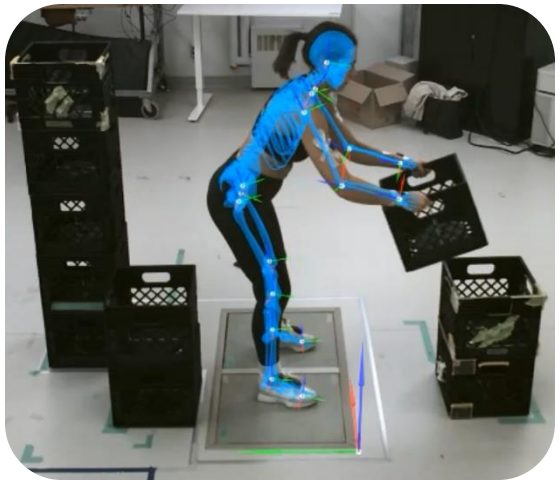
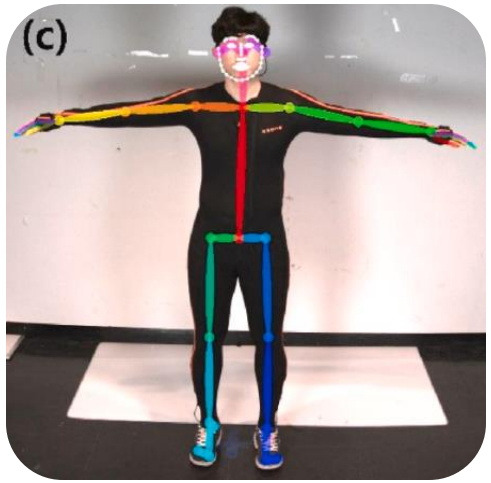
Markerless Mocap & Computer Vision

- Technological & machine learning advancements enabling identification of key points of human body from RGB images
- 3D human pose estimated from multi-view or single-view images/videos

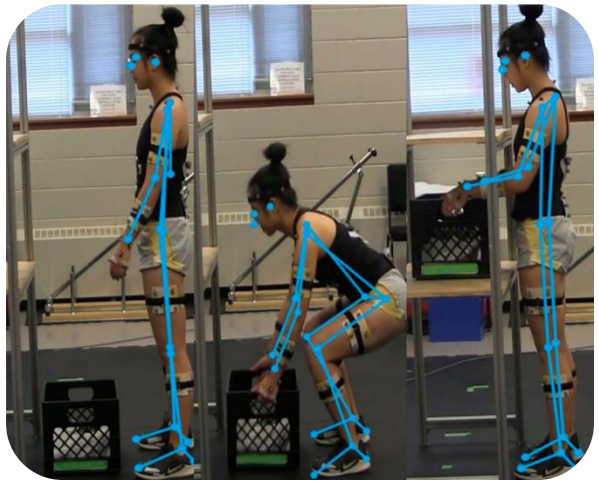
Multi-view Methods





Adapted from Kim et al., 2021

Single-view Methods

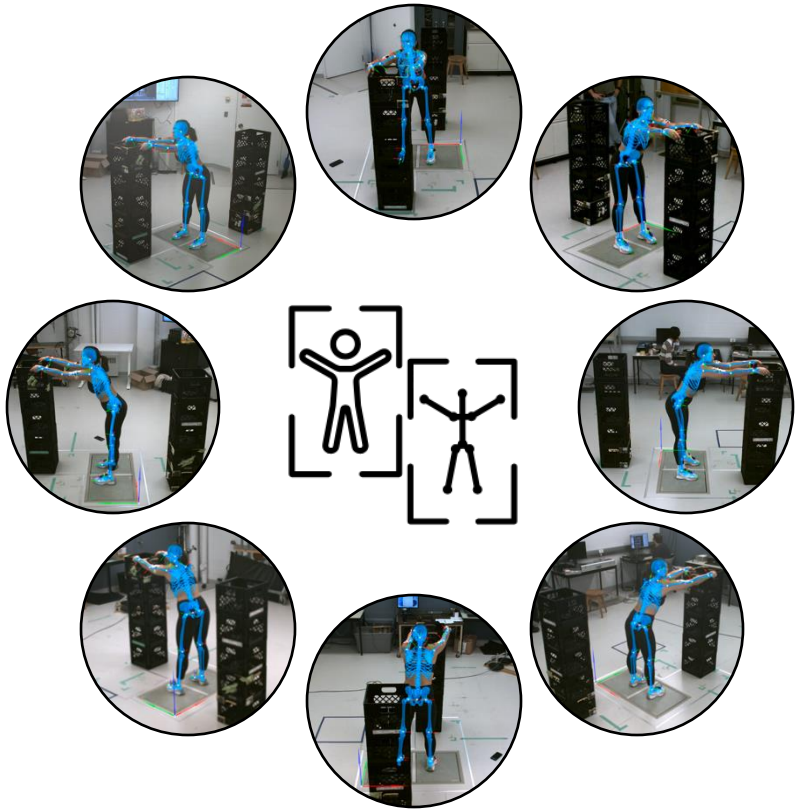


Adapted from Remedios & Fischer, 2021

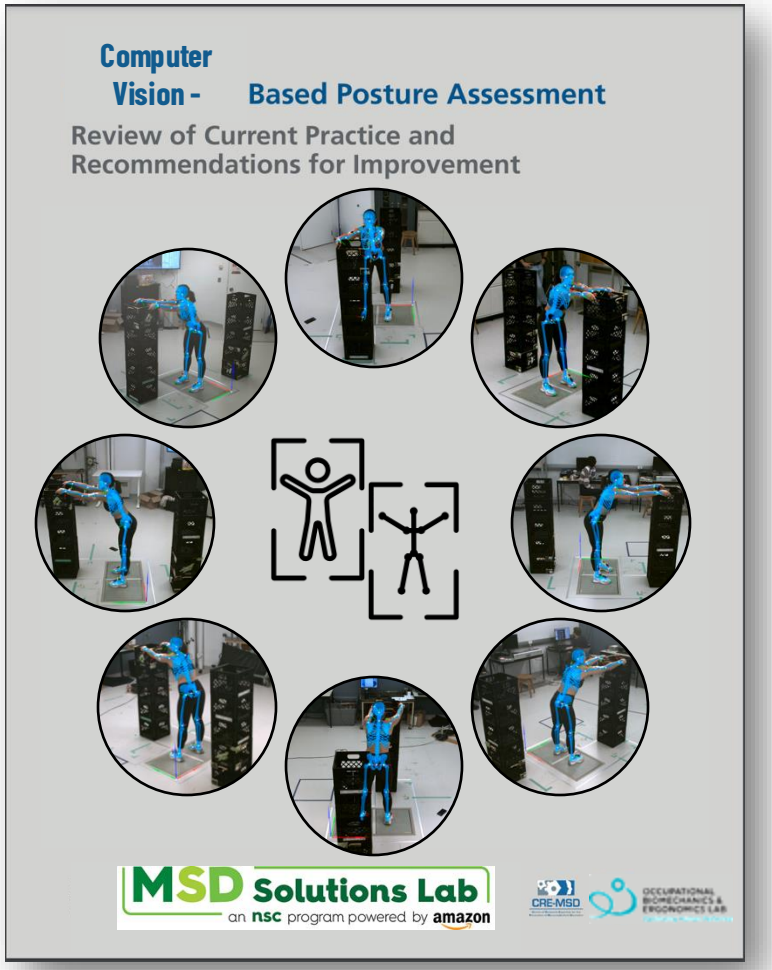
Adapted from Paudel et al., 2022

Computer Vision – novel technology to assess MSD risks

- Rapid emergence of computer vision-based MSD assessment tools
- Many questions surrounding best practices for using these technologies
  - Is there an optimal viewing angle improved for pose accuracy?
  - What if I need to film the same job at 2 or more plants but can't film from the same viewing angle at all plants?
  - Does speed of motion influence image blur and therefore pose accuracy?
  - Do outputs differ depending on the pose estimator approach?



Developing Guidelines & Best Practices for Users



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AMONG HEALTHY, ABLE-BODIED INDIVIDUALS PERFORMING A SERIES OF SIMULATED OCCUPATIONAL TASKS, DOES:

- the angle of video recording,
- the task pace, or
- the computer vision approach

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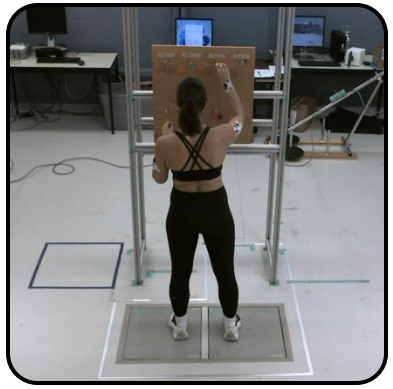
influence estimated **trunk or shoulder elevation angles** relative to angles estimated using a lab grade motion capture approach.

Participants & Tasks

- 40 participants (20 M, 20 F)
- 6 different tasks
- Fast & Slow speeds

Above Shoulder Work



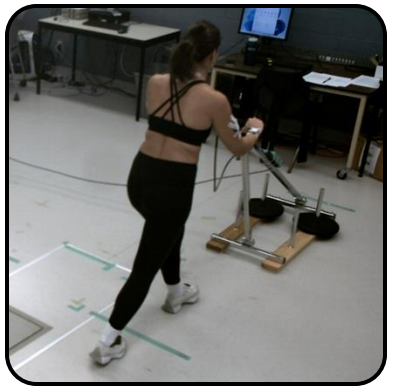
Cutting/Trimming

Packaging

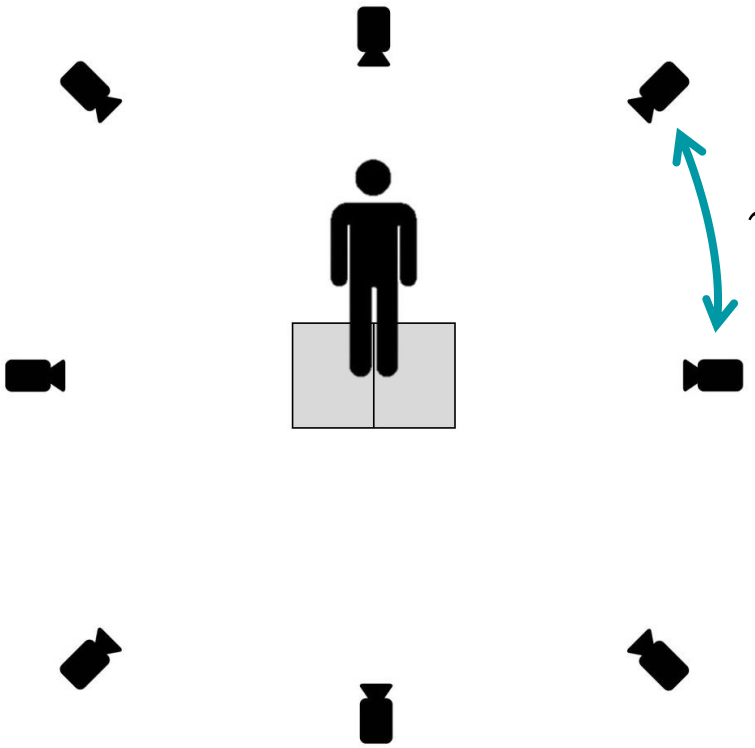
Floor-Shoulder Lift

Palletizing

Cart Push/Pull



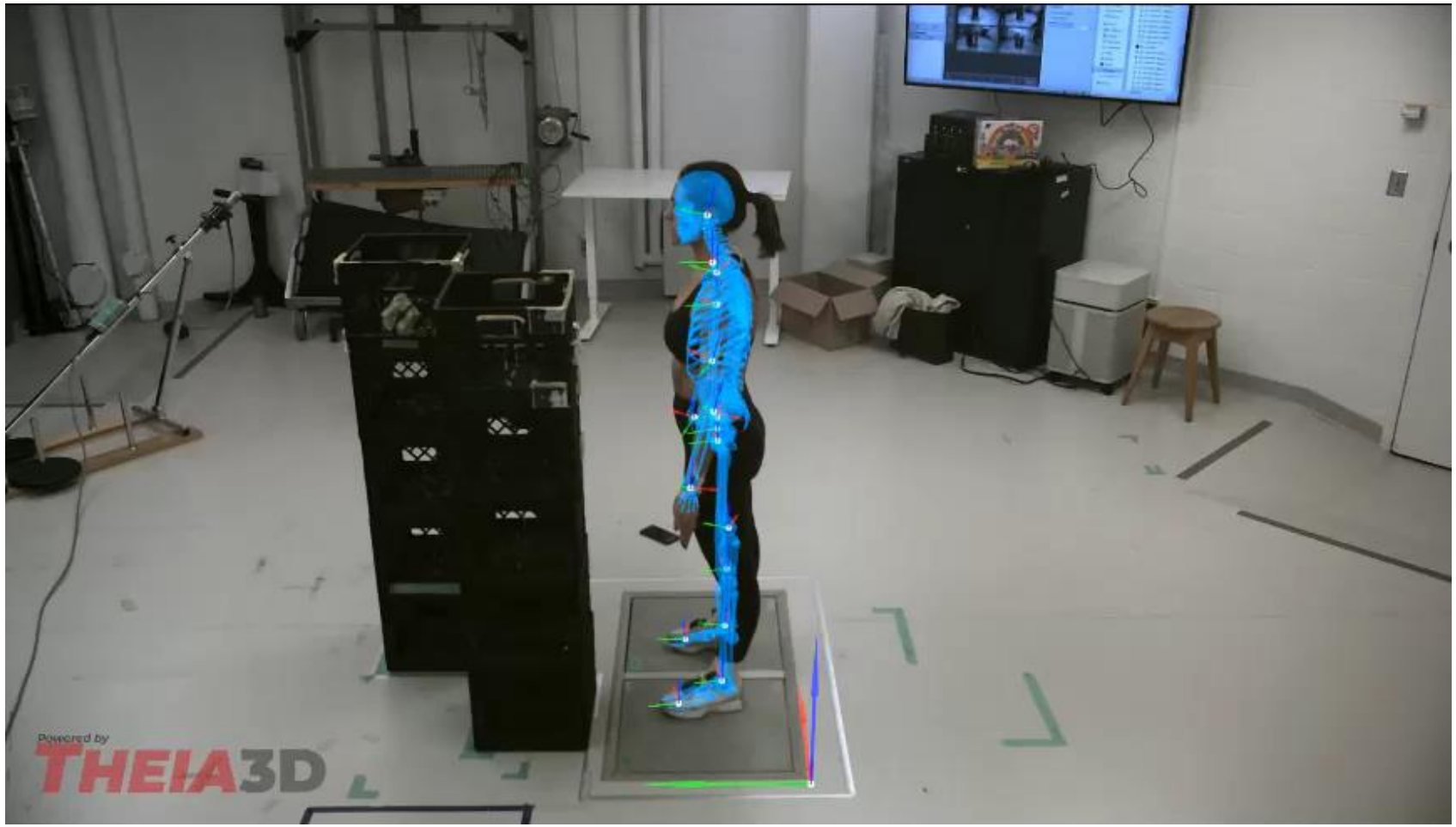
8 Cameras Capturing Synchronized Videos



~45° increments

Data
Pre-processing

Palletizing Example (Theia Skeletal Overlay)



Single Camera Pose Estimated Data

- Each video is processed through 4-5 separate pose estimators

Image/Video Removed Due to Data Sharing Agreements

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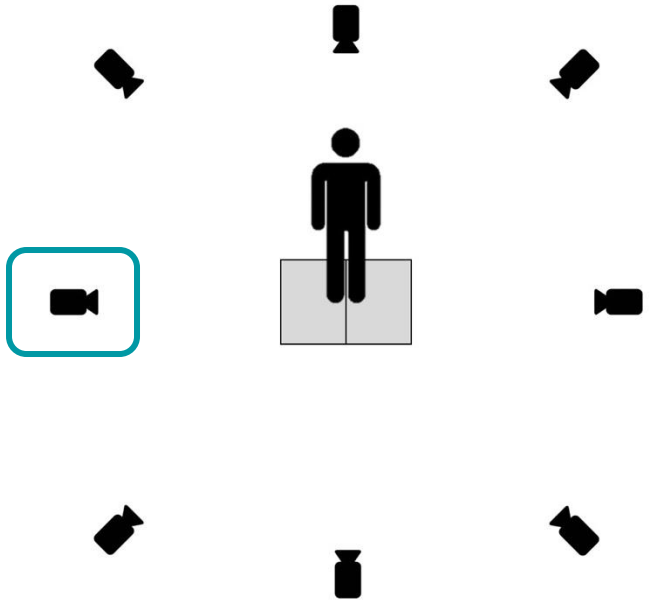
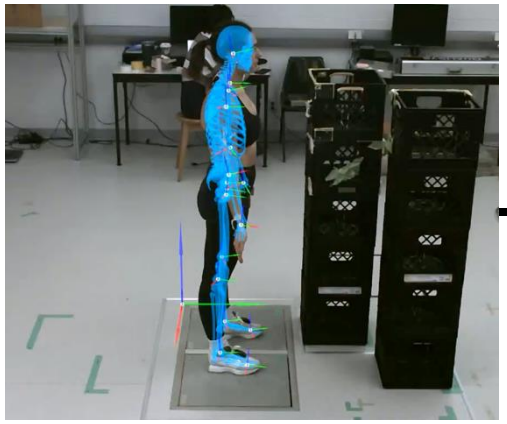
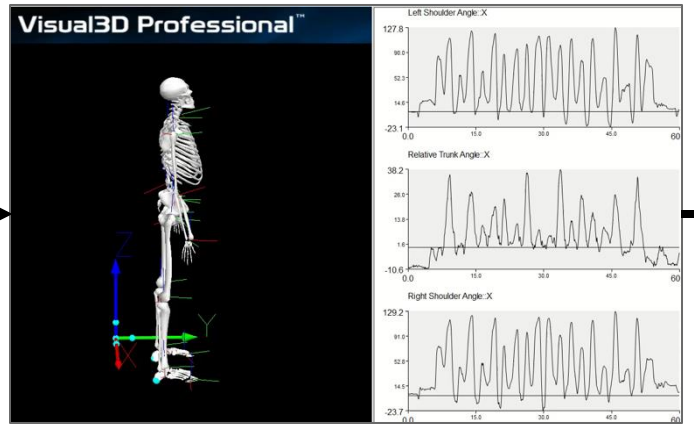
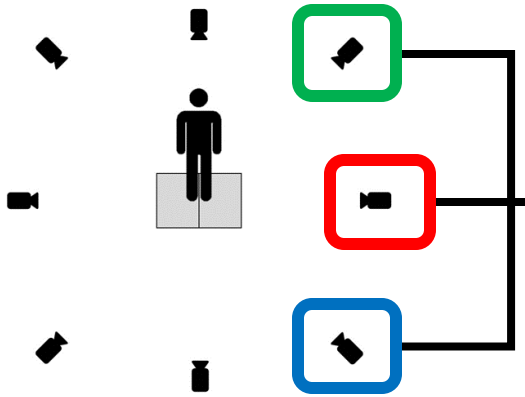


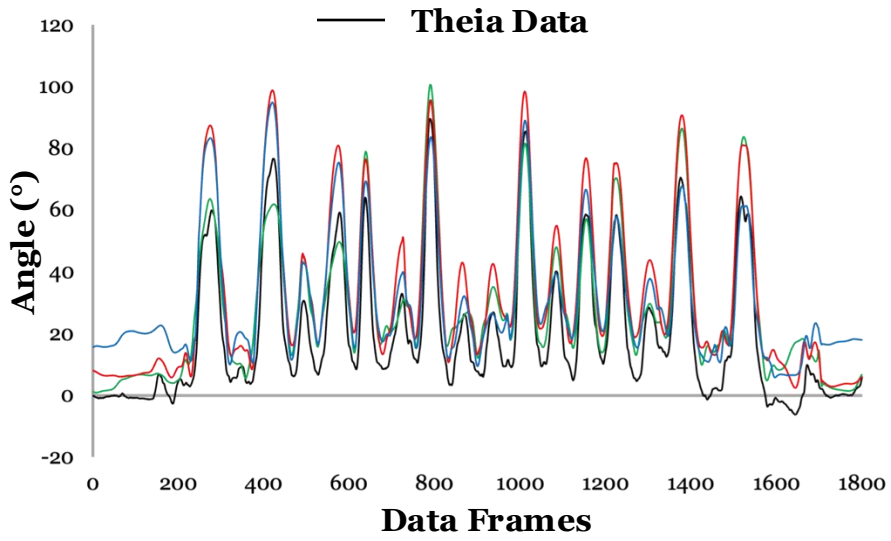
Extract Shoulder Elevation & Trunk Angles → Compare Data







Pose Estimation Data



$$\text{RMSD} = \sqrt{\sum_{i=1}^{n} \frac{(\hat{y}_i - y_i)^2}{n}}$$

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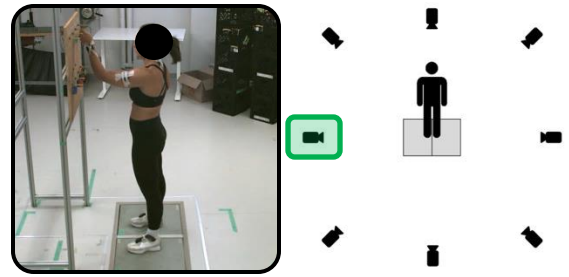
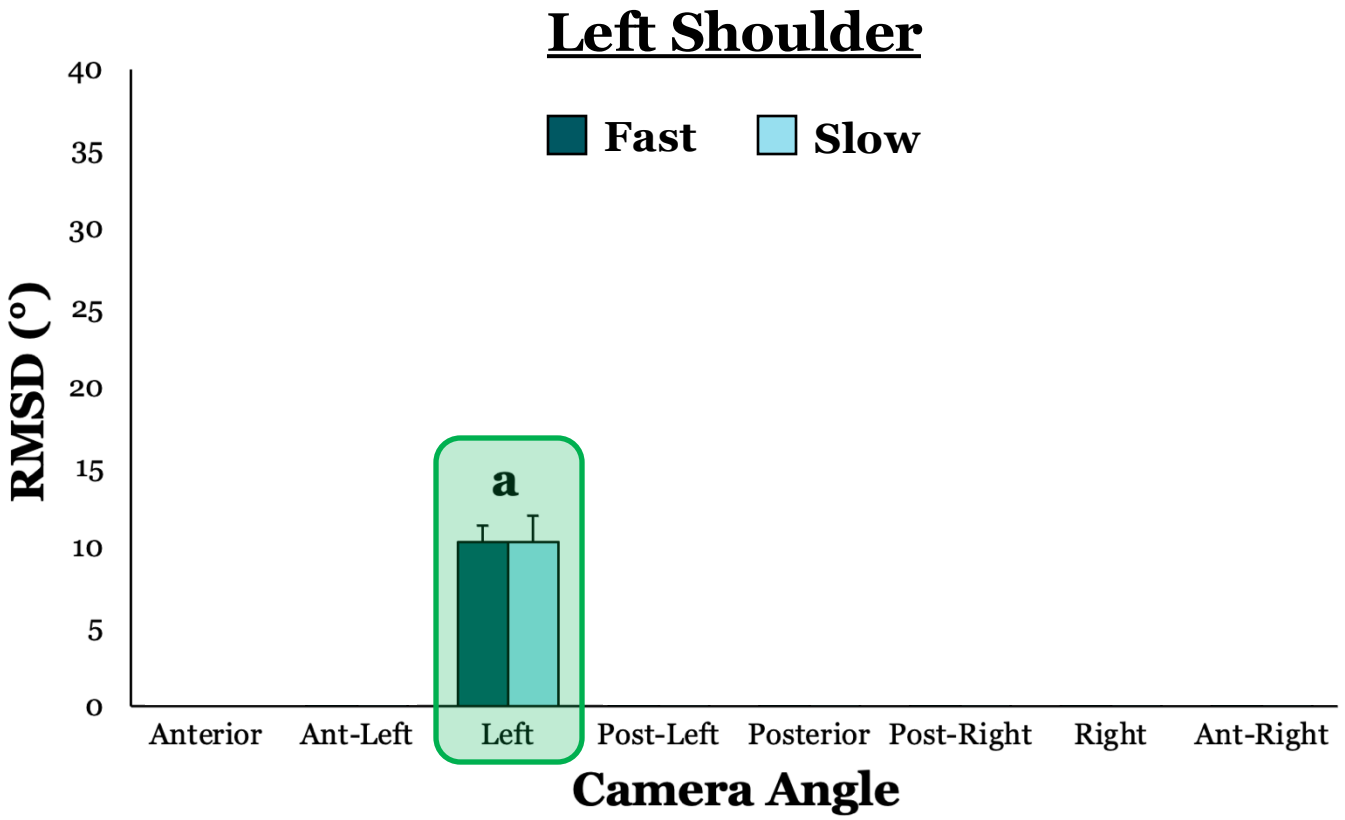
RESULTS (SO FAR)

CAMERA ANGLES & MOVEMENT PACE

Left Shoulder Elevation – ASW





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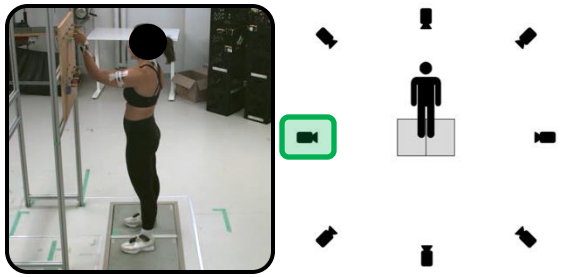
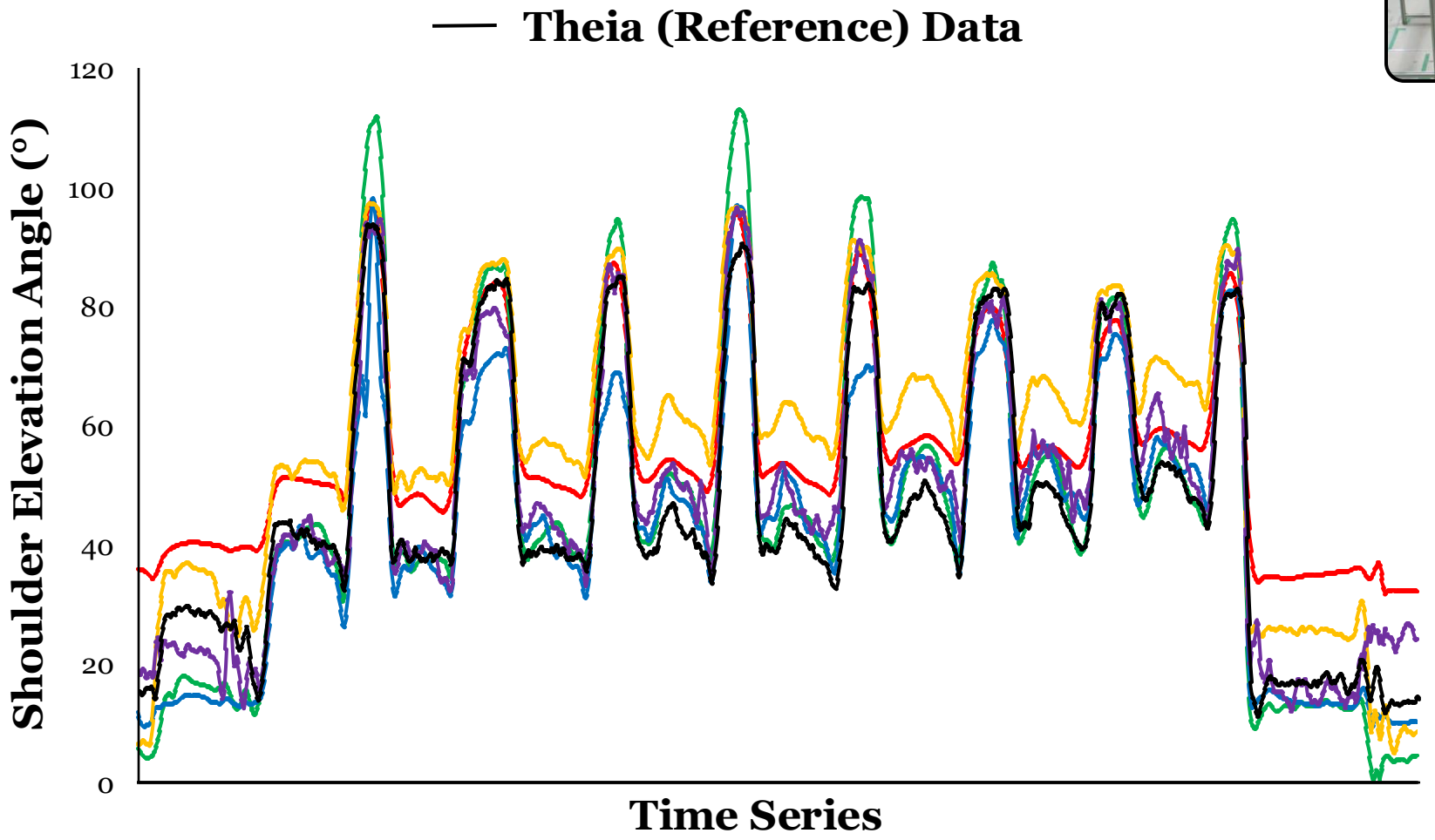
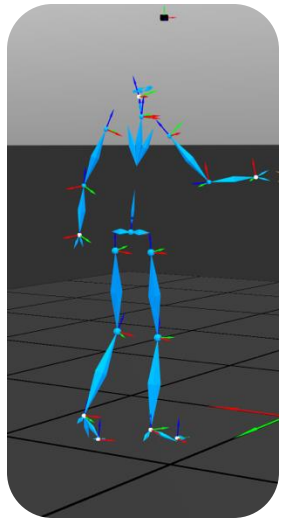
Left Shoulder Elevation – ASW



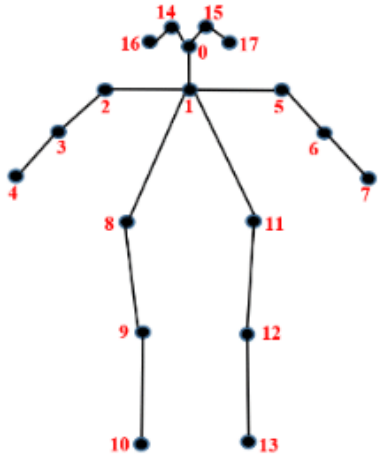


Key Take Away – We're not comparing the same thing!

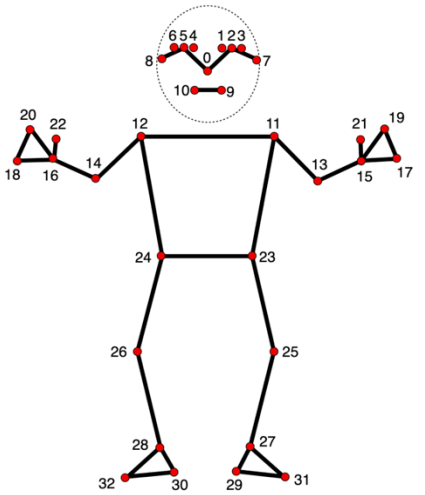
Theia



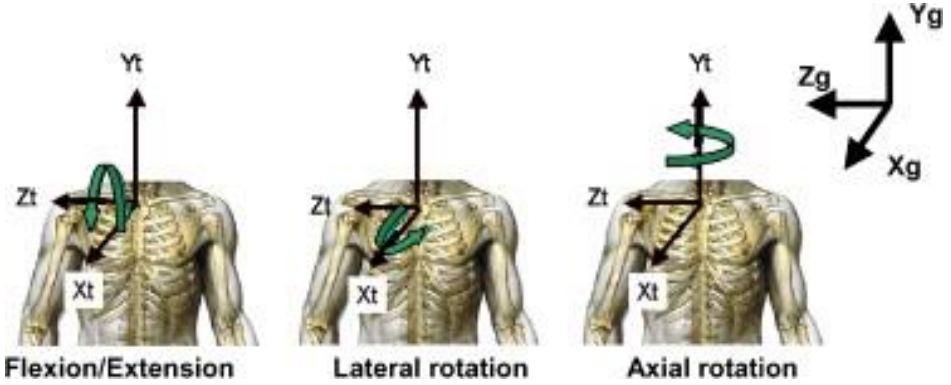
Open Pose



Media Pipe



International Society of Biomechanics



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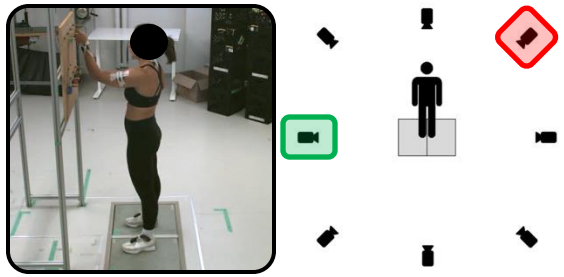
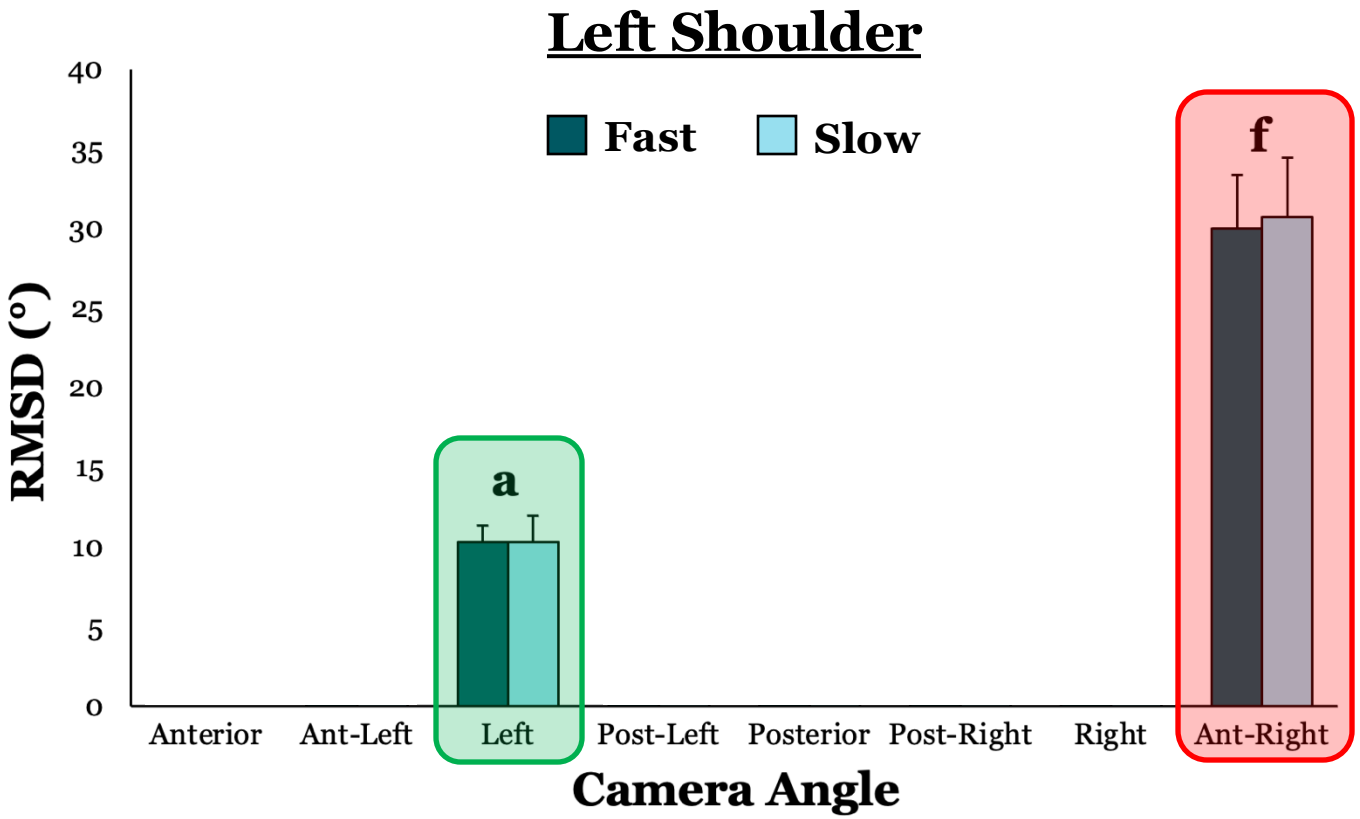
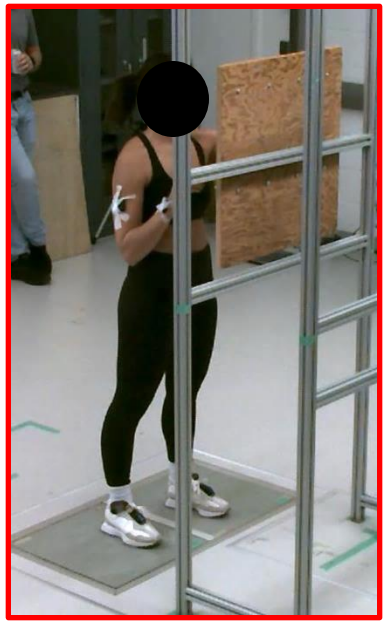
Left Shoulder Elevation – ASW







- Partial body occlusions on contralateral side

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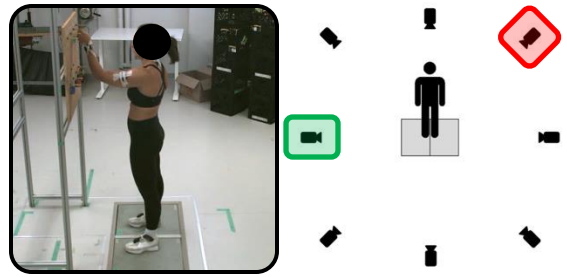

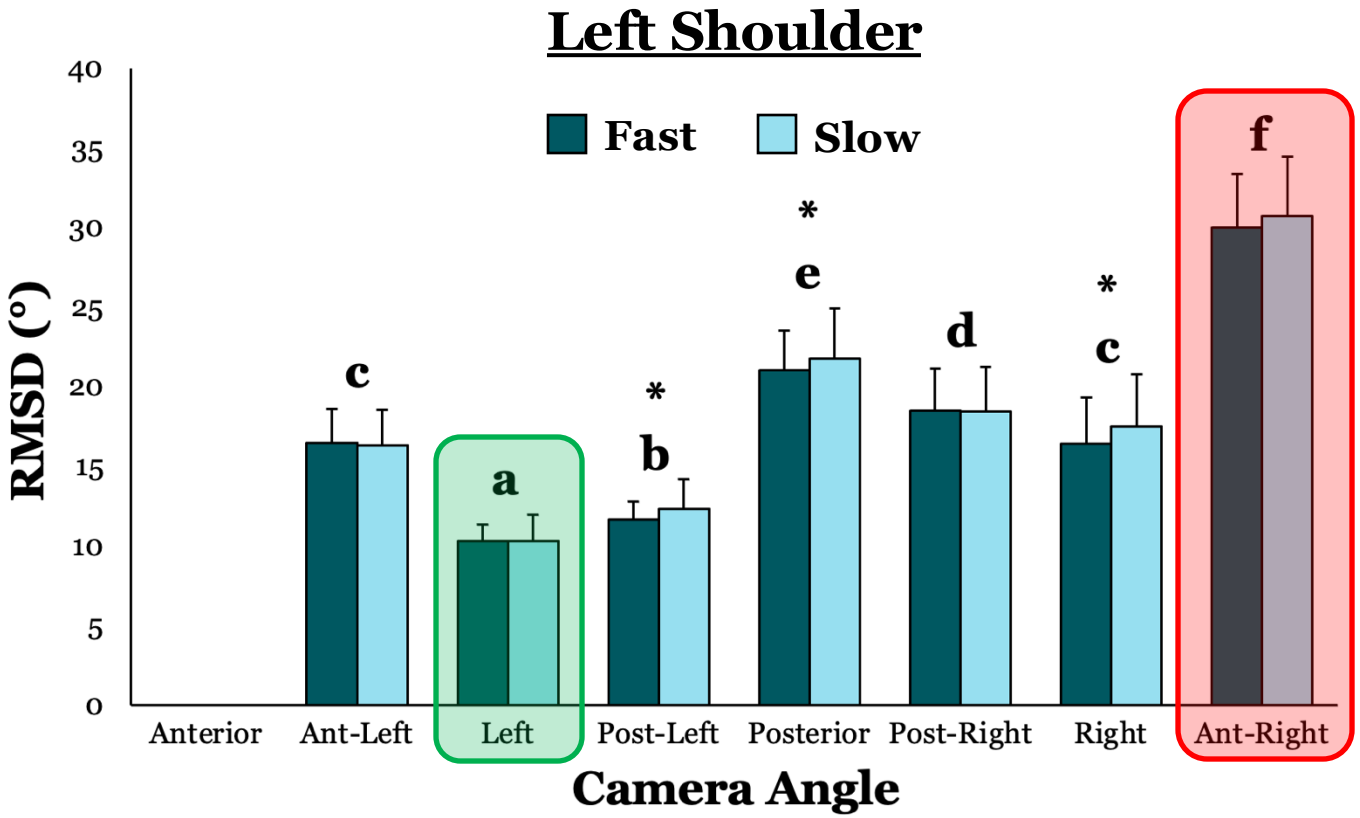

Key Take Aways:

- Side view to plane of motion performs best
- Avoid occlusion of view
- Slower pace → greater RMSD in "non-optimal" camera views

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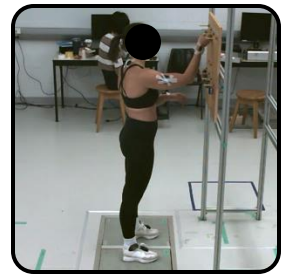
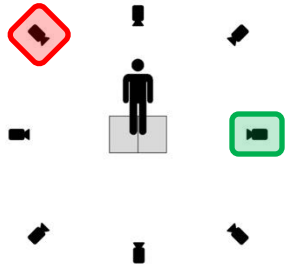
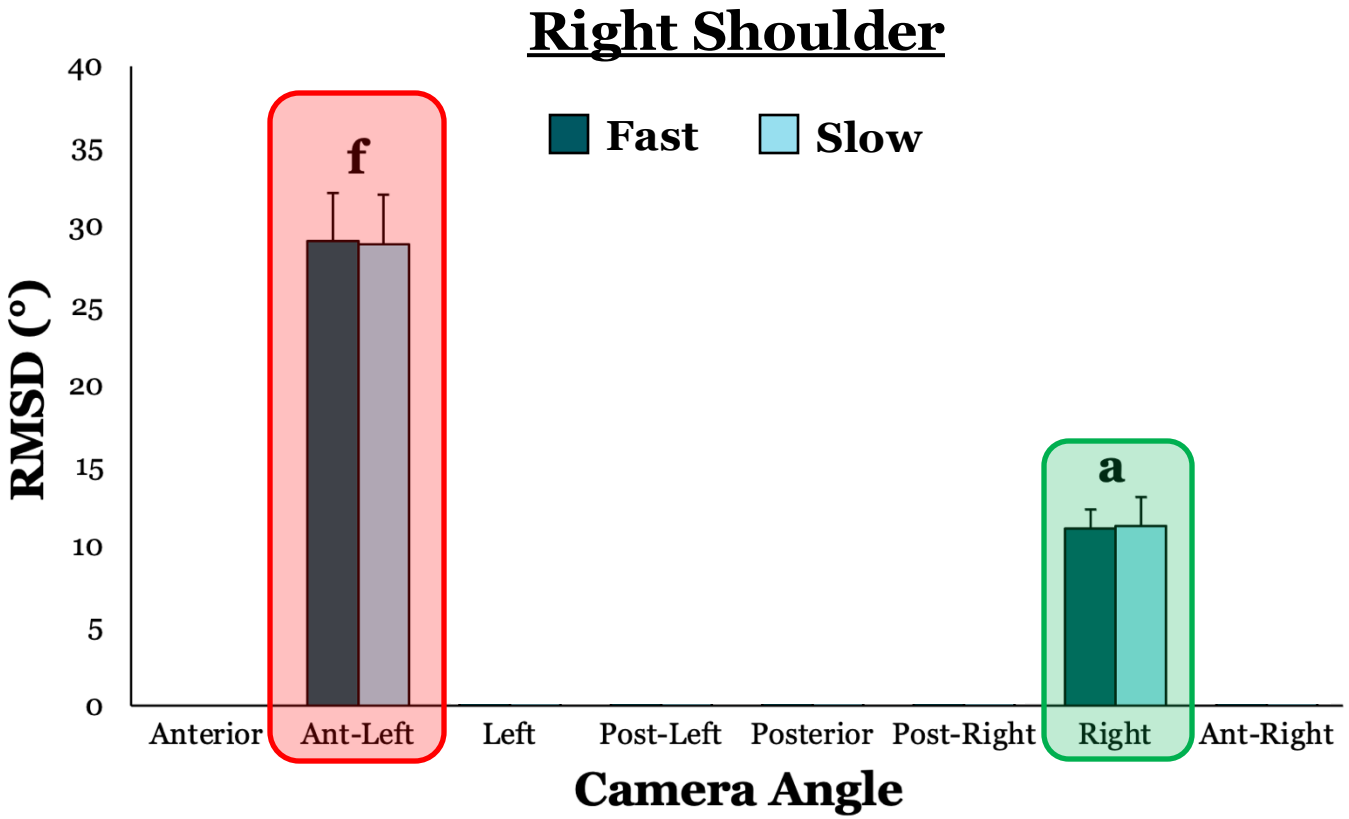
Right Shoulder Elevation – ASW







- Similar results, but just flipped for the right side

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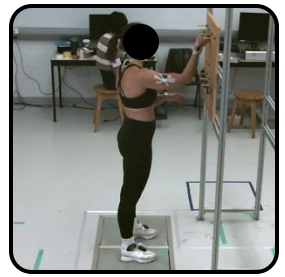
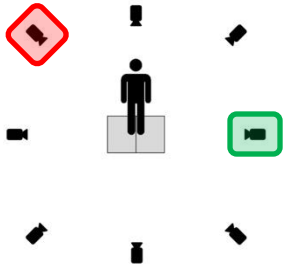
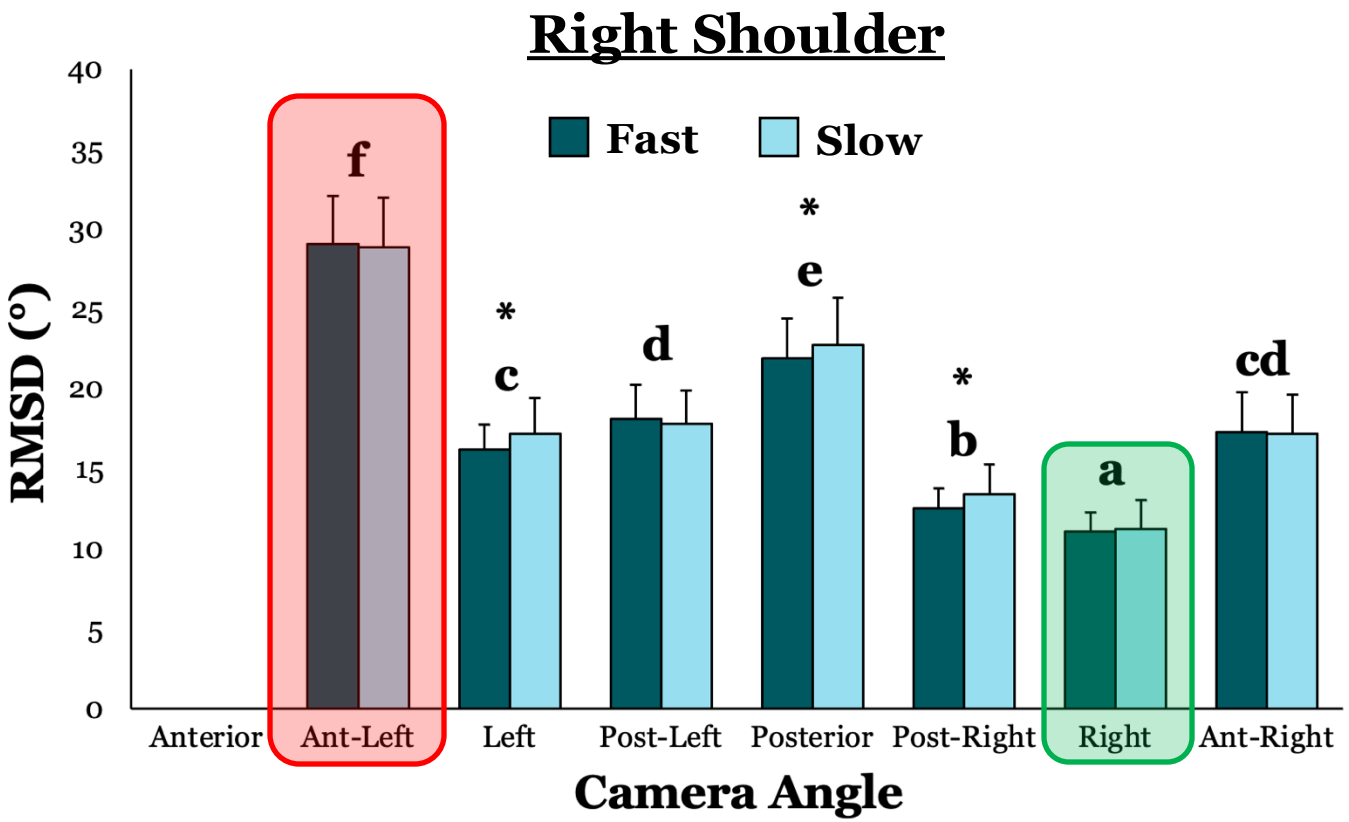
Right Shoulder Elevation – ASW







Key Take Aways:

- Perpendicular view to plane of motion → lower RMSD
- Avoid occlusion of view
- Record motion on same side of joint of interest

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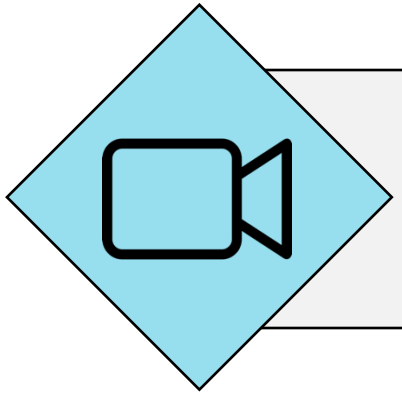
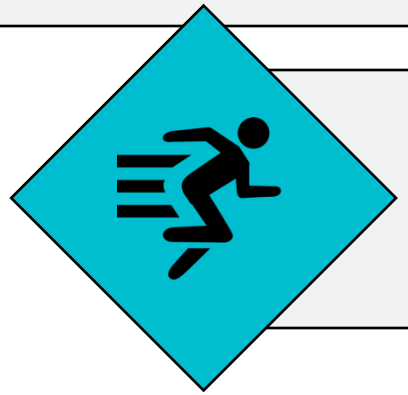
Key Take Aways (so far)



Video Recording Angle Matters!

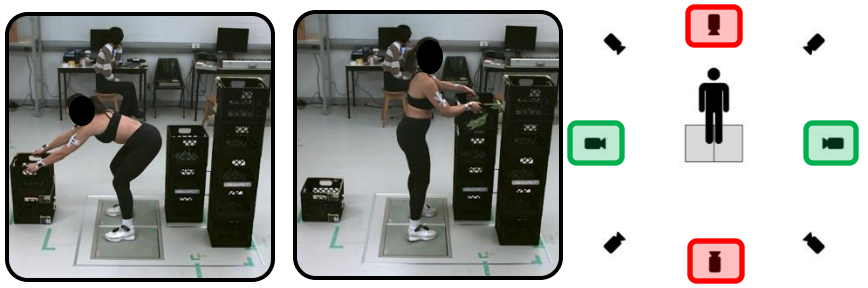
- Perpendicular to motion plane, avoid occlusions
- Record on same side as joint of interest

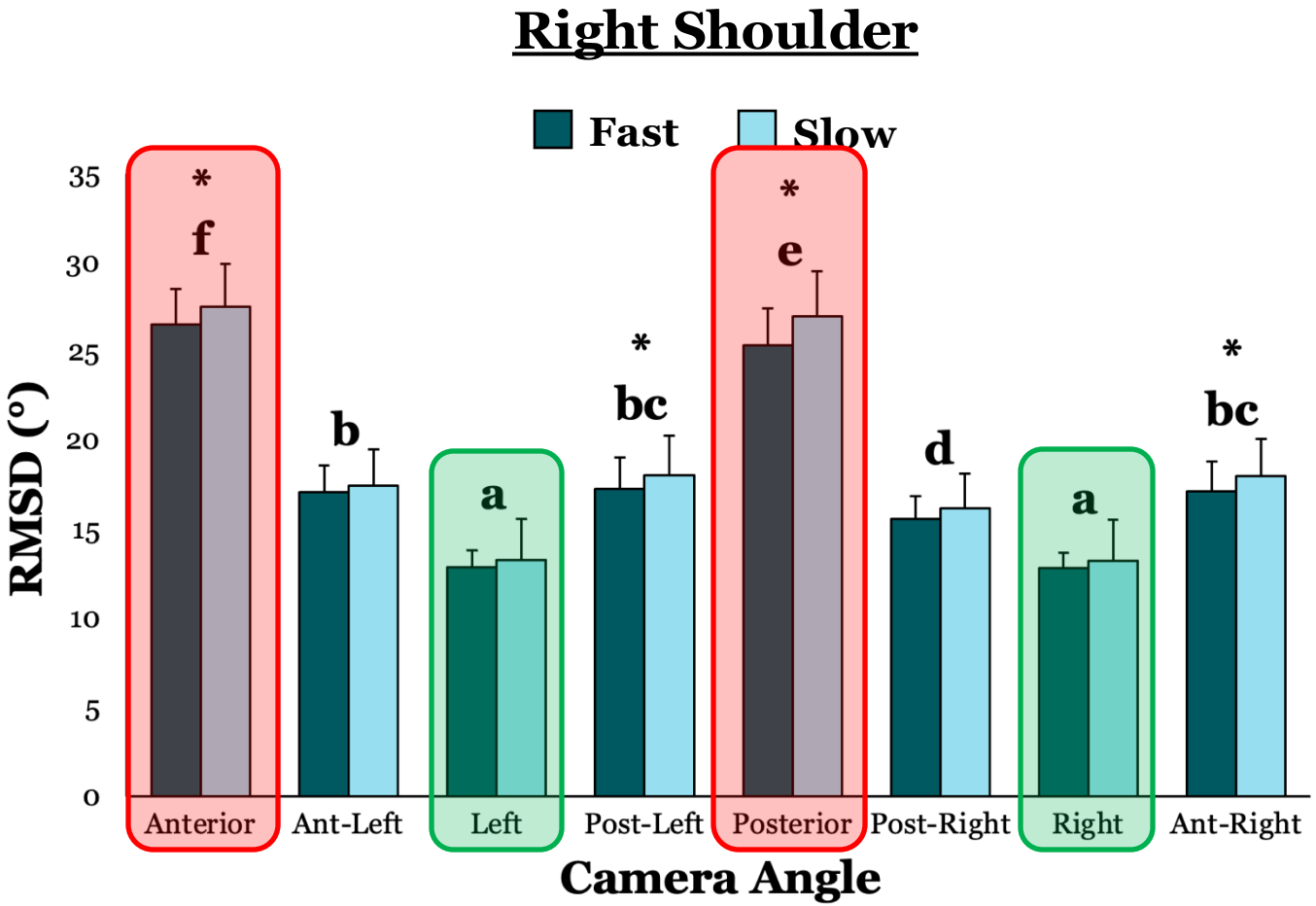


Limited Influence of Movement Pace

- For videos recorded from “optimal views”

Right Shoulder Elevation - Palletizing





Key Take Aways:

- Perpendicular view of major plane of motion performs best
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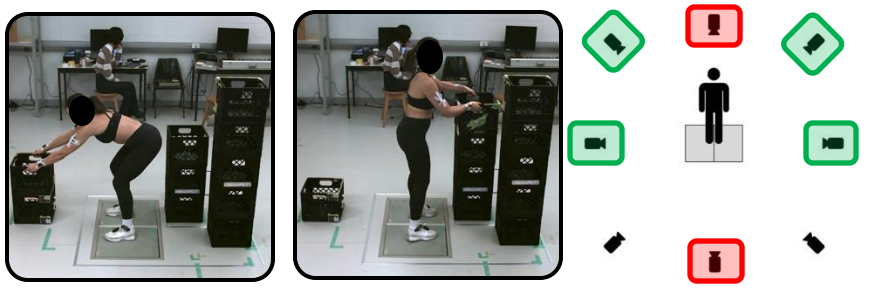
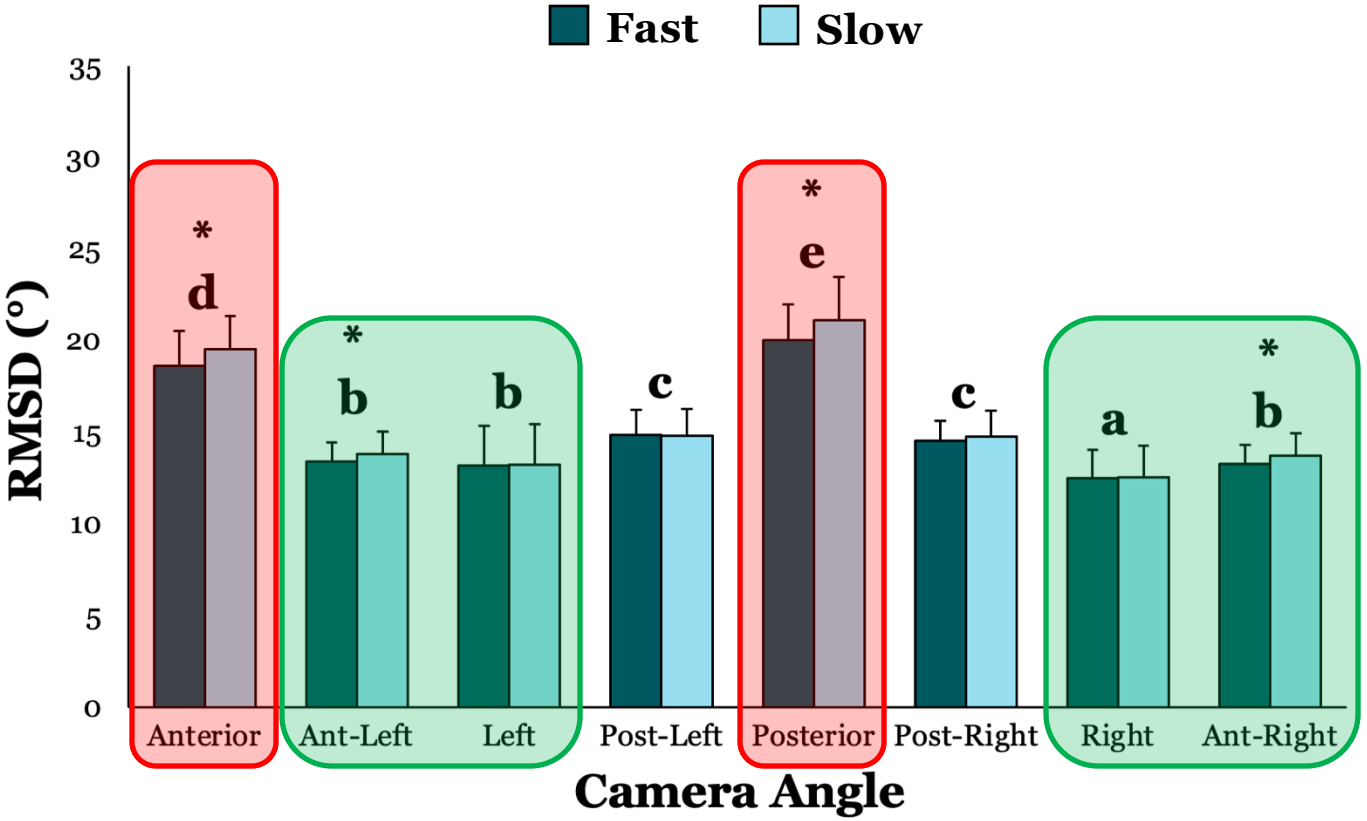
Trunk Angle - Palletizing





Key Take Aways:

- Perpendicular view of major motion plane → lower RMSD
- Limited influence of movement pace in "optimal" views

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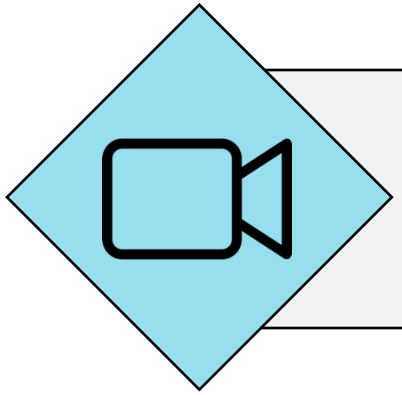
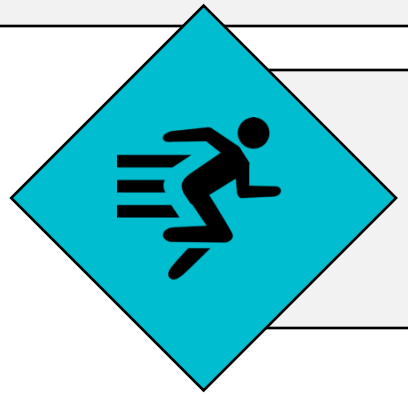
Key Take Aways (so far)



Video Recording Angle Matters!

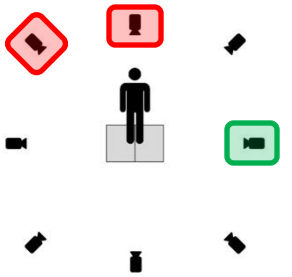
- Perpendicular to motion plane, avoid occlusions
- Record on same side as joint of interest

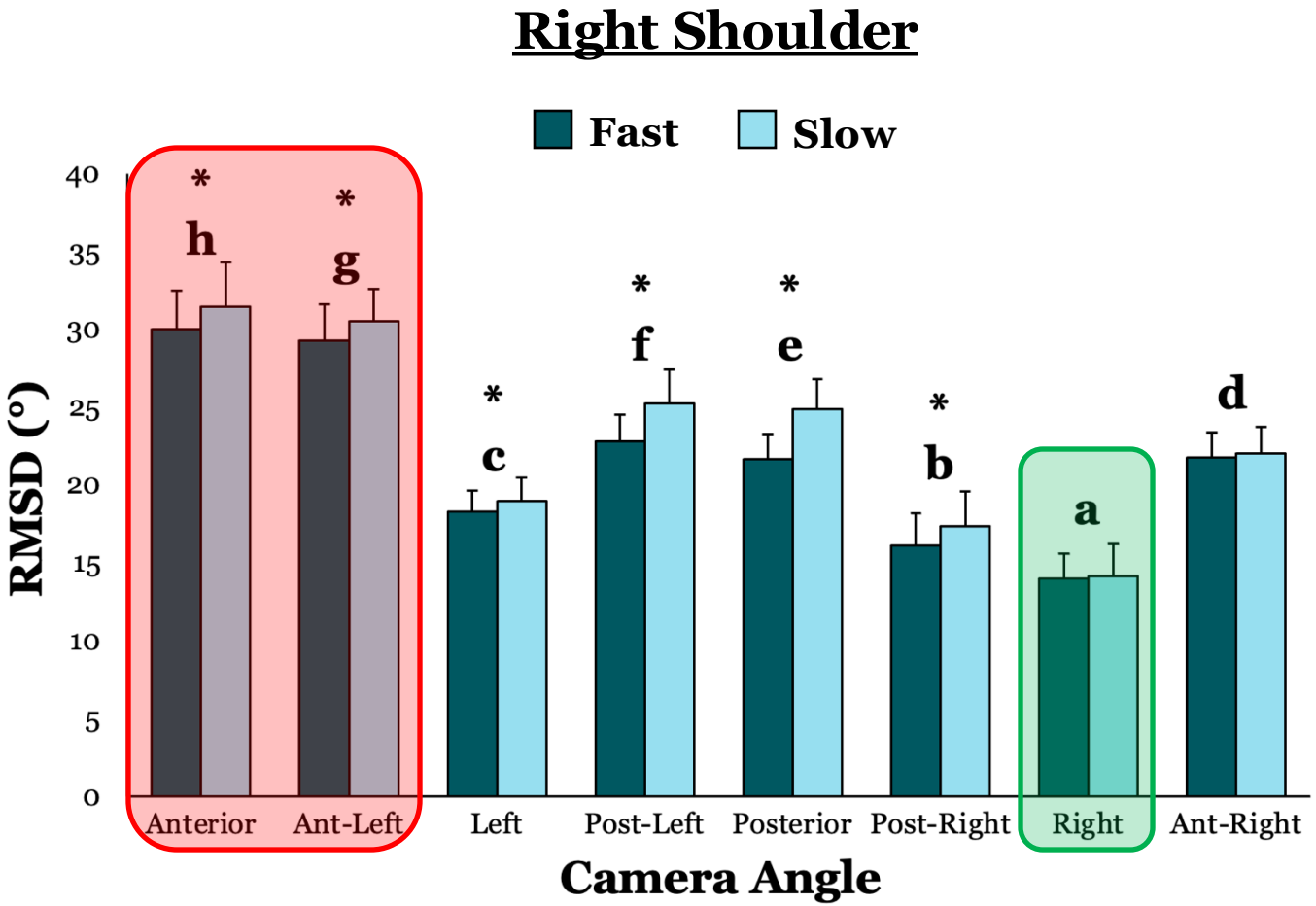


Limited Influence of Movement Pace

- For videos recorded from “optimal views”

Right Shoulder Elevation - Packaging





Key Take Aways:

- Side view of major plane of motion on same side as joint of interest
- Similar to results from ASW task

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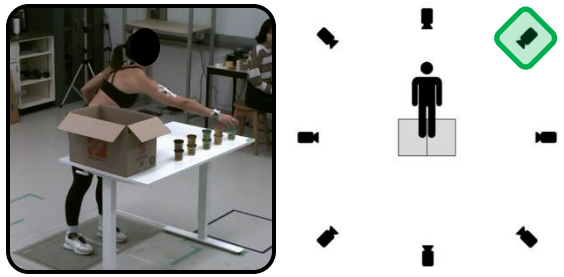
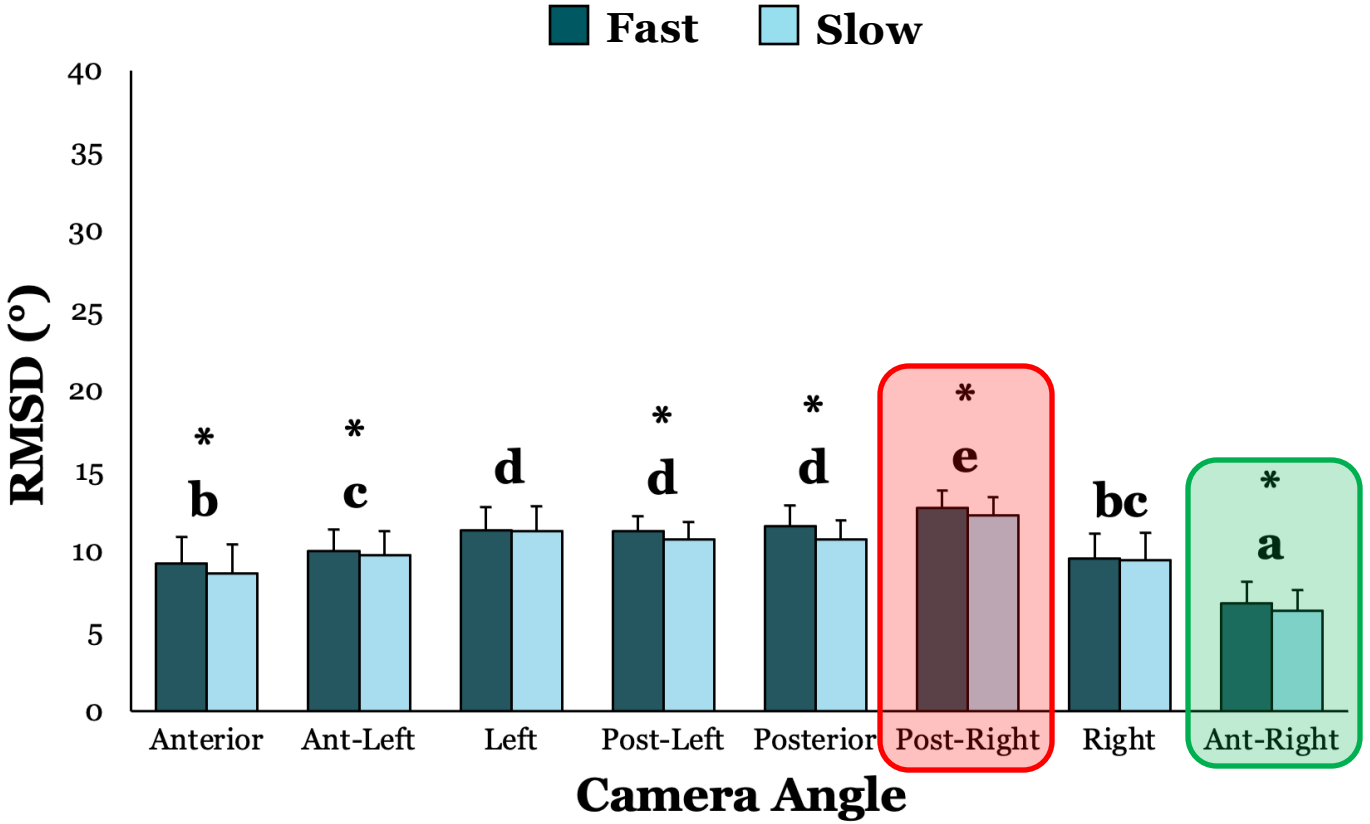
Trunk Angle - Packaging





Key Take Aways:

- Camera angle perpendicular to major plane of motion performs best
- Slightly greater RMSD in fast paced movements across most angles

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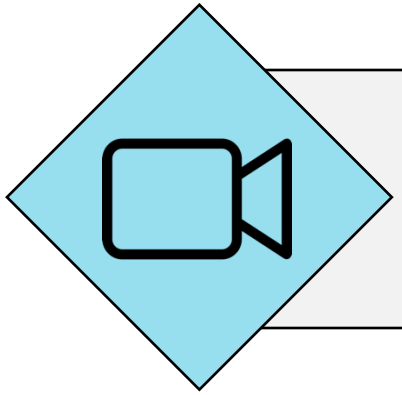
Key Take Aways (so far)



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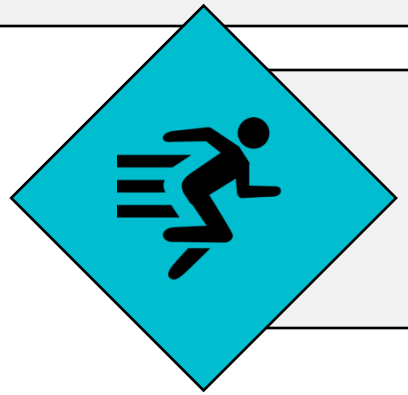
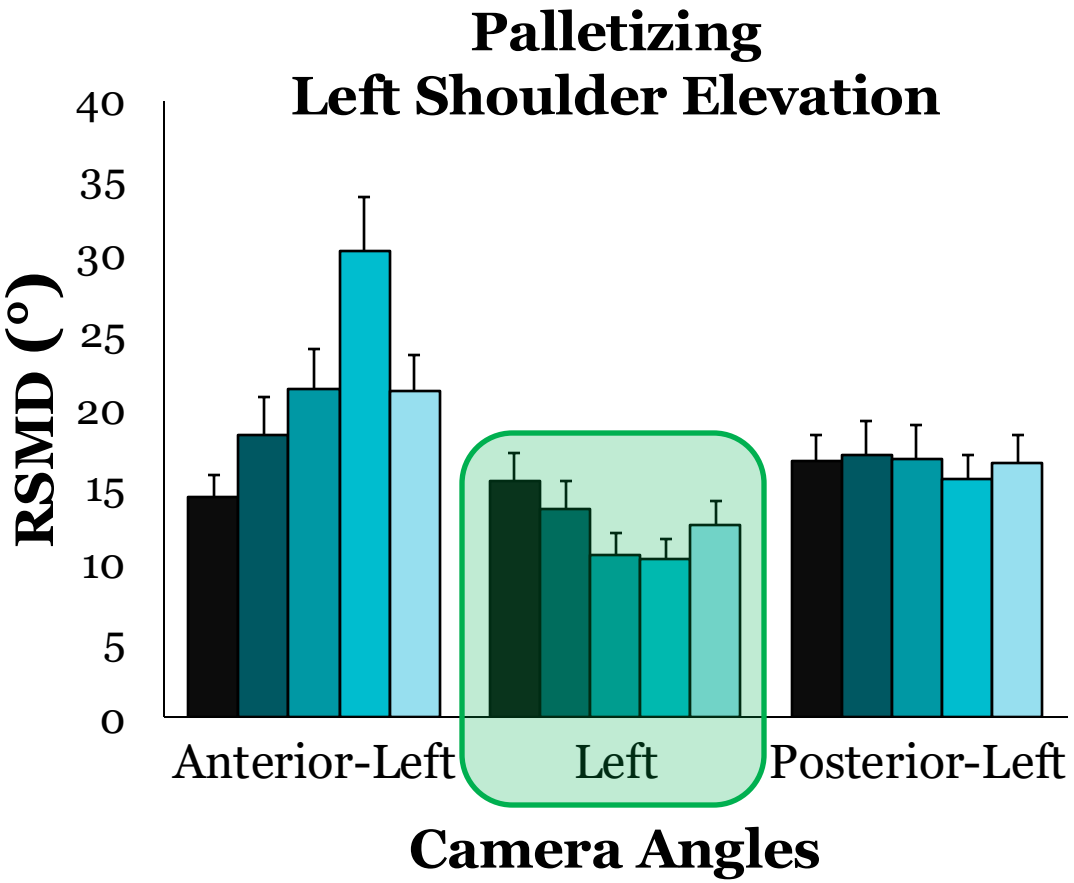
- Perpendicular to motion plane, avoid occlusions
- Record on same side as joint of interest

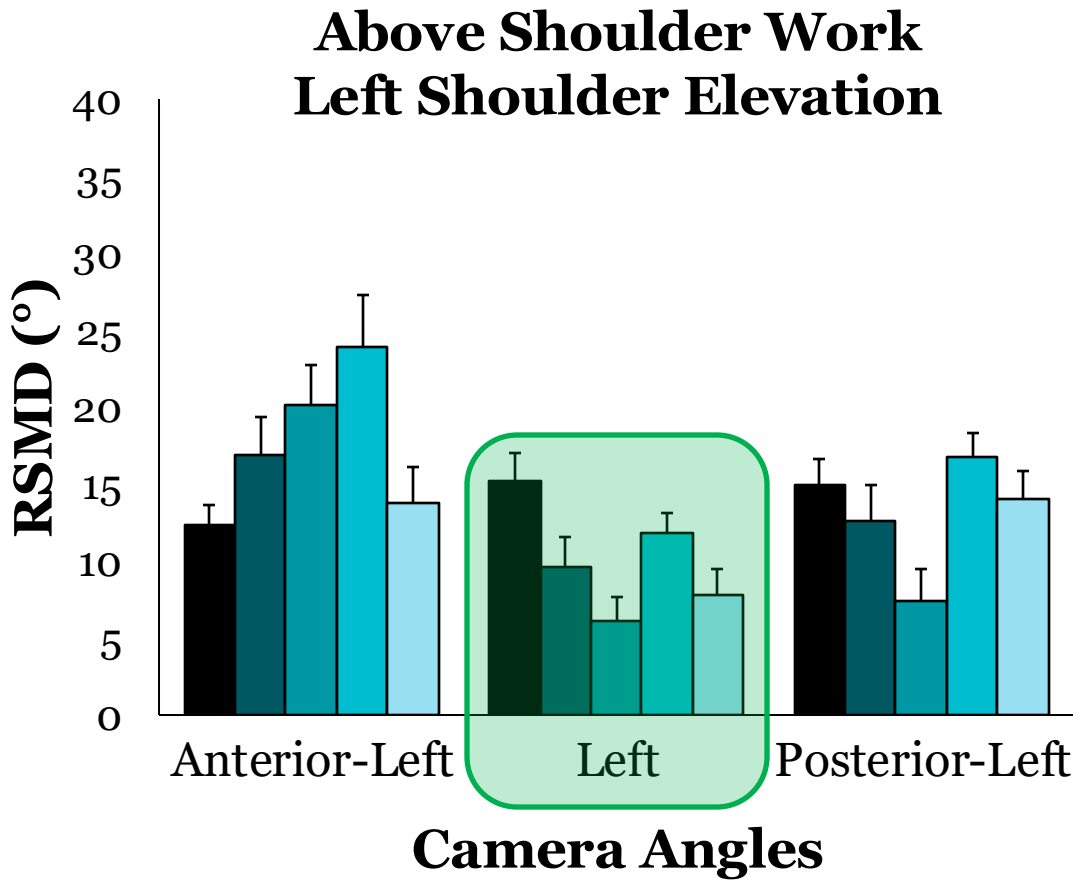


Limited Influence of Movement Pace

- For videos recorded from “optimal views”

Key Take Away – Similar Results Across Companies





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** Not representative of full data-set as we are still processing/analyzing data*

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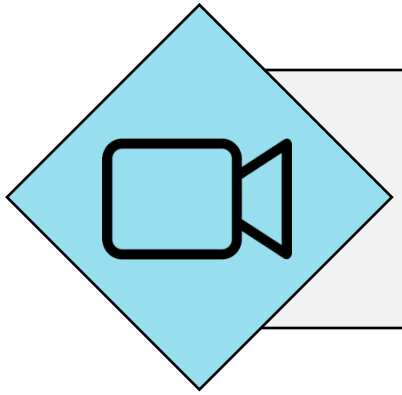
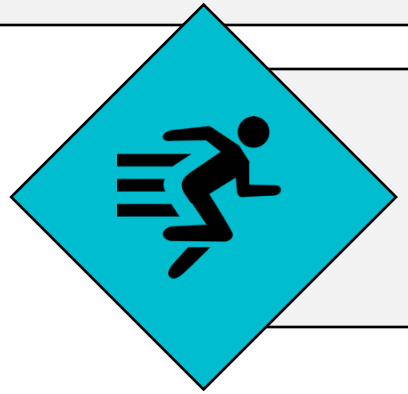
Key Take Aways (so far)



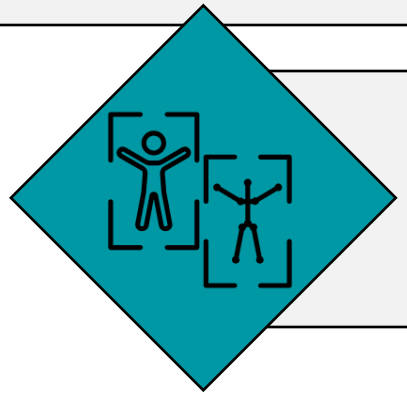
Video Recording Angle Matters!

- Perpendicular to motion plane, avoid occlusions
- Record on same side as joint of interest



Limited Influence of Movement Pace

- For videos recorded from "optimal views"



Subtle differences but similar results & interpretation across companies

- Further data analysis required**

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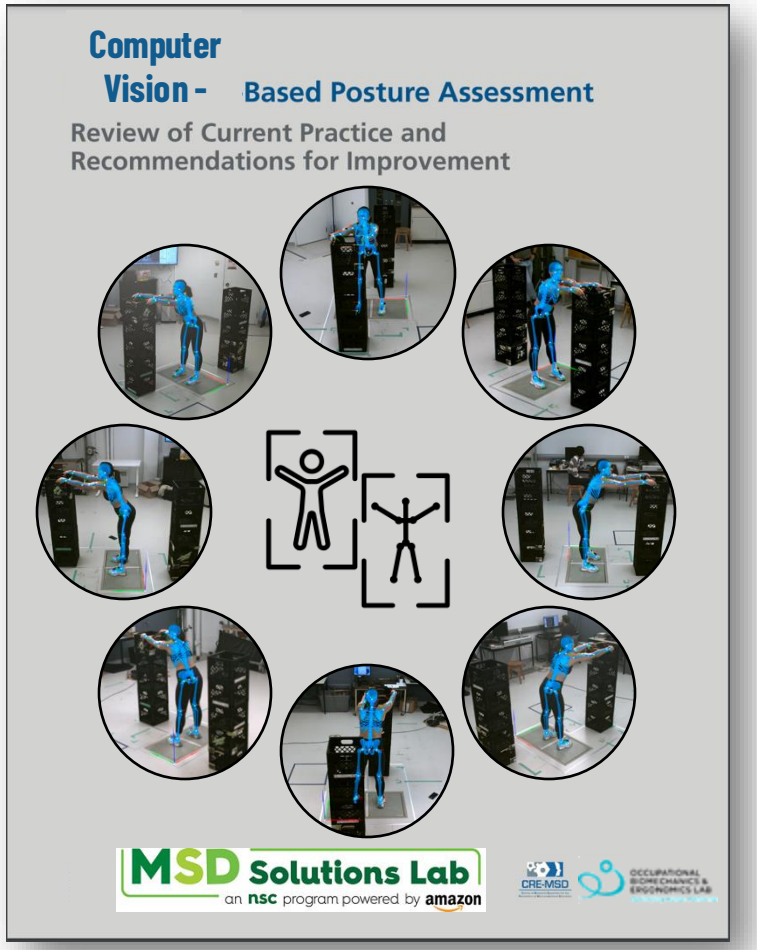
What Does This All Mean for Ergonomics Now?

- Not as simple as “point & shoot”
- Requires training/guidance to capture data appropriately
- Integration with existing single task assessment tools
  - NIOSH
  - LM-MMH equations
  - REBA/RULA
  - Strain Index, etc.



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Bridging Ergonomics from the Past, Present, & Future

Ontario Universities Back Pain Study

- Captured videos of workers on various tasks
  - Side profile of trunk flexion/extension
- Manual entry of postural information to match stick figures to the worker's posture
- Identified biomechanical factors associated with reporting of low back pain
  - Peak & cumulative spine loading
  - Peak flexion & flexion velocity

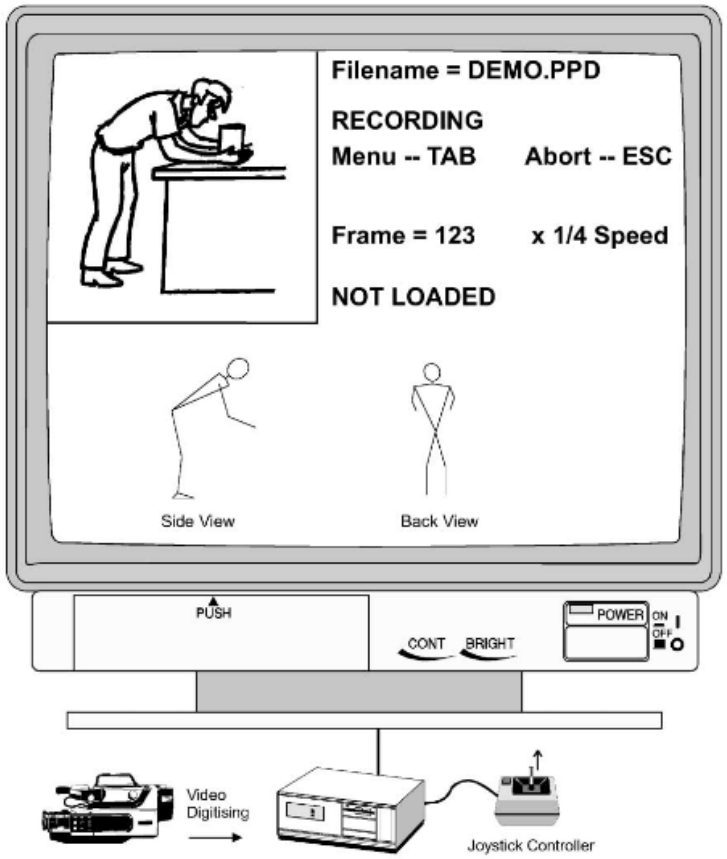

Image from Neumann et al., 2001

What Does This All Mean for Ergonomics in the Future?

- Ability to capture time series data in the workplace like never before!!
- Modern workplaces involve performing multi-task work → cumulative exposures
- Development of multi-task assessment tools using in-field exposure data

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Thank You! Any Questions?

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