2024 Ladder Safety Month Webinar
Safe Ladder Use in Construction

Hosted by CPWR & the National Campaign to Prevent Falls in Construction with partners…

Moderator: Douglas Trout, MD, NIOSH Office of Construction Safety and Health

Panelists:

Kurt Beschorner, Ph.D., Associate Professor, Department of Bioengineering, University of Pittsburgh
Chad Lingerfelt, Director of Training and Jobsite Safety & Security, Werner Co.
Richard Trewyn, Director of Risk Education and Training, NRCA
Mike Van Bree, Vice President of the American Ladder Institute

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NATIONAL LADDER SAFETY MONTH

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Ladder Safety Research at the University of Pittsburgh

Kurt Beschorner, Ph.D.

Human Movement and Balance Lab

University of Pittsburgh

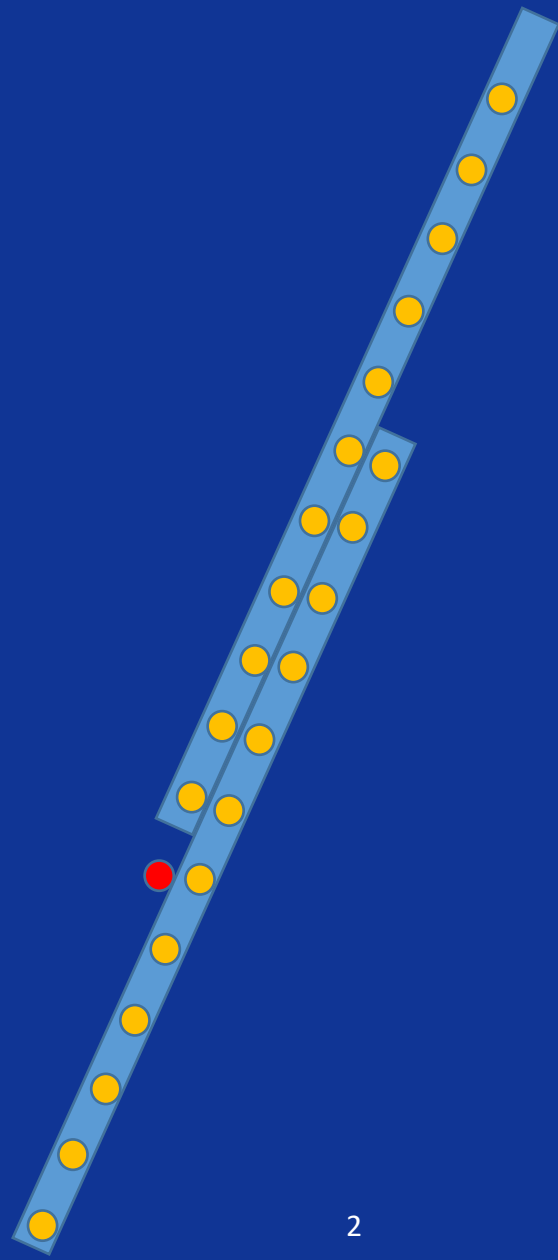
CPWR Webinar

Pitt®

Human Movement and Balance Laboratory

Our motivation

- **“An injured employee slippe of two ladder sections.”**
- **“…the victim lost his balance e two ladder sections where th slightly”**



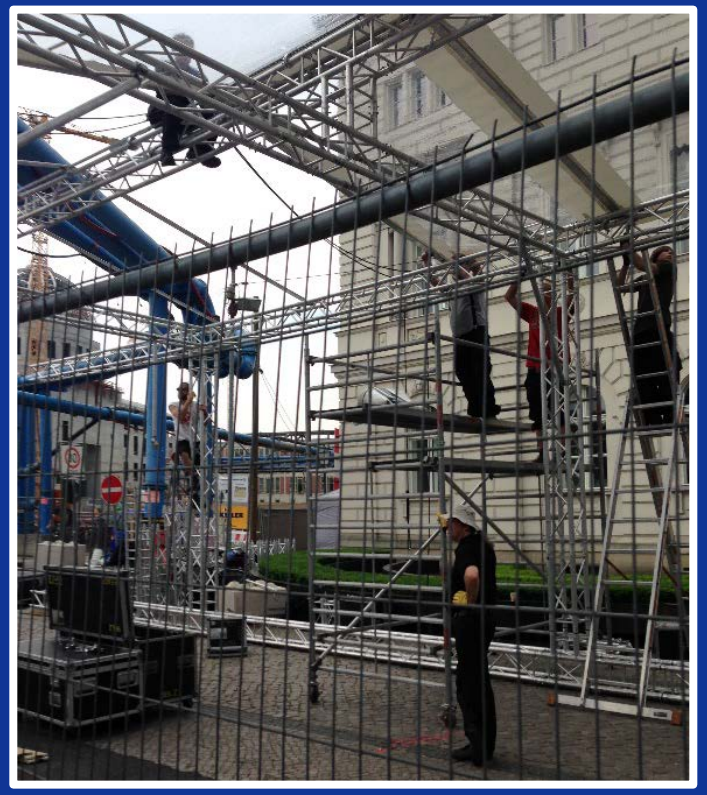
NIOSH FACE REPORT, June 8, 1998, Worker Dies After Falling 15 Feet From An Extension Ladder, https://www.cdc.gov/niosh/face/stateface/mn/98mn013.html.

Falls to lower Levels

Ladders are associated with:

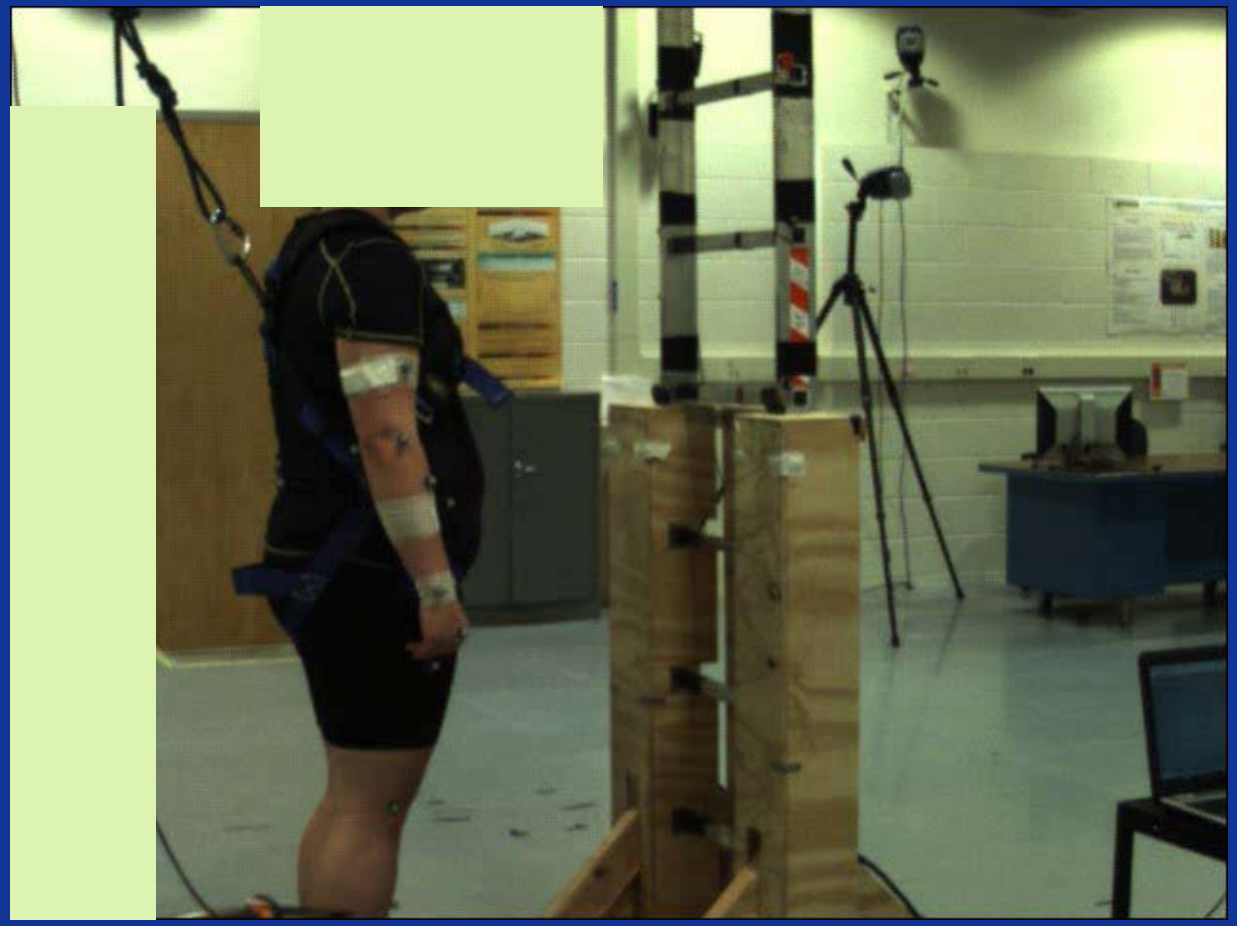
- **15,000 non-fatal falls**
- **113 fatal falls**

Median of 20 days away from work for ladder-related falls

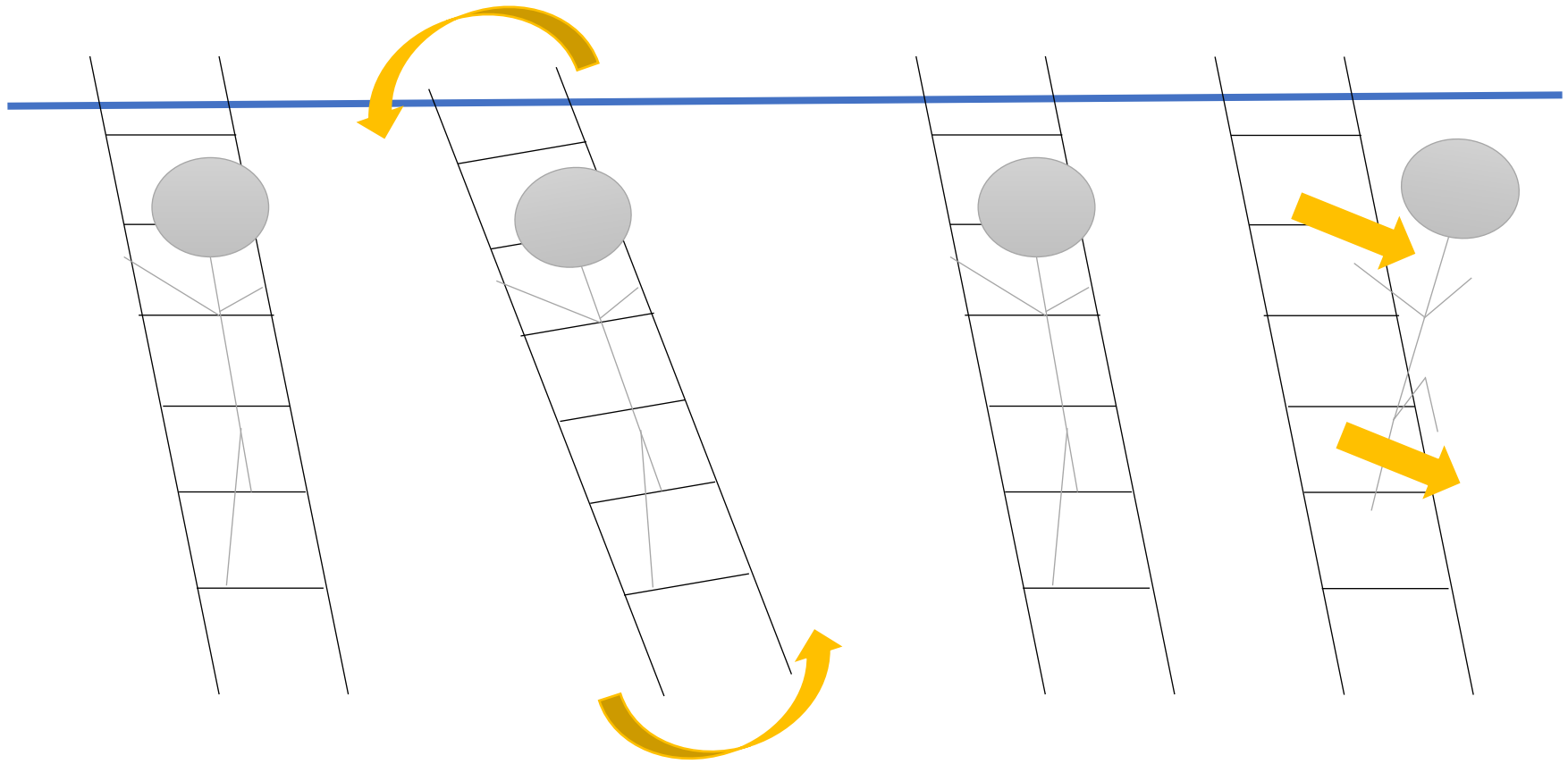


[1]Socias, C.M., et al.. (2014). *Morbidity and mortality weekly report.*

Why laboratory testing for ladder safety?



Ladder Fall Type



Falls <u>with</u> Ladder **Falls <u>from</u> Ladder**

[3]Shepherd, G.W., et al. (2006). *Ergonomics.*

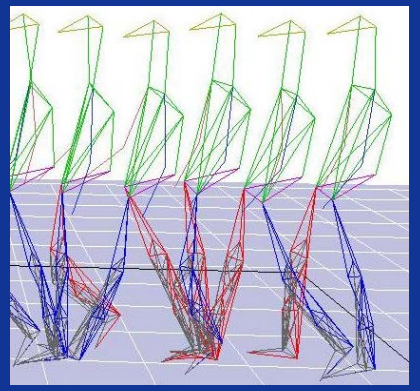
Slips commonly cause occupational ladder fall events

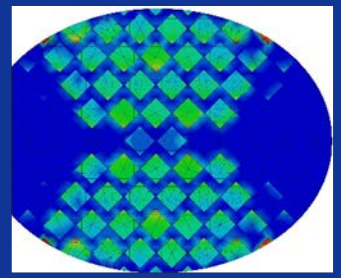
- **“Slip on rungs” was the initiating event for 14% of ladder-related fatalities[1]**

- **“Slipped/lost balance” was the initiating event for 25% of occupational non-fatal falls [2,3]**

[1]Shepherd, G. W., Kahler, R. J., & Cross, J. (2006). Ergonomic design interventions–a case study involving portable ladders. *Ergonomics, 49*(3), 221-234.
[2]Smith, G. S., Timmons, R. A., Lombardi, D. A., Mamidi, D. K., Matz, S., Courtney, T. K., & Perry, M. J. (2006). Work-related ladder fall fractures: identification and diagnosis validation using narrative text. *Accident Analysis & Prevention, 38*(5), 973-980.
[3]López, M. A. C., Ritzel, D. O., González, I. F., & Alcántara, O. J. G. (2011). Occupational accidents with ladders in Spain: Risk factors. *Journal of Safety Research, 42*(5), 391-398.

Research philosophy





Engineering mechanics analyses

Human motion

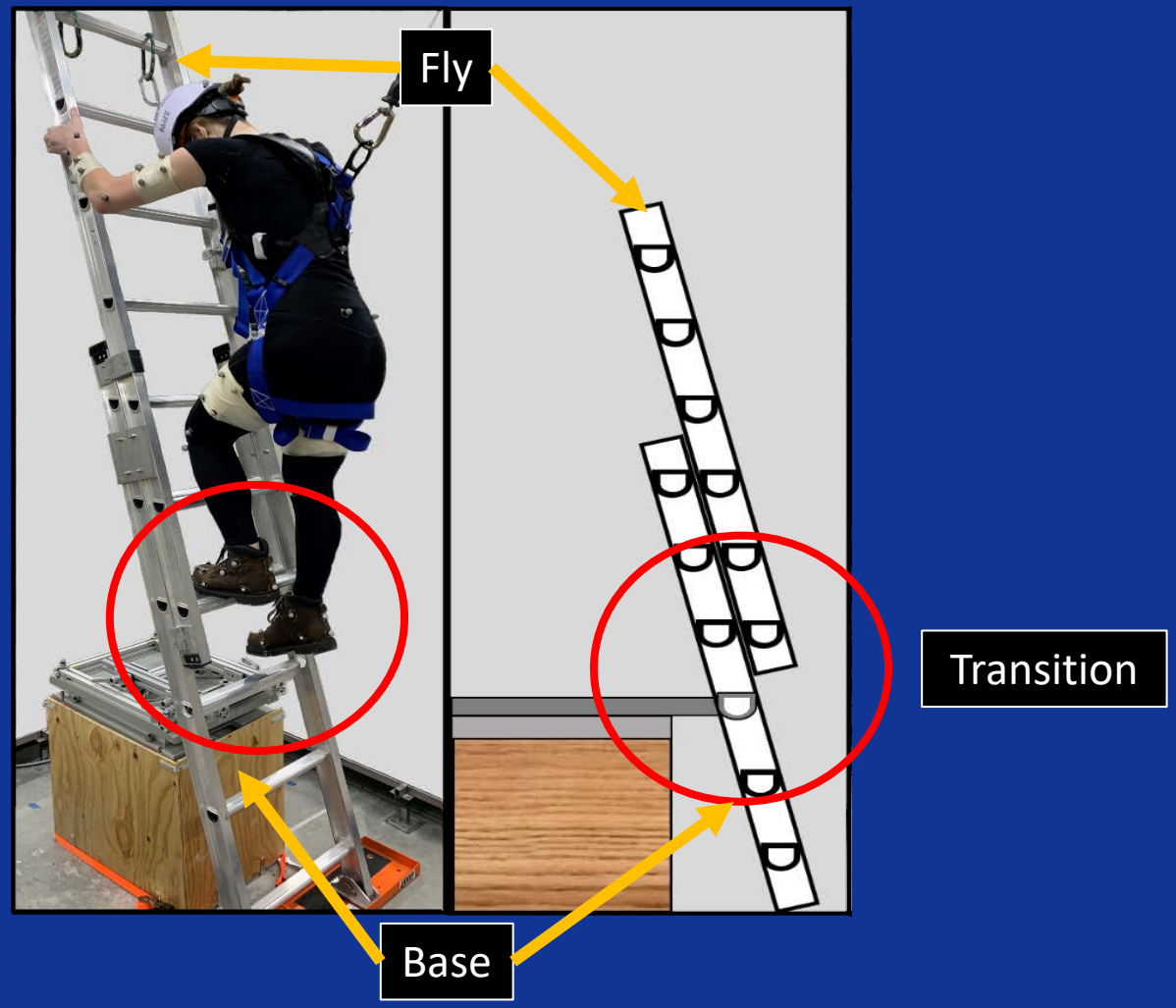
Ergonomic interventions

Question 1: Ladder fly design and its effect on fall risk

Fly Configuration Experiment

Traditional

Reversed



- Kinematic & Kinetic data collected for:
  - 20 Participants
  - 3 Ascents/Descents
- Investigated:
  - Required Coefficient of Friction (RCOF)

Fly Configuration Experiment

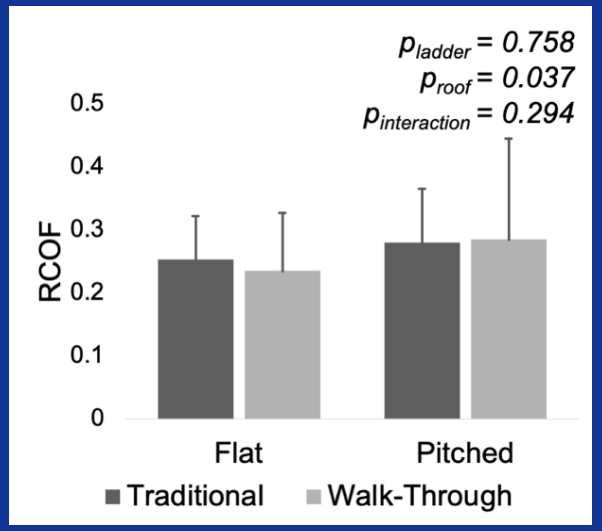
- Kinematic & Kinetic data collected for:
  - 20 Participants
  - 3 Ascents/Descents
- Investigated:
  - Required Coefficient of Friction (RCOF)
  - Foot Placement Corrections (FPCs)
  - User Preference

Question 2: Transitioning between ladder and roof

Roof-to-ladder transition

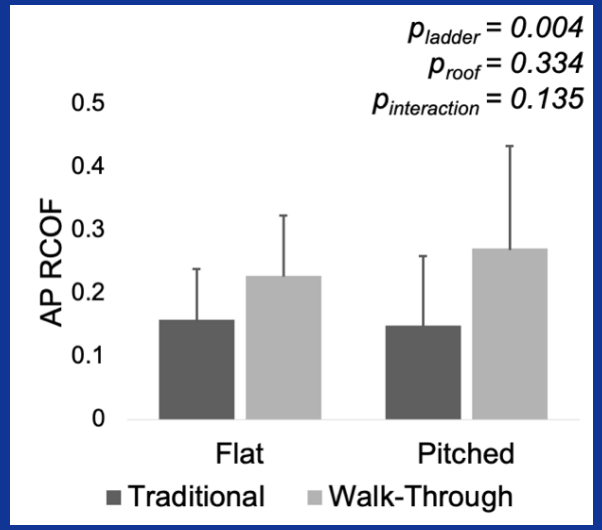
Do walk-through attachments reduce slip risk during roof-to-ladder transitions?

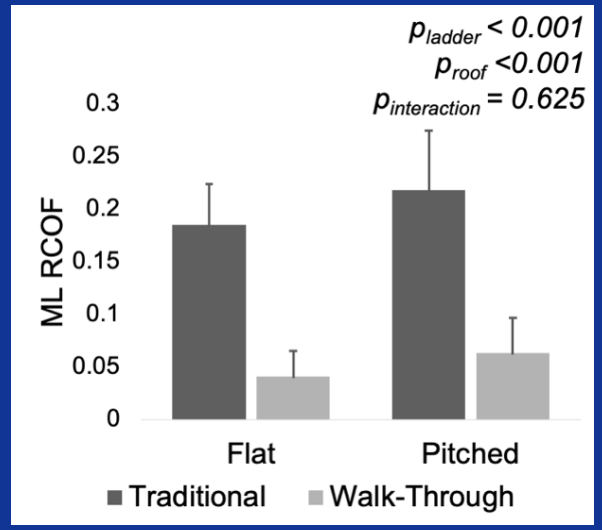
Magnitude *and* direction of friction are important for ladder transitioning



Medial/lateral friction values are higher than expected and highly related to ladder design

Ridges in ladder rung may be dangerous!



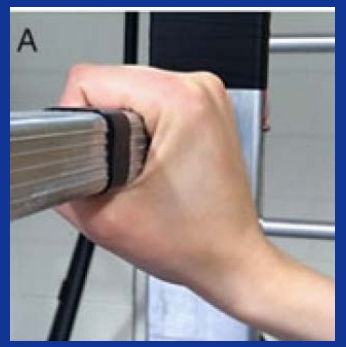


Griffin, S.C., Williams, V., Vidic, N. and Beschorner, K.E., 2023. During roof-to ladder transitions, walk-through extensions modify required friction direction. *Journal of Biomechanics*, *159*, p.111780.

Question 3: Effect of toe space on fall risk
Question 4: Grasping rail or rung?

Impact of ergonomic design and human factors on slipping risk

Controlled grasping



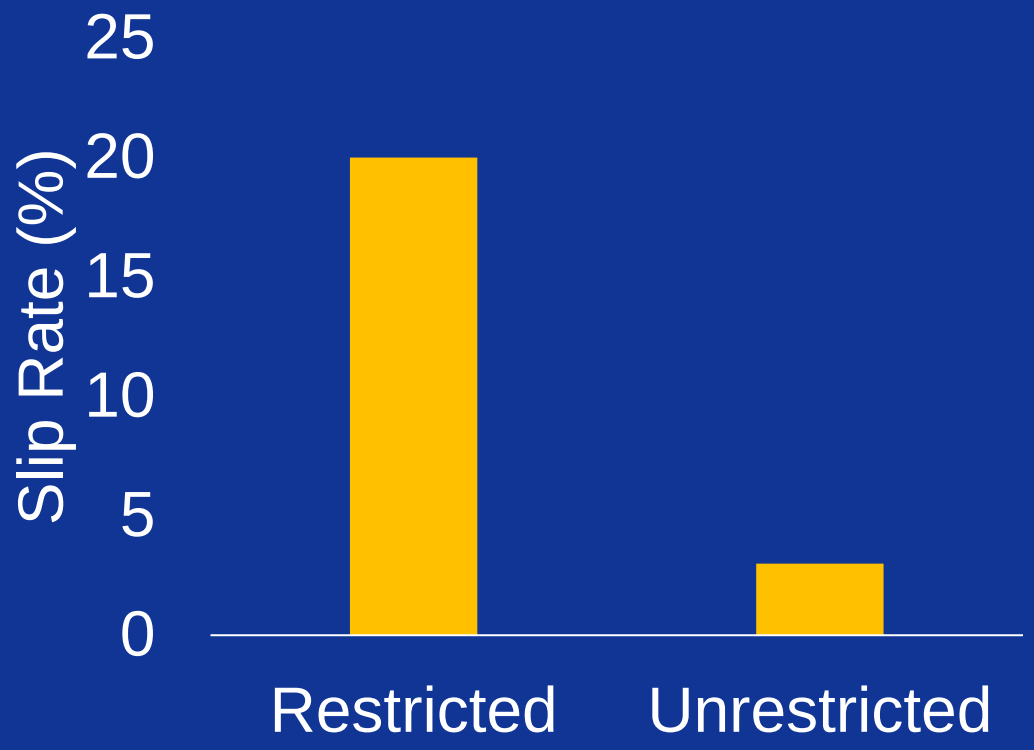
Controlled foot placement

Pliner, E. M., Campbell-Kyureghyan, N. H., & Beschorner, K. E. (2014). Effects of foot placement, hand positioning, age and climbing biodynamics on ladder slip outcomes. *Ergonomics*, *57*(11), 1739-1749.

Environmental factors: restricted foot placement

Restricted

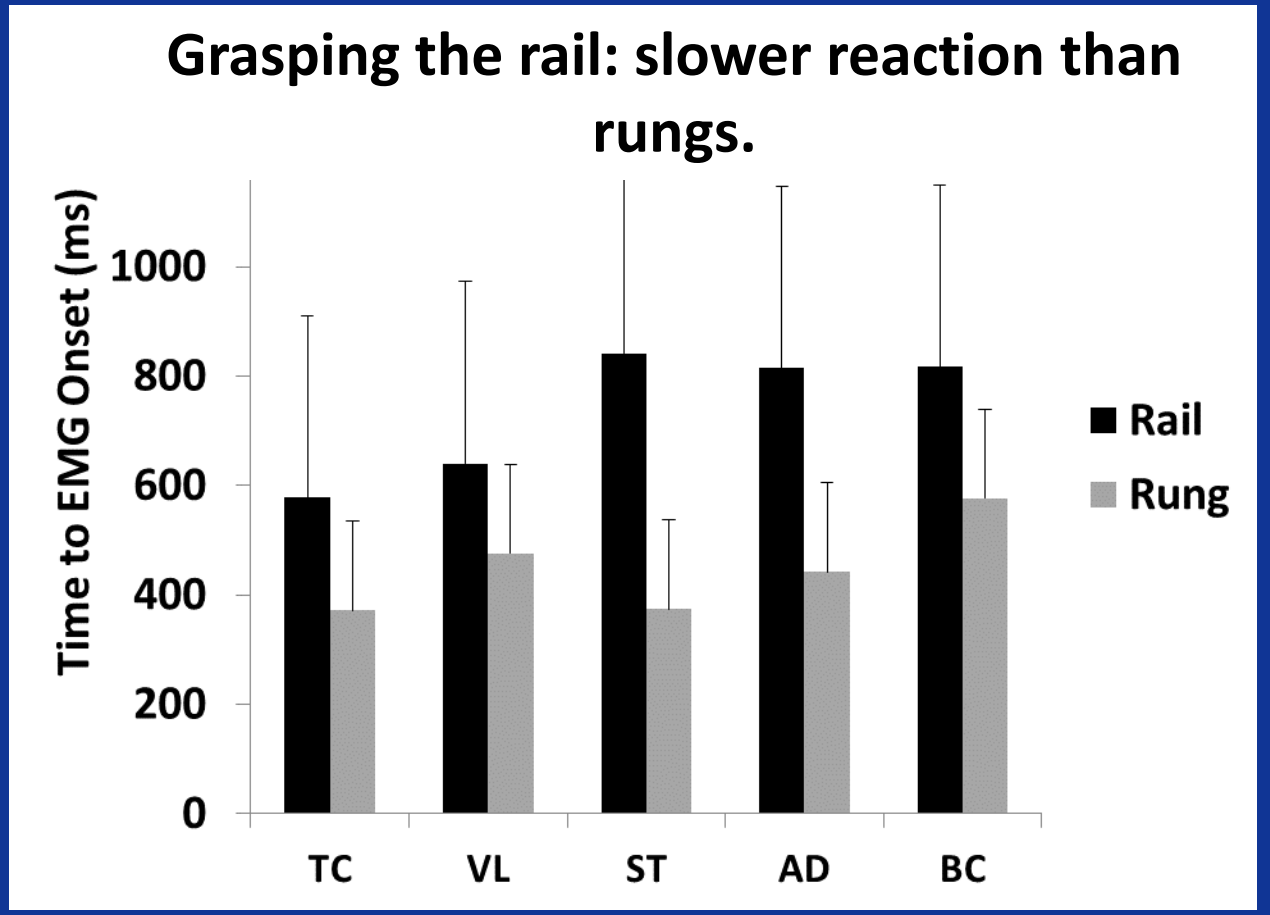
Unrestricted



Pliner, E. M., Campbell-Kyureghyan, N. H., & Beschorner, K. E. (2014). Effects of foot placement, hand positioning, age and climbing biodynamics on ladder slip outcomes. *Ergonomics*, *57*(11), 1739-1749.

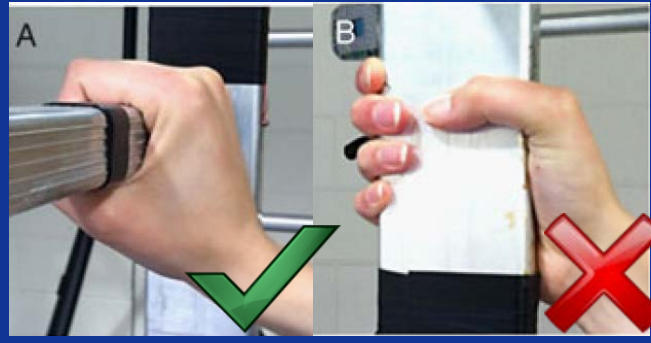
Ladder Climbing Observed in Hydro Power Plants

Human factors: Influence of grasp location on response speed



Schnorenberg, A.J., Campbell-Kyureghyan, N.H., Beschorner, K.E., 2015, Biomechanical Response to Ladder Slipping Events: Effects of Hand Placement, *Journal of Biomechanics* 48 (14), 3810-3815.

Factors associated with greater safety

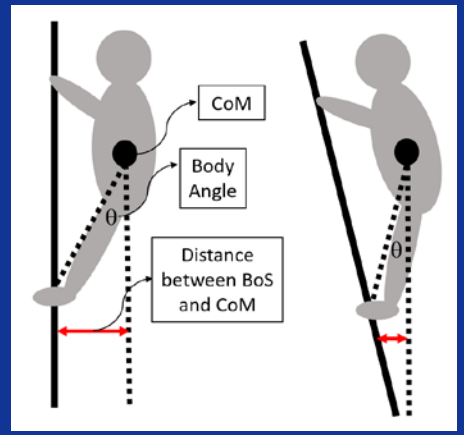


Environmental

- Unrestricted foot placement
- Non-vertical ladders (~75°)
- Revising extension ladder design to flip base/fly*
- Use walk-through devices or improve lateral friction of rungs

Human factors

- Grasping rungs instead of rails
- Keeping body weight over feet
- Maintaining level feet



*Not advocating modifying existing ladders but new designs

Acknowledgements:

- **NIOSH R01 OH 011799: Predicting slips during ladder climbing: novel methods for assessing shoe-rung friction**
- **NIOSH R21 OH 010038: Quantifying the Recovery Response and Role of Hand Strength During Ladder Falls**
- **NIOSH T42 OH 008672: Effects of Hand and Foot Positions on Ladder Slip and Fall Outcomes**
- **OSHA SH-24880-13-60-F-55: Safety and Ergonomics for Renewable Energy**

Discussion

- **What are some research findings that we feel are ready to put into action?**

- **What are some topics about ladder fall safety where we think we need more research?**

Thank You!

Put our research into action!

- **Links to full access articles are shared on:**
  - **LinkedIn: “Kurt Beschorner”**
  - **Twitter: @kurt_beschorner**
  - **E-mail me at beschorn@pitt.edu**