

WEBINAR

Recipe for Prevention of MSD: Learnings from Biomechanical Responses in Team Lifting and Sudden Load Drops

Dr. Peter Keir | July 19, 2022

Recipe for Prevention of MSDs: Learnings from biomechanical responses in team lifting and sudden load drops

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CRE-MSD

Objectives of today's webinar

- Introduce issues with lifting in the masonry trade
- Team lifting & Joint action
- A look at our 4 person lift/drop study
 - Analysis + interpretation
 - Secondary analysis of joint action (covid-19 pivot)
- Discussion of potential solutions and issues
- Take home points

The Problem(s)

- Masonry and Allied Trades Labour Management Committee (under IHSA)
- Industry concerns
 - Lifting heavy slabs
 - Awkward lifts
 - Materials
 - Environment
 - Multi-person lifts
 - Drops
 - Injuries to others



Lifting in Industry

- Awkward and heavy lifts are common in masonry work
- Often exceed limits for single workers
- Majority of heavy lifts
→ teams of 2 or more



(Coffey et al., 2016; Sharp et al., 1997; van der Molen et al., 2004; Visser et al., 2014)

Masonry and MSDs

- Masons at risk for developing musculoskeletal disorders (MSDs)
 - Work with heavy construction materials
 - Weight, lifting frequency, and postural challenges
- Construction sector responsible for 10% of all lost time claims in Ontario (WSIB)
 - 22% Upper extremity
 - 20% Back



Team Lifting

- Guidelines for weight limit not well established for team lifting
 - 25 kg/lifter × total number of lifters (Marras et al., 1999)
 - 50-80% of summed strength of team (Barrett & Dennis, 2005)
 - 1.75x strength of individual for a team of 4 (Barrett & Dennis, 2005)
- Mixed findings regarding biomechanical demands
 - Maximum voluntary isometric contraction (MVIC) higher in group scenario vs individually (Lee, 2004)
 - ↑ Number of lifters, ↓ lumbar spine torque and compression force (Dennis & Barrett, 2002; Visser et al., 2015)

Joint Action

- The coordination of multiple people acting together to accomplish a task.



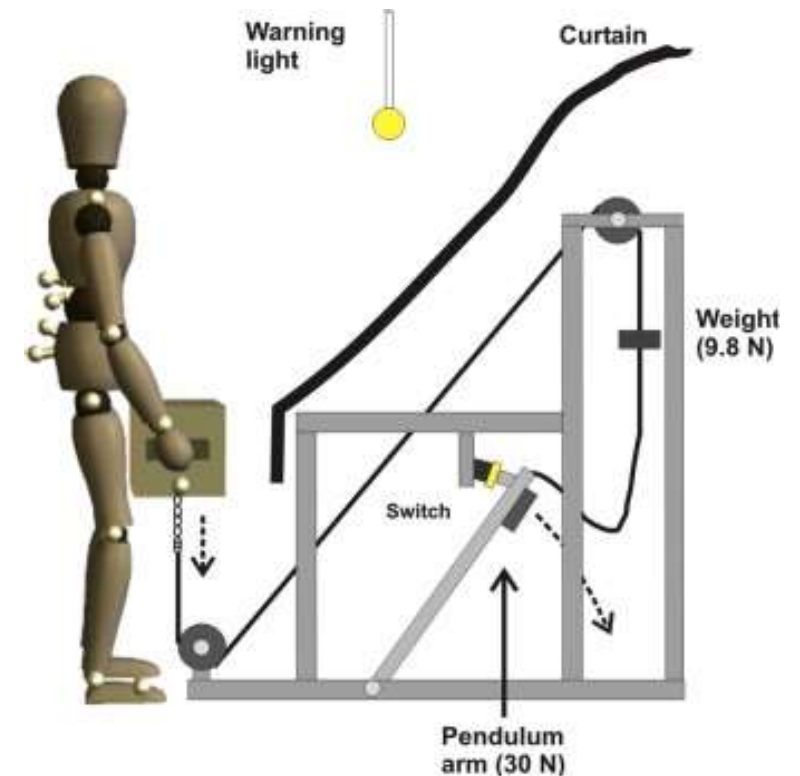
(Sebanz et al., 2006; van der Wel, 2011; Vesper et al., 2011; Vesper et al., 2017)

Joint Action Coordination

- 2 or more actors coordinate their actions under real time constraints
- Intentionally ↓ variability of actions to ↑ predictability and coordination
- Can these underlying mechanisms inhibit the desired outcome?

Sudden Loading

- Various approaches
 - Sudden horizontal force to cause trunk flexion (Skotte et al., 2004)
 - Sudden loading of box held in hands (Hwang et al., 2008; Mawston et al., 2007a; Grondin & Potvin, 2009)
 - Sudden pull from loaded box (Mawston et al., 2007b)
 - Sudden load release (Zhou et al., 2013)
- Primarily studied in **single** lifters
- What happens with **multiple** lifters?



Objective

To quantify changes in external forces and muscle activity (EMG) with unanticipated drops during team lifting

Rationale

- Masonry and Allied Trades Labour Management Committee (under IHSA)
 - Concerns about workers lifting awkward, very heavy stone slabs
 - Need information related to drops and injury risk with multi-person lifts
- Notes:
 - Masons handle blocks ~ 2.5 hours/day
 - Stones & slabs may exceed 200 kg

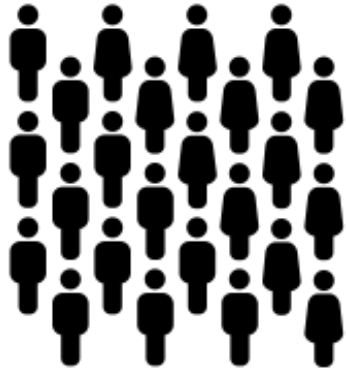
(Barrett & Dennis, 2005; van der Molen et al., 2008)

Purpose

- To determine distribution of hand forces and muscular demands during 4-member slab lifts
- To determine how demands change in response to a sudden release by a single team member

METHODS - Participants

24 Participants

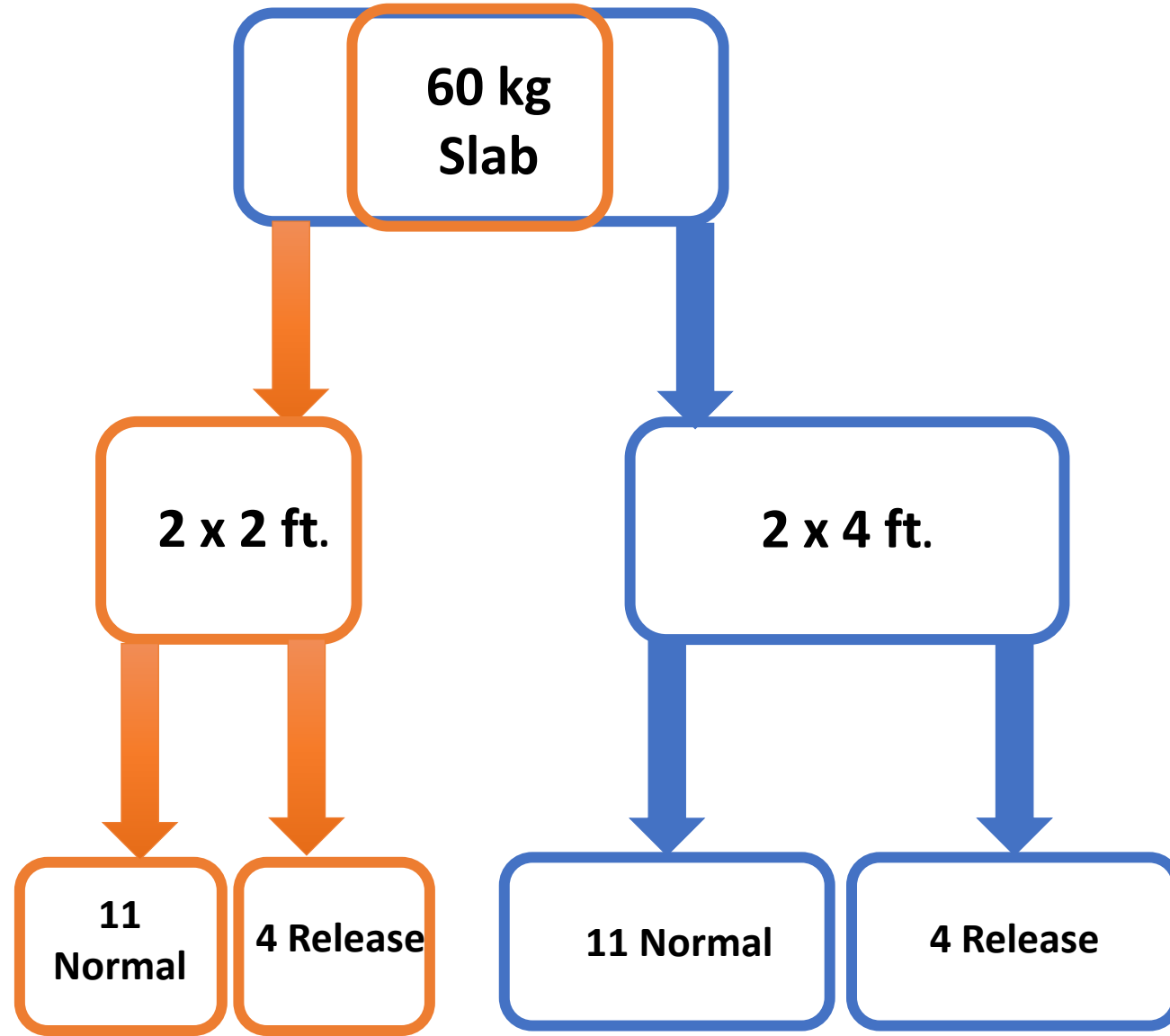


6 Groups of 4

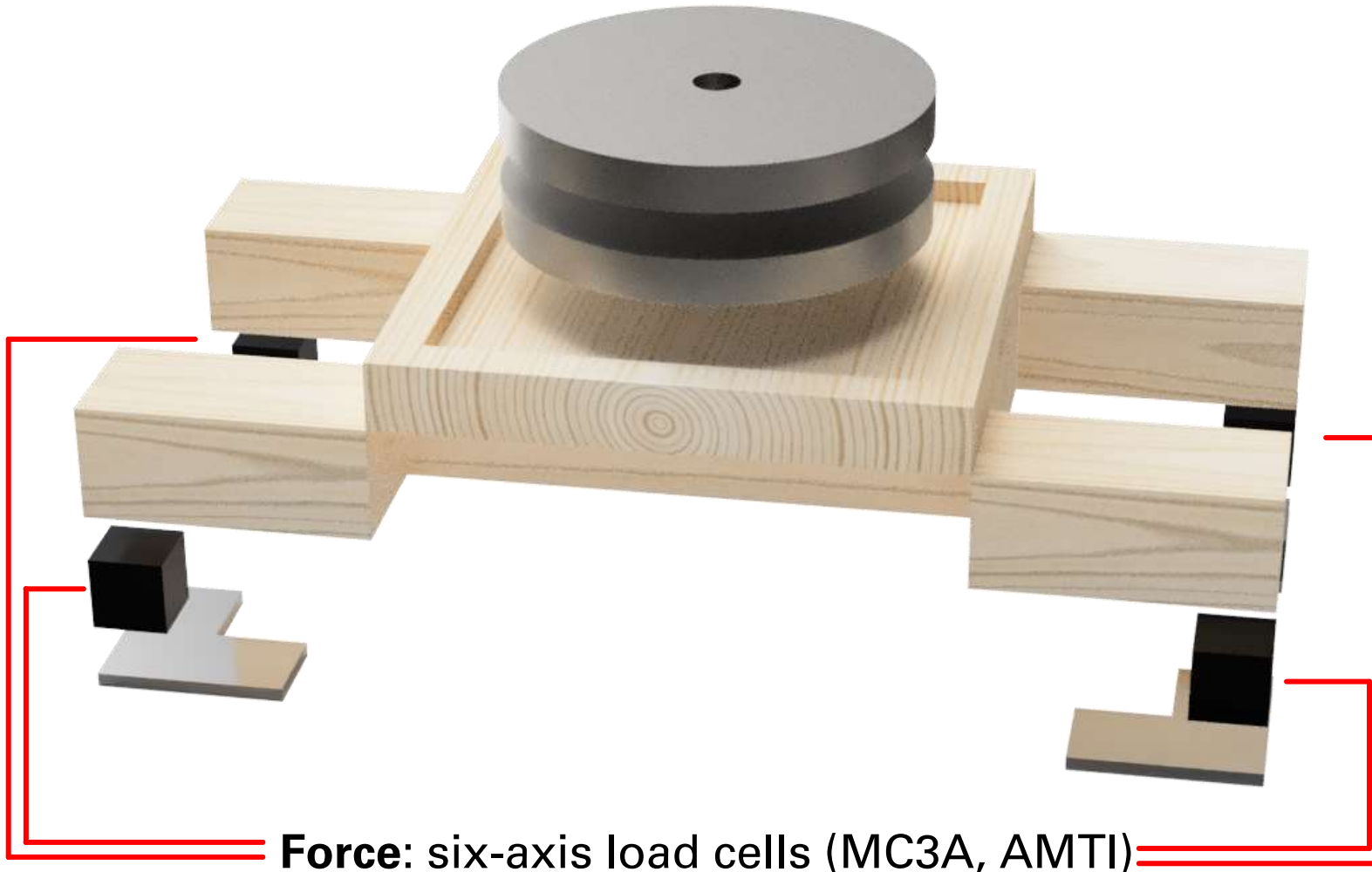


No prior injuries

Protocol



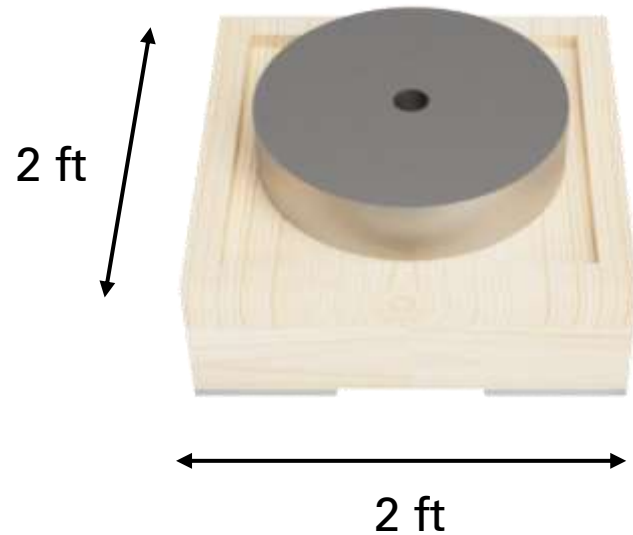
"Slab"



Force: six-axis load cells (MC3A, AMTI)

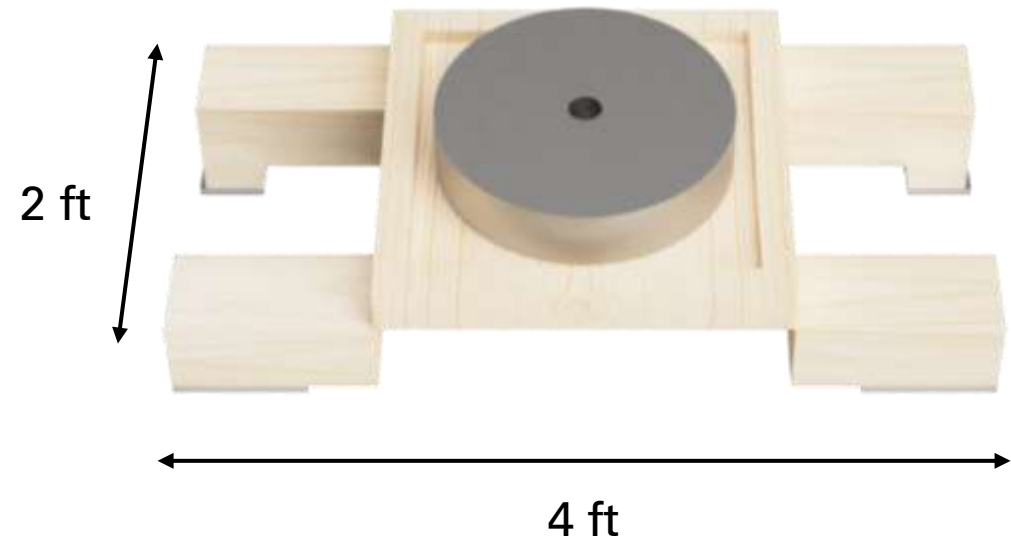
Total mass:
60 kg

Trials split between two configurations



Square

15 Trials
11 NON-DROP
4 DROP



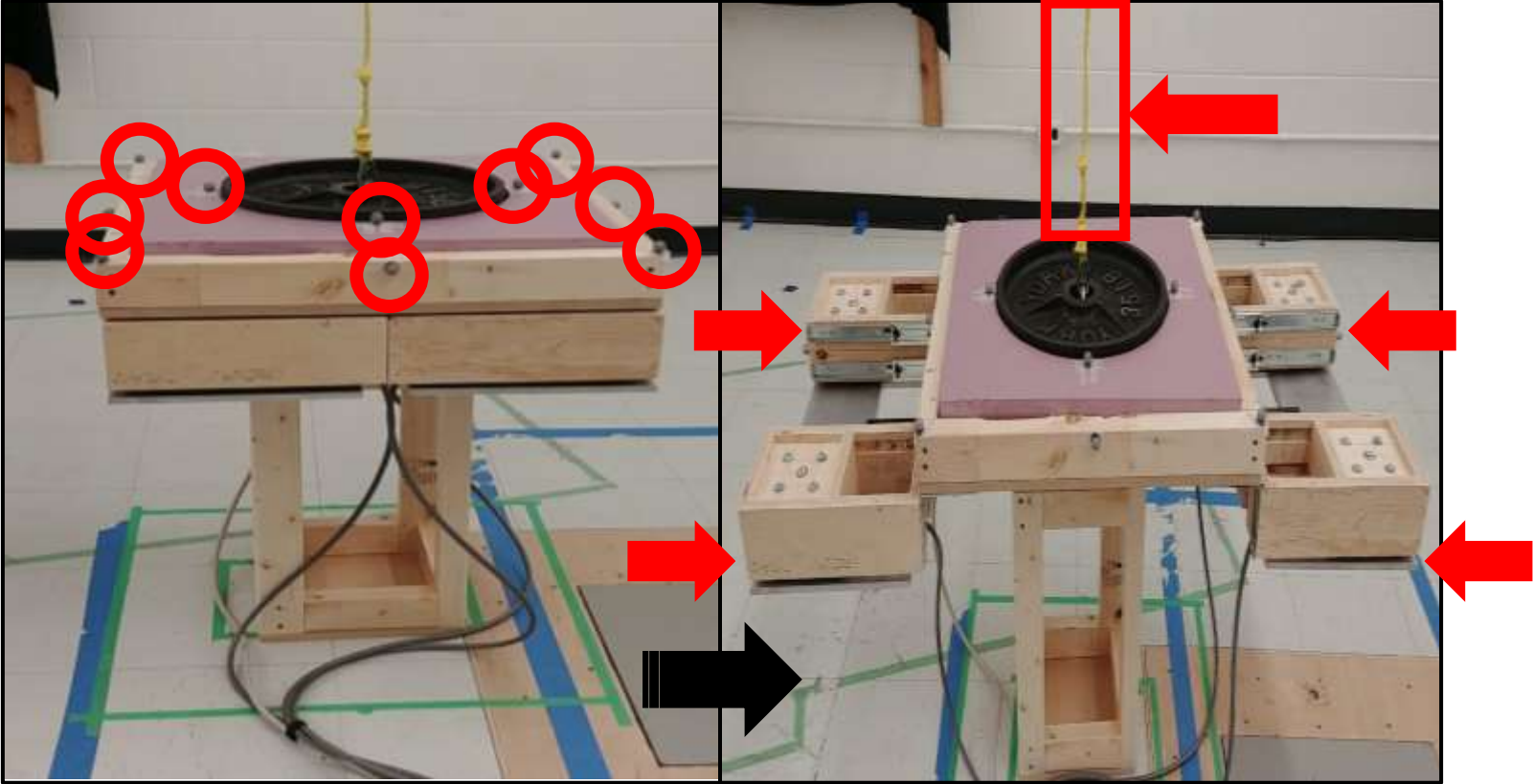
Rectangle

15 Trials
11 NON-DROP
4 DROP

The "slab" set up

Square
2' x 2'

Rectangular
2' x 4'



Protocol

- 24 healthy males (6 groups of 4)
- Start with 2' x 2' slab (square) or 2' x 4' slab (rectangle)
 - 30 trials total, 15 per configuration



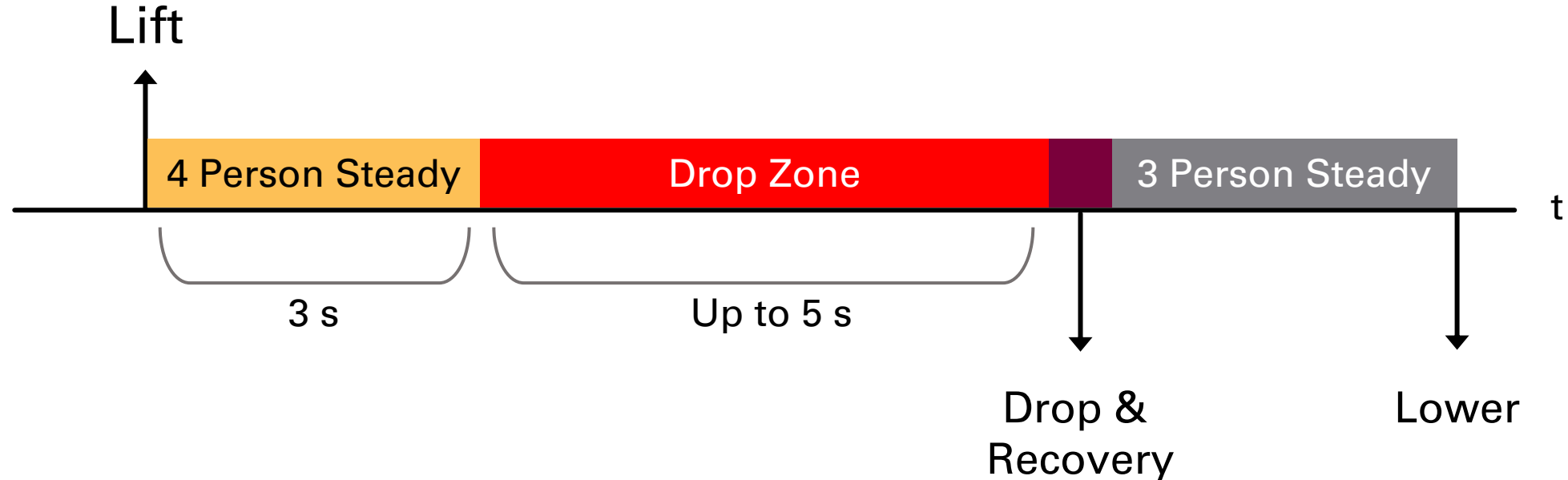
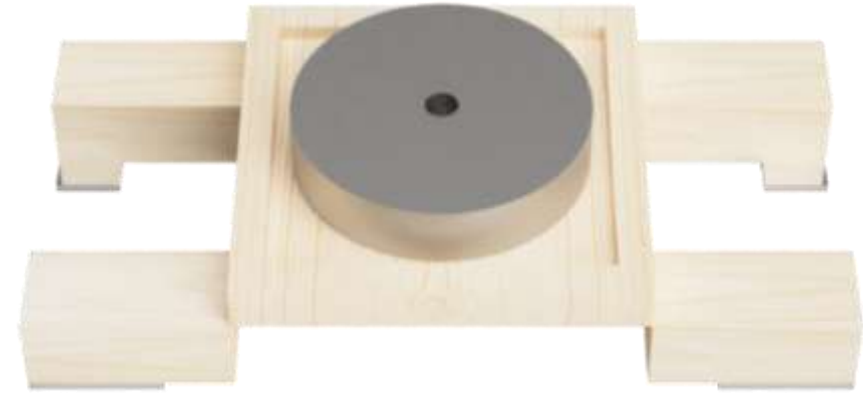
11 x NON-DROP trial (lift and hold)



4 x DROP trial

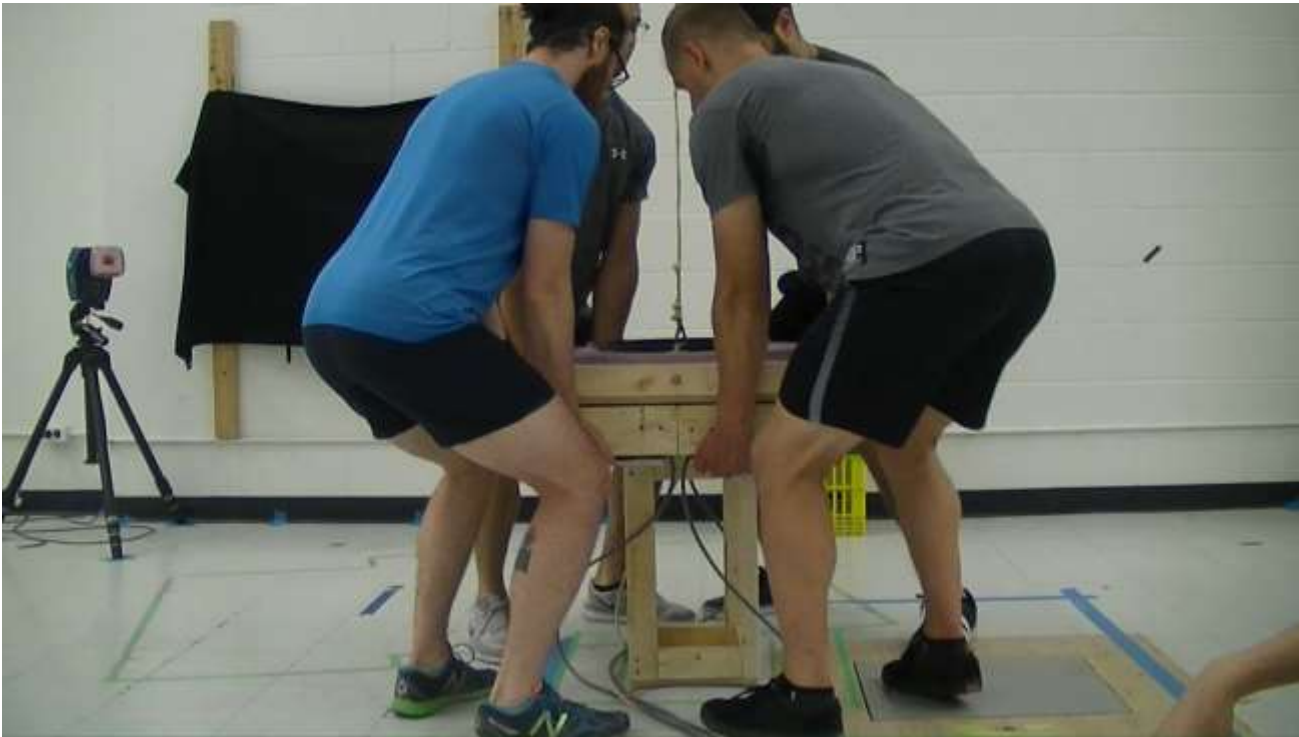
Trials

- 30 trials in total
 - 22 NON-DROP (lift and hold)
 - 8 DROP
- Lift from knee to knuckle height



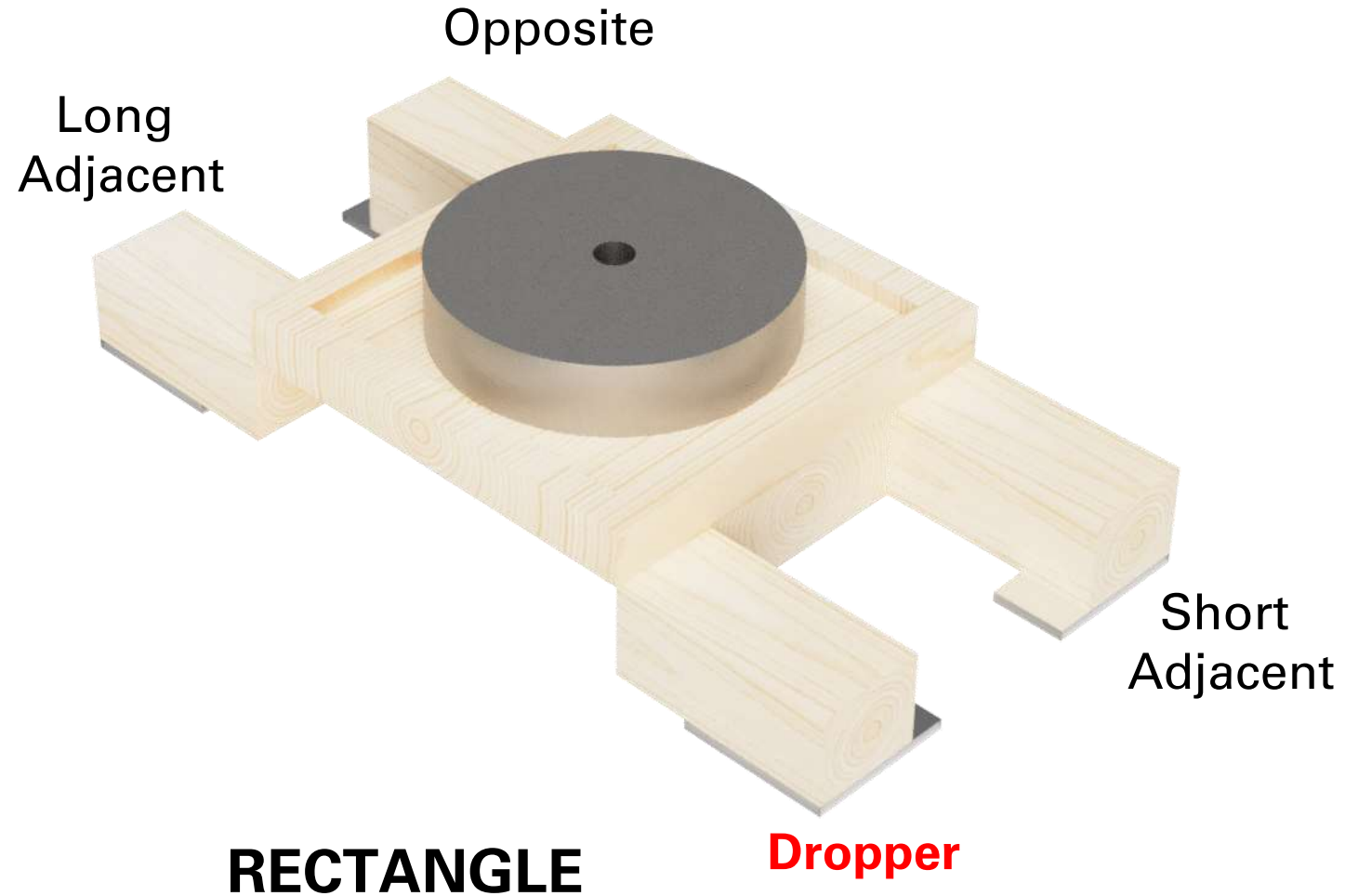
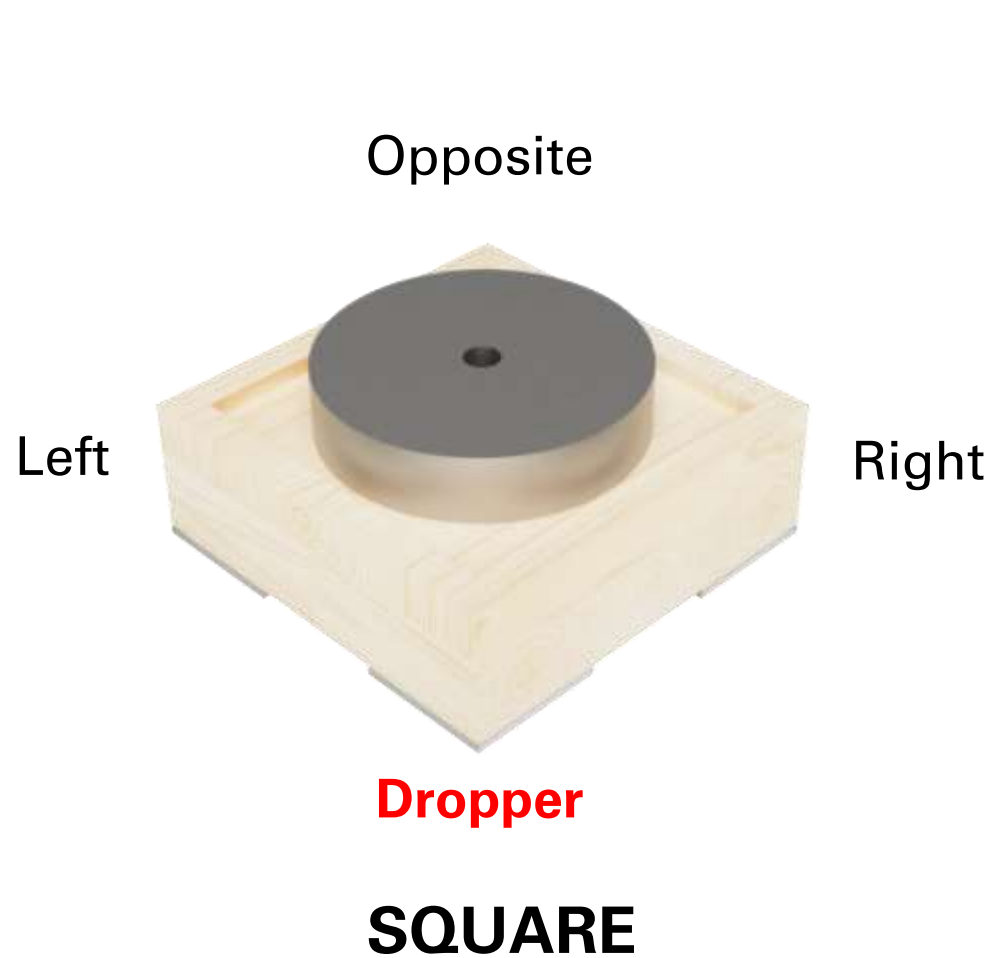
Protocol

DROP TRIAL



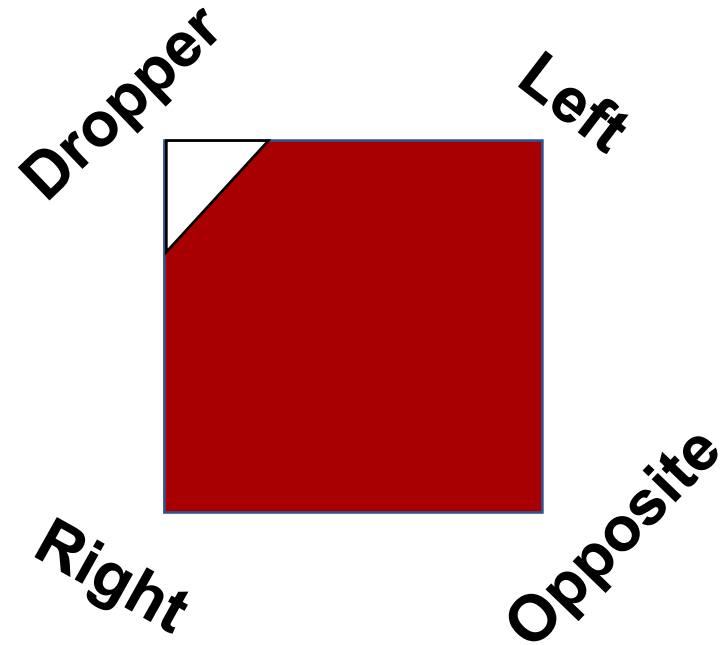
- Lifter at each corner
 - Force each corner (*AMTI MC3*)
 - EMG – Right side (*Delsys Trigno*)
 - Anterior Deltoid
 - Biceps
 - Upper trapezius
 - Lumbar Erector Spinae
- Motion Capture of slab
 - *Motion Analysis Corp.*
- Protocol
 - Lift from knee to knuckle height
 - Stabilize load for 3 seconds
 - 5 second “DROP ZONE”
 - Remaining 3 lifters stabilized load

Force & EMG recorded for each position

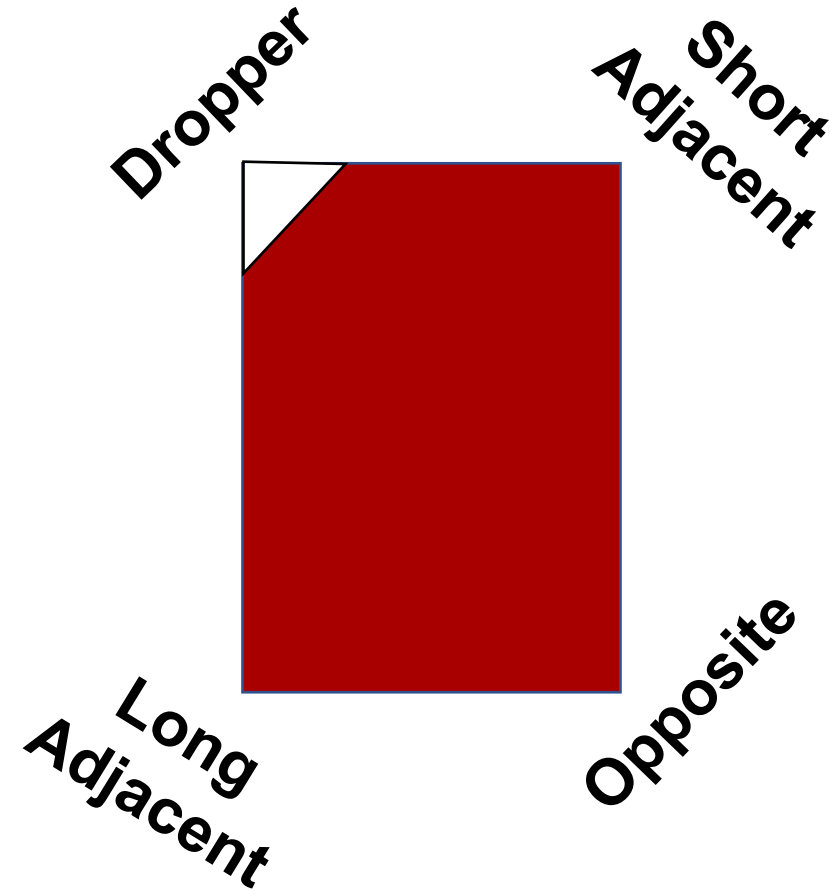


Analysis

Square
2' x 2'

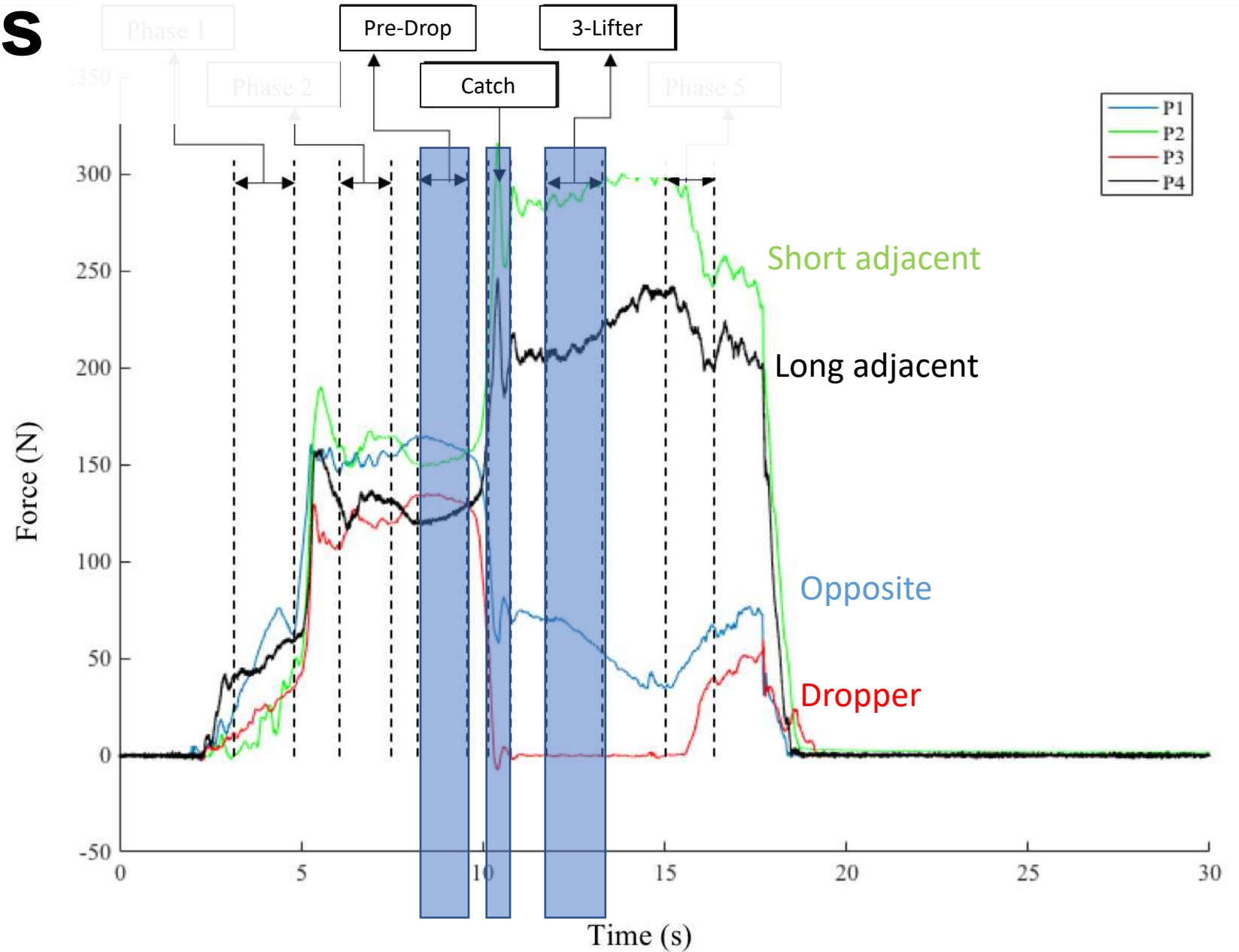
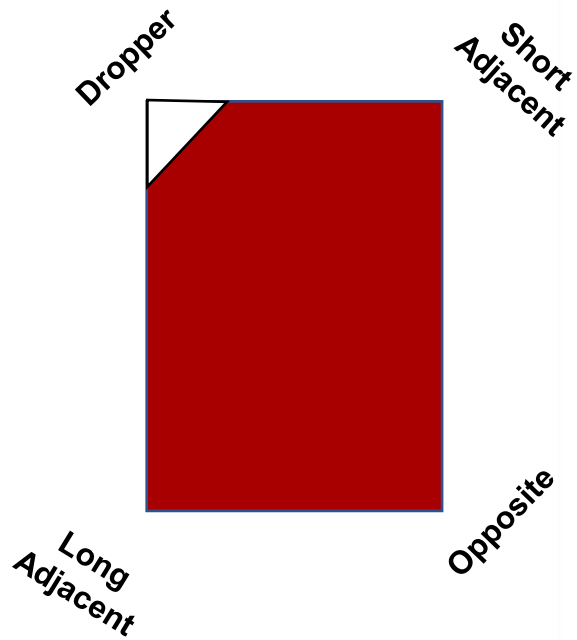


Rectangular
2' x 4'

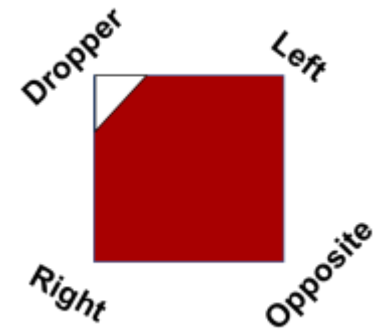
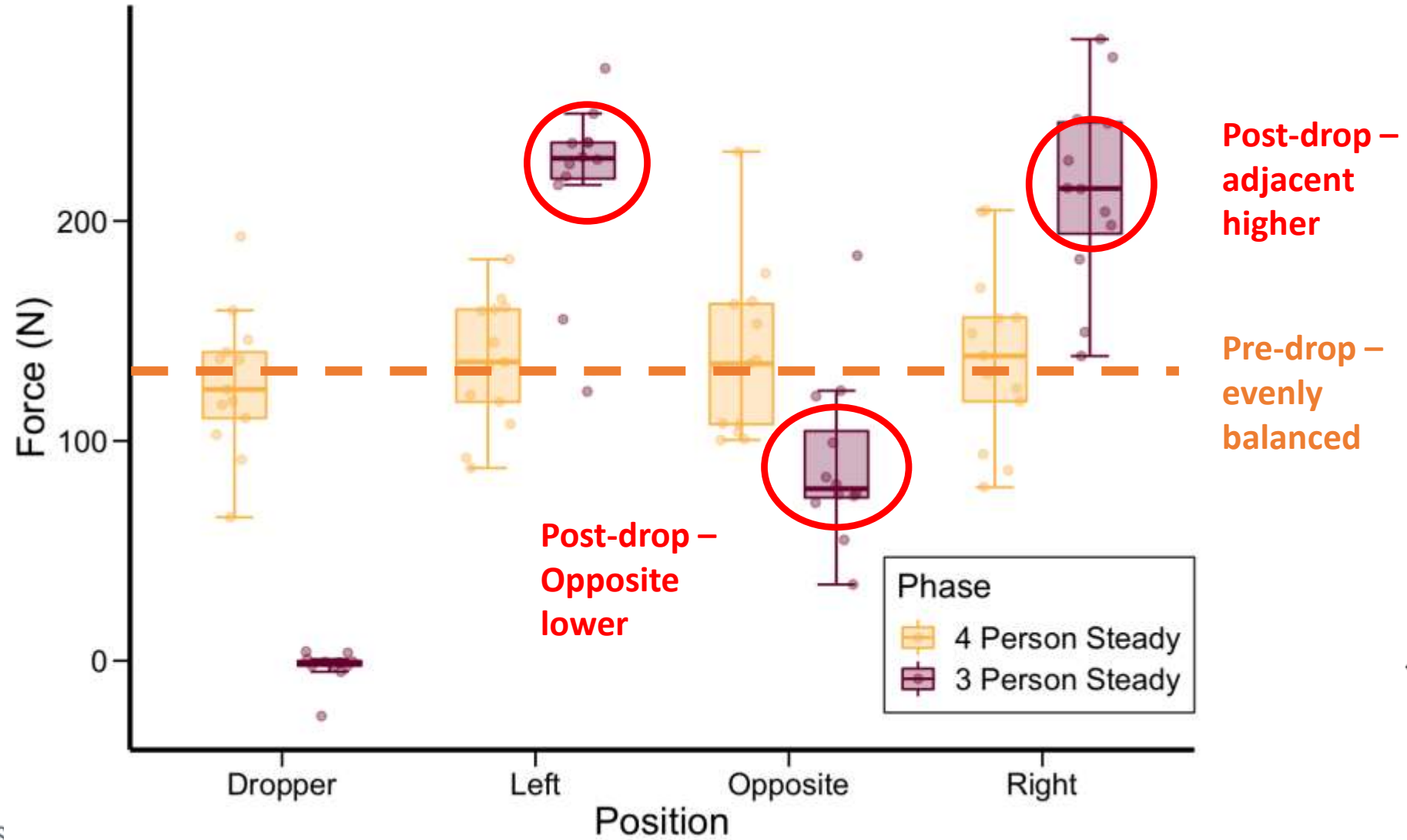


Results

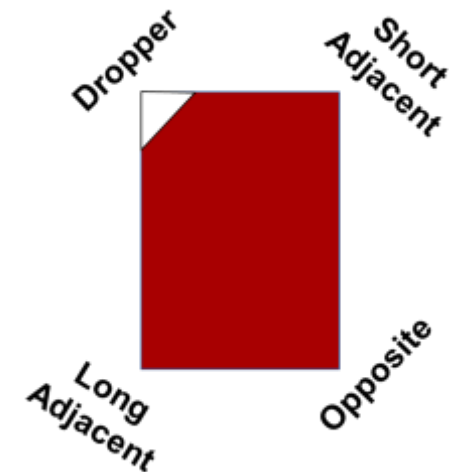
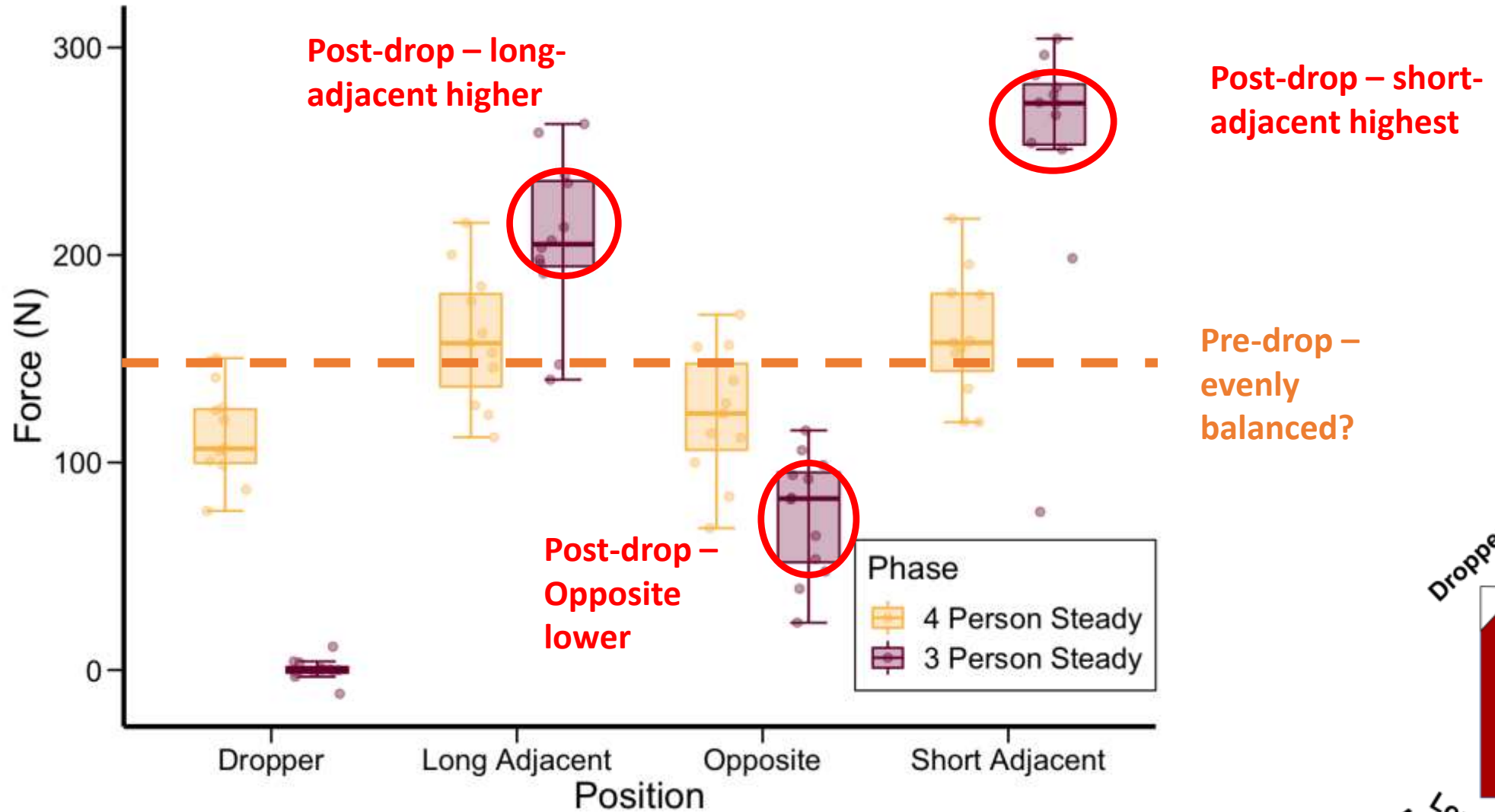
Lifting Phases



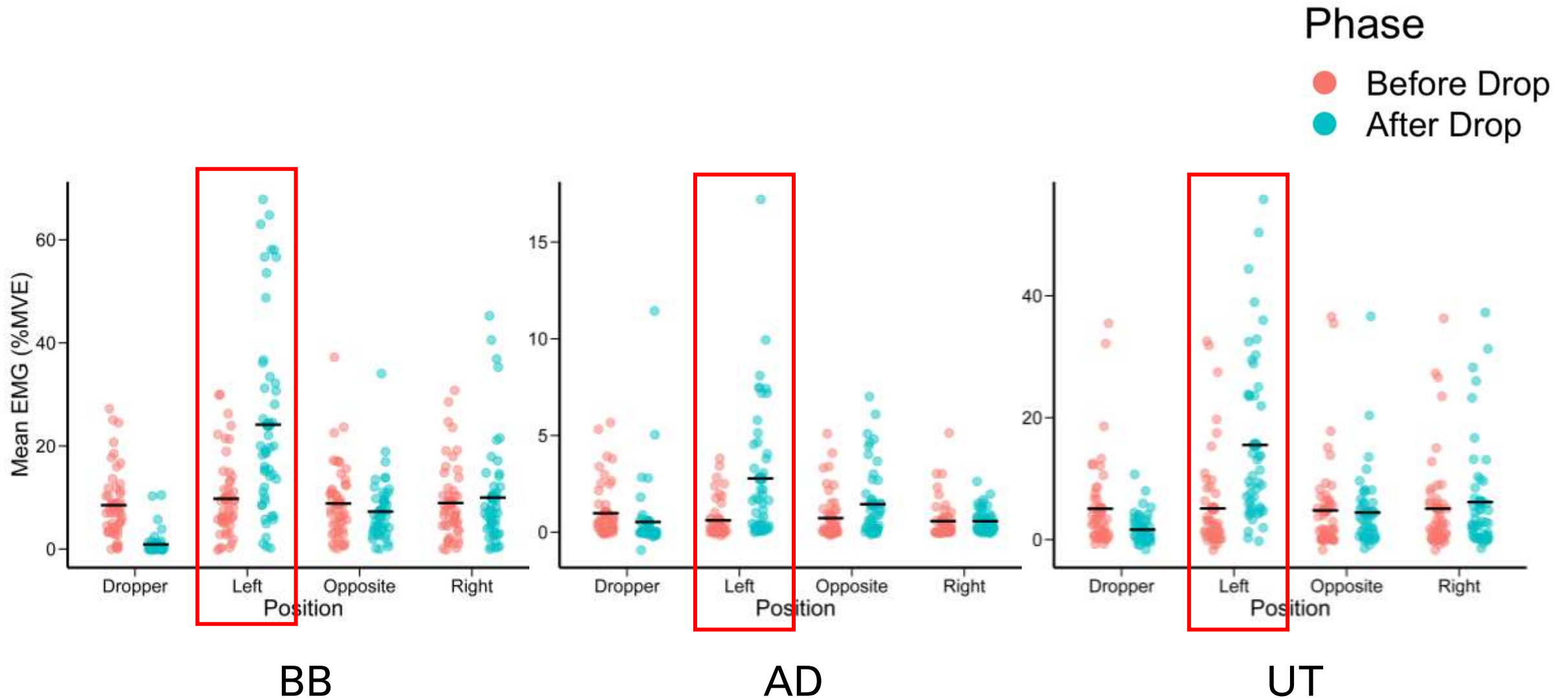
Square Load – ↑ Load on Adjacent Lifters



Rect. Load – ↑ Load on Short Adjacent Lifter



↑ Muscle activity for lifter to the left of dropper



Discussion

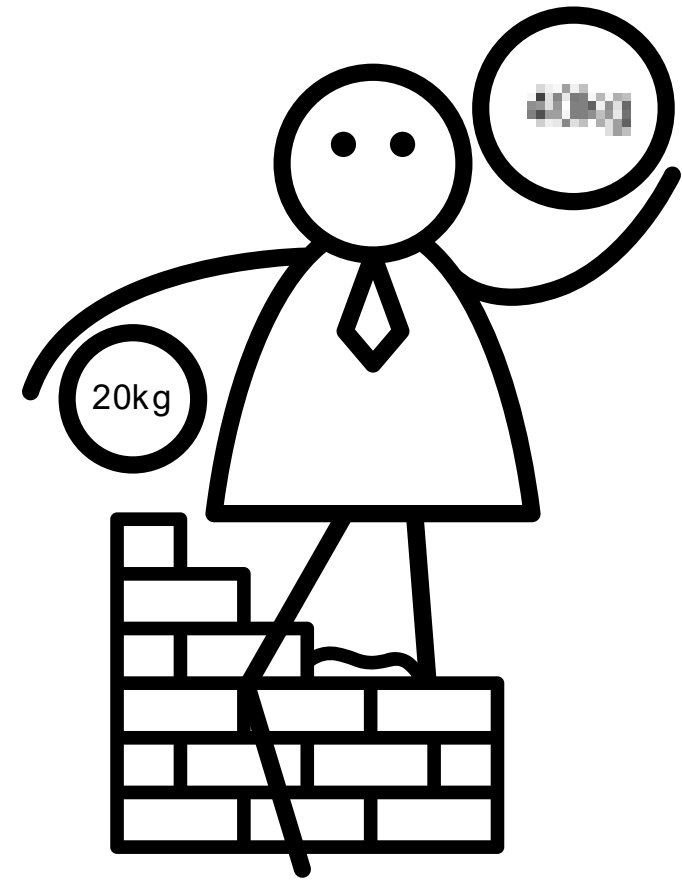
- Shape of the load affected load distribution pre and post release
- Following release, adjacent lifters experienced \uparrow loading
 - Heightened response during 2x4 configuration for short edge lifter
 - Greater risk of injury
- Opposite lifter experienced \downarrow loading

Key Findings

- **Load shape & position** alter force contribution following sudden load release
 - Peak force contribution of up to 43% of total team load
 - Short adjacent lifter
 - Drop trial exceeded NIOSH lifting recommendations
- Lifter **closest to dropper** experienced greater **upper extremity** (BB, AD, UT) muscle activity
 - Sudden load release in team lifting possible mechanism of injury for masonry workers

Limitations

- Participants not height, weight, or strength matched
- Slab weight
 - Very conservative (light) load
 - 60 kg split amongst 4 people for safety
 - Concrete slabs can weigh up to 200 kg
- EMG recorded unilaterally (right side only)
- Lift → hold → lower protocol - Not realistic
- Task specific lifts
 - Lift and carry
 - Knuckle to shoulder lifts



TAKE HOME POINT

The lifter closest to the dropper experiences the greatest biomechanical demand during sudden load release

Further analysis



Riley Craig Thesis Pivot

An investigation of biomechanical signals and their contribution to joint action during team lifting

Riley Craig

MSc Thesis Defence

Thursday August 19th, 2021

Purpose

- The aim of this thesis was to investigate how individuals work together during a four-person lifting task involving an unexpected release from a single team member.
- Do a lifter's biomechanical signals alert other lifters of an imminent release during a four-person lifting task where the goal is to elicit an unexpected response from a group following a load release?

Questions

1. Is a connection between the dropper and lifter opposite evident via biological signals?
2. Do other lifters share a similar connection?

Hypotheses

1. Dropper will alert lifters via
 1. ↑ vertical force
 2. ↑ muscle activity - %MVE (dropper)
2. Correlated response by other lifters as in (1)
3. Individual lifter response will be coordinated :
 1. First response - Lifters adjacent to dropper
 2. Then - Lifter opposite the dropper
4. Timing of biomechanical responses
 1. Anticipatory muscle activity

Protocol

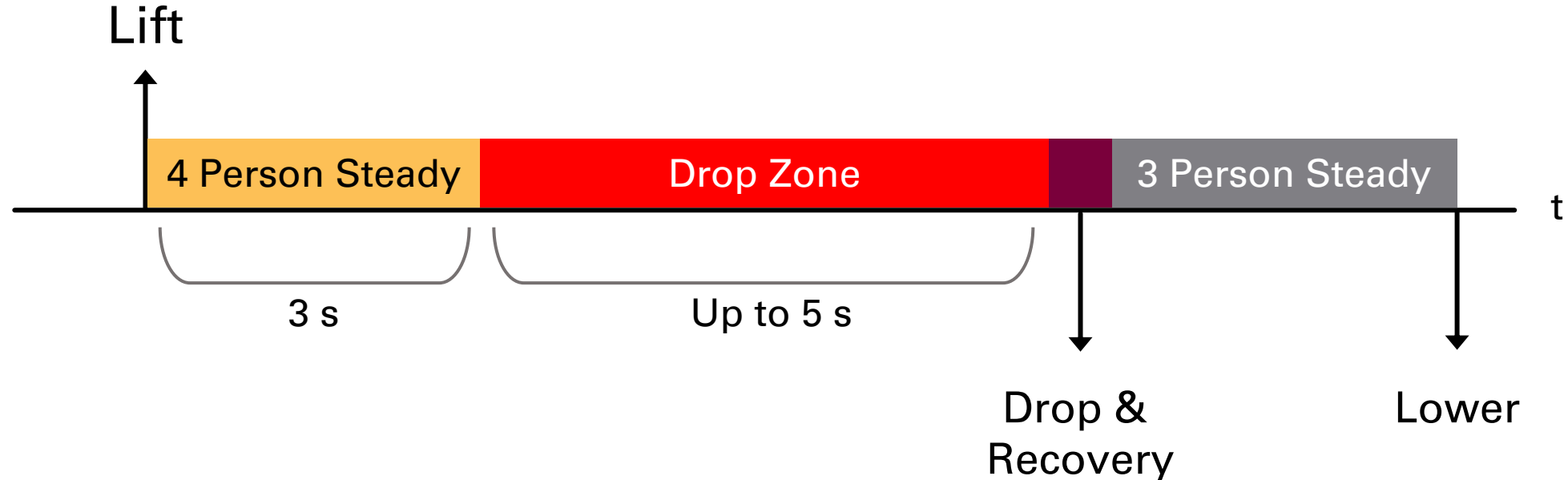
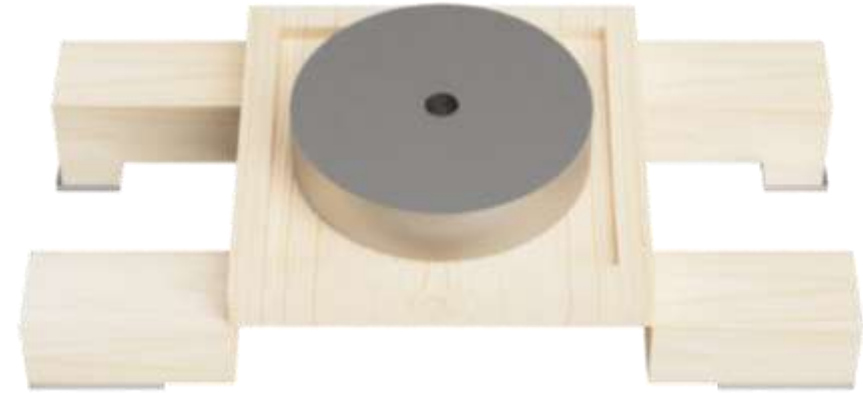
DROP TRIAL



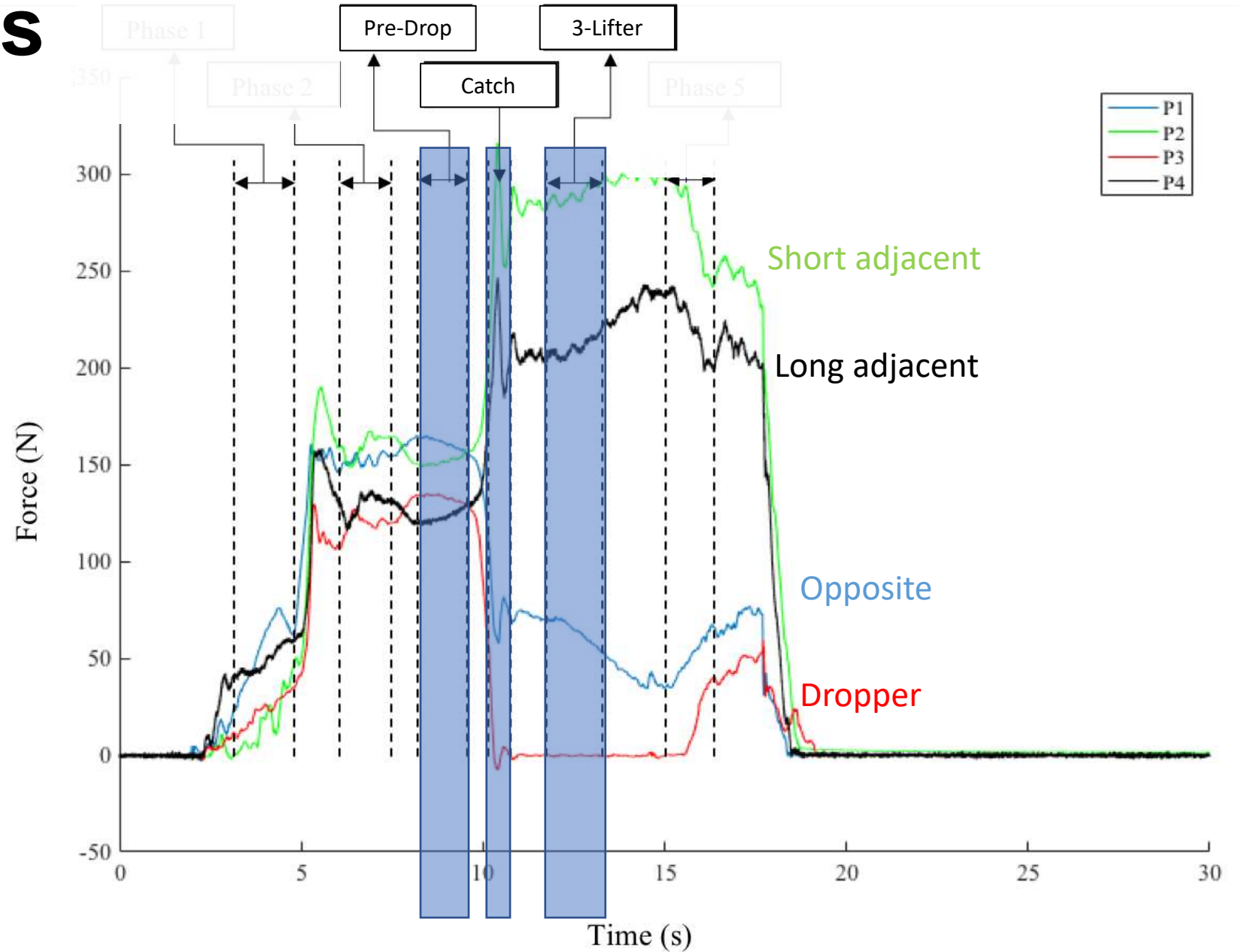
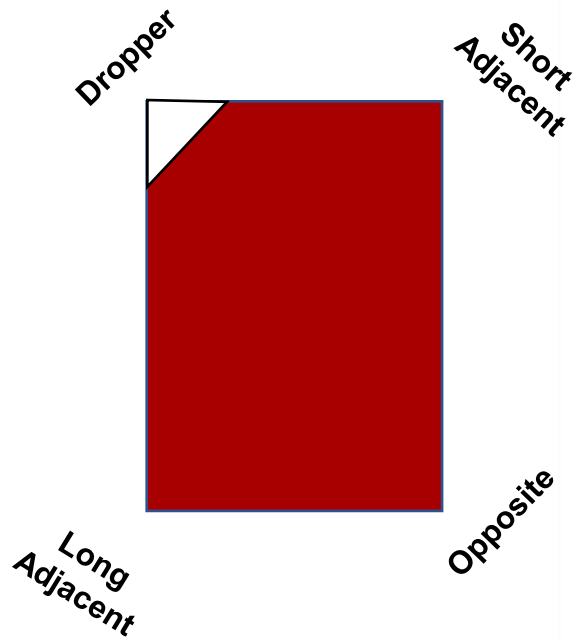
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Trials

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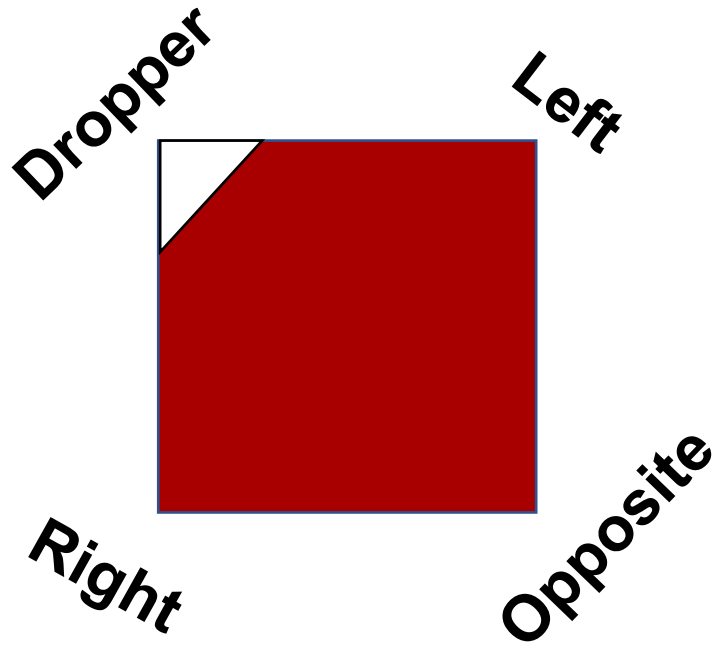


Lifting Phases

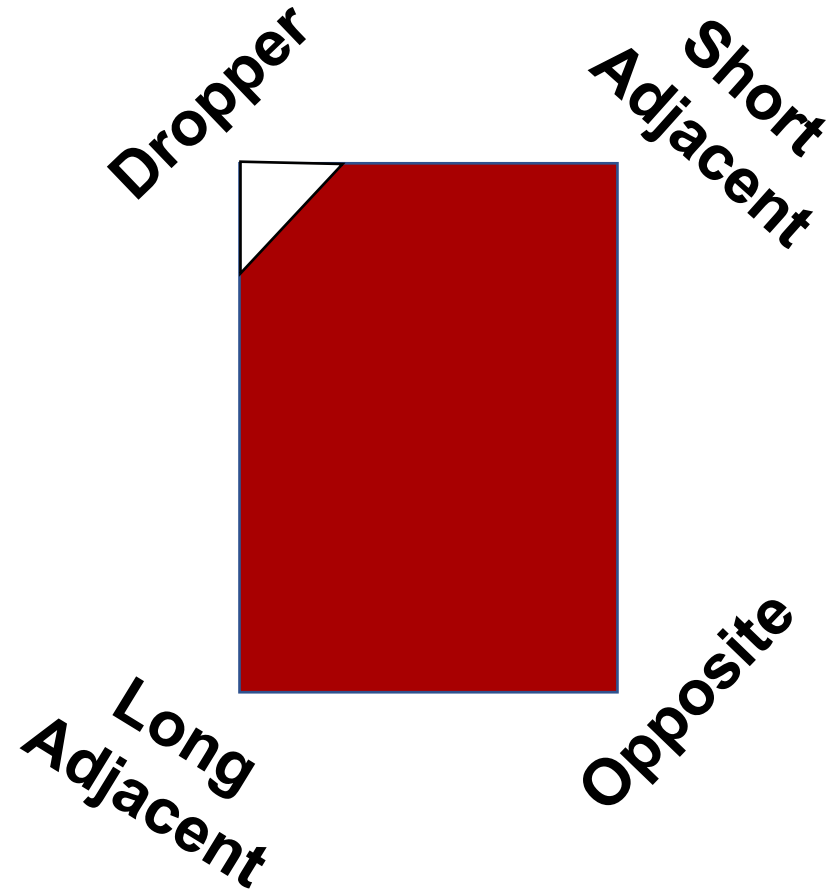


Analysis

Square
2' x 2'

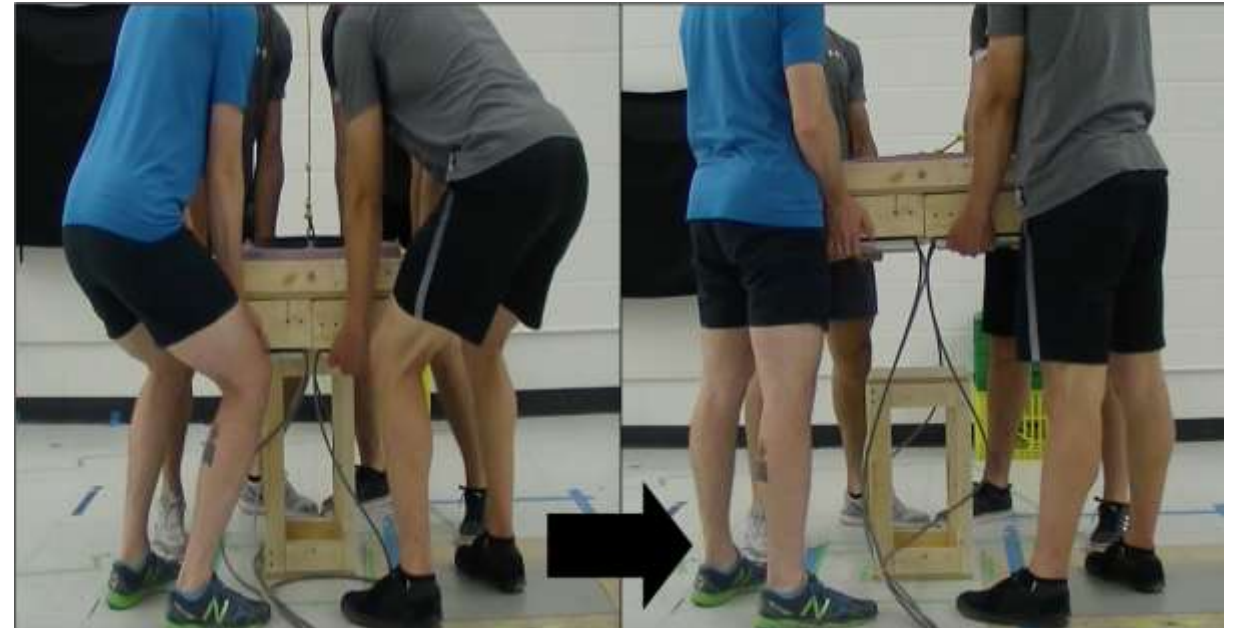


Rectangular
2' x 4'



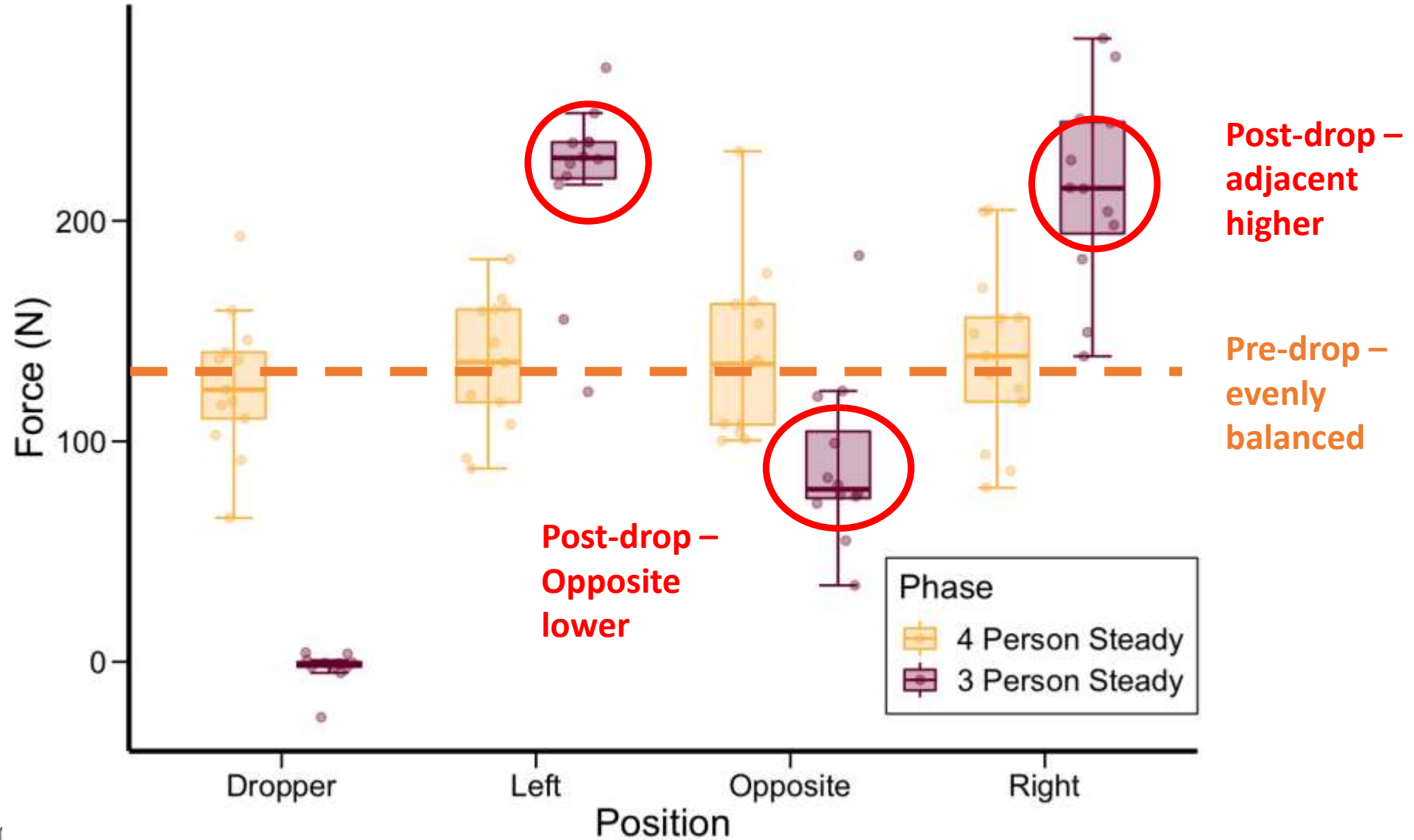
Control condition - No-Drop Trials

- Control/baseline
 - Force
 - EMG
- Variance and SD
 - EMG
 - Vertical and resultant force
- Means, SD, and coefficient of variation

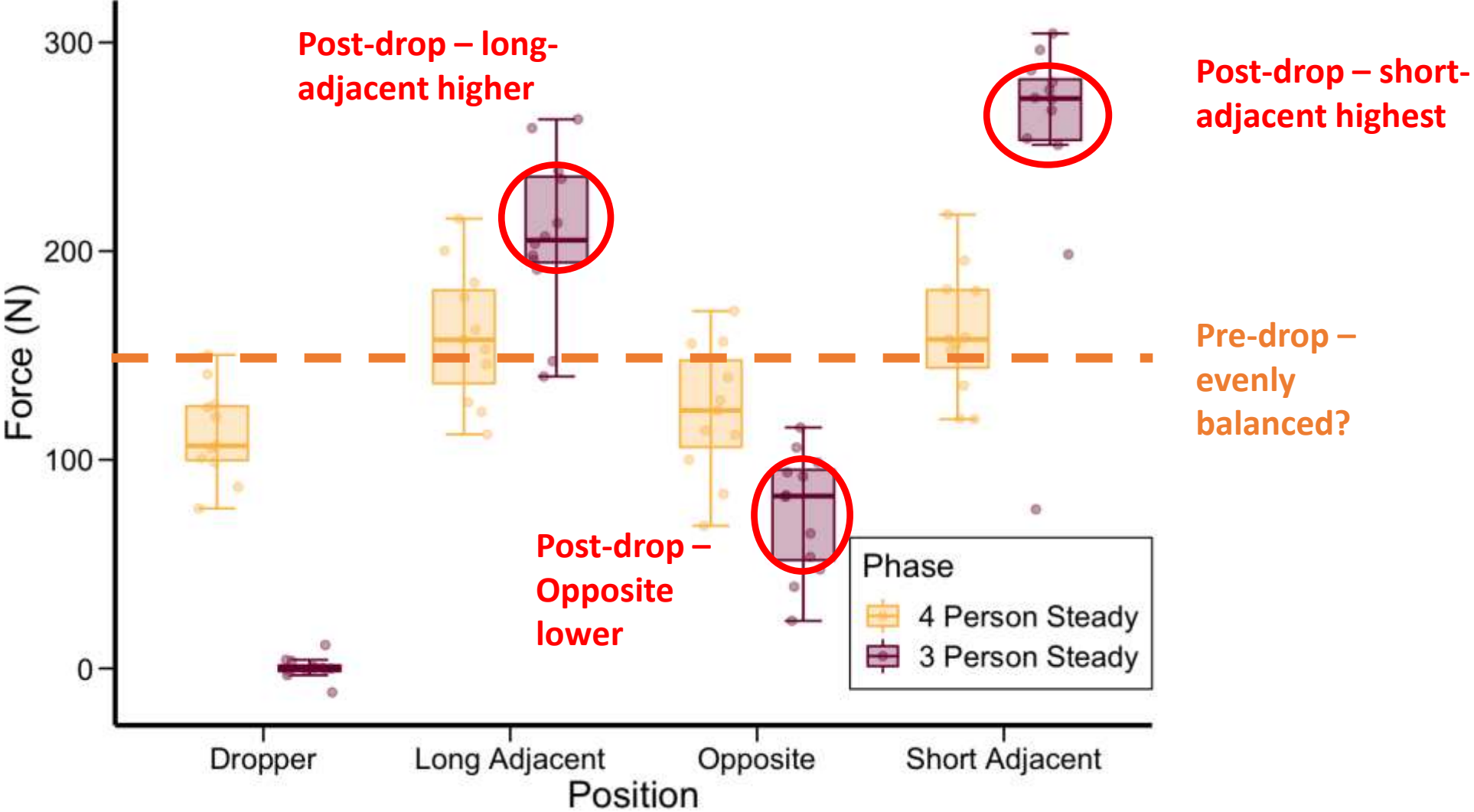


Results

Square Load – ↑ Load on Adjacent Lifters (post-drop)

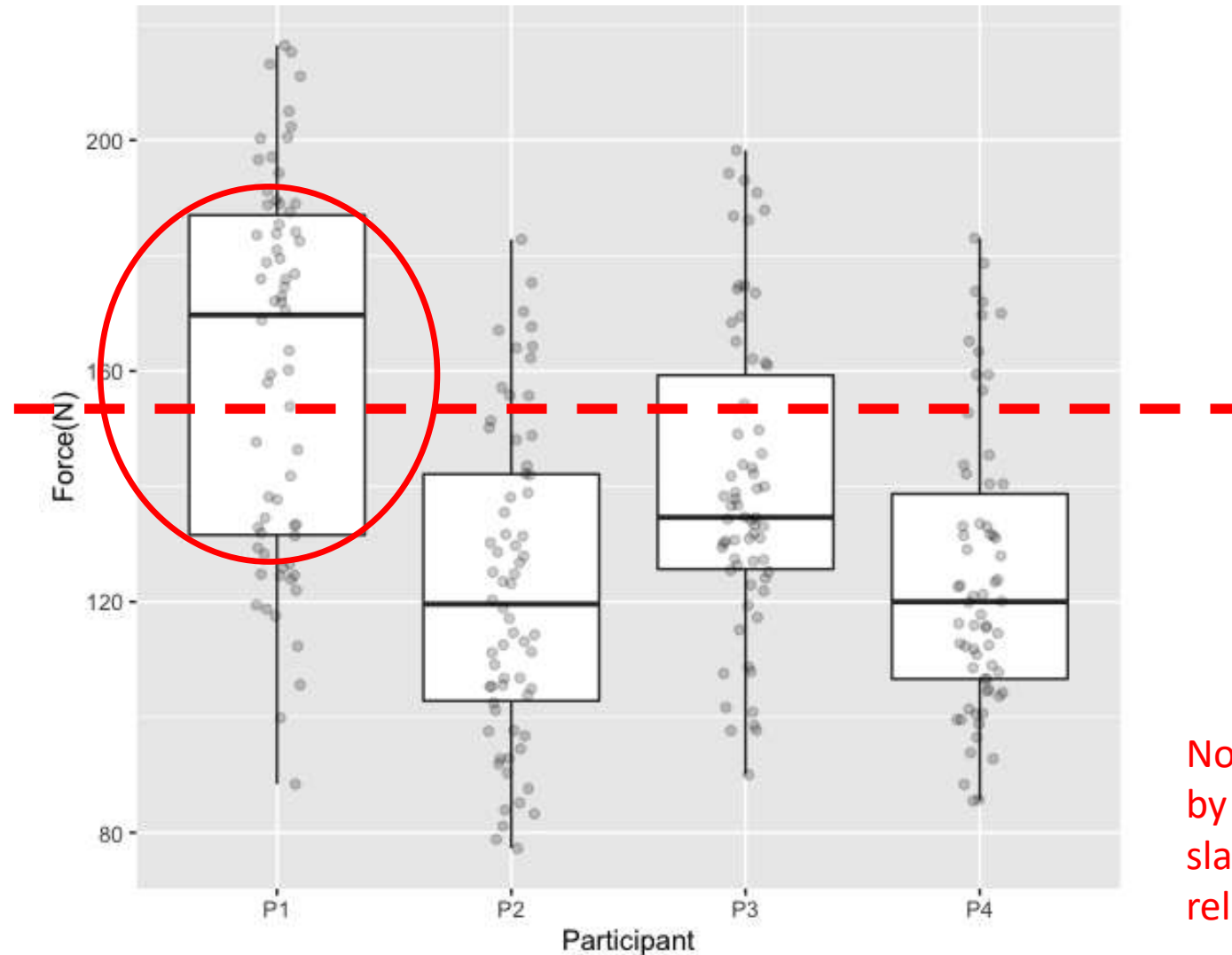


Rect. Load – ↑ Load on Short Adjacent Lifter – post drop



Steady State Forces for Non-Drop Trials (Square)

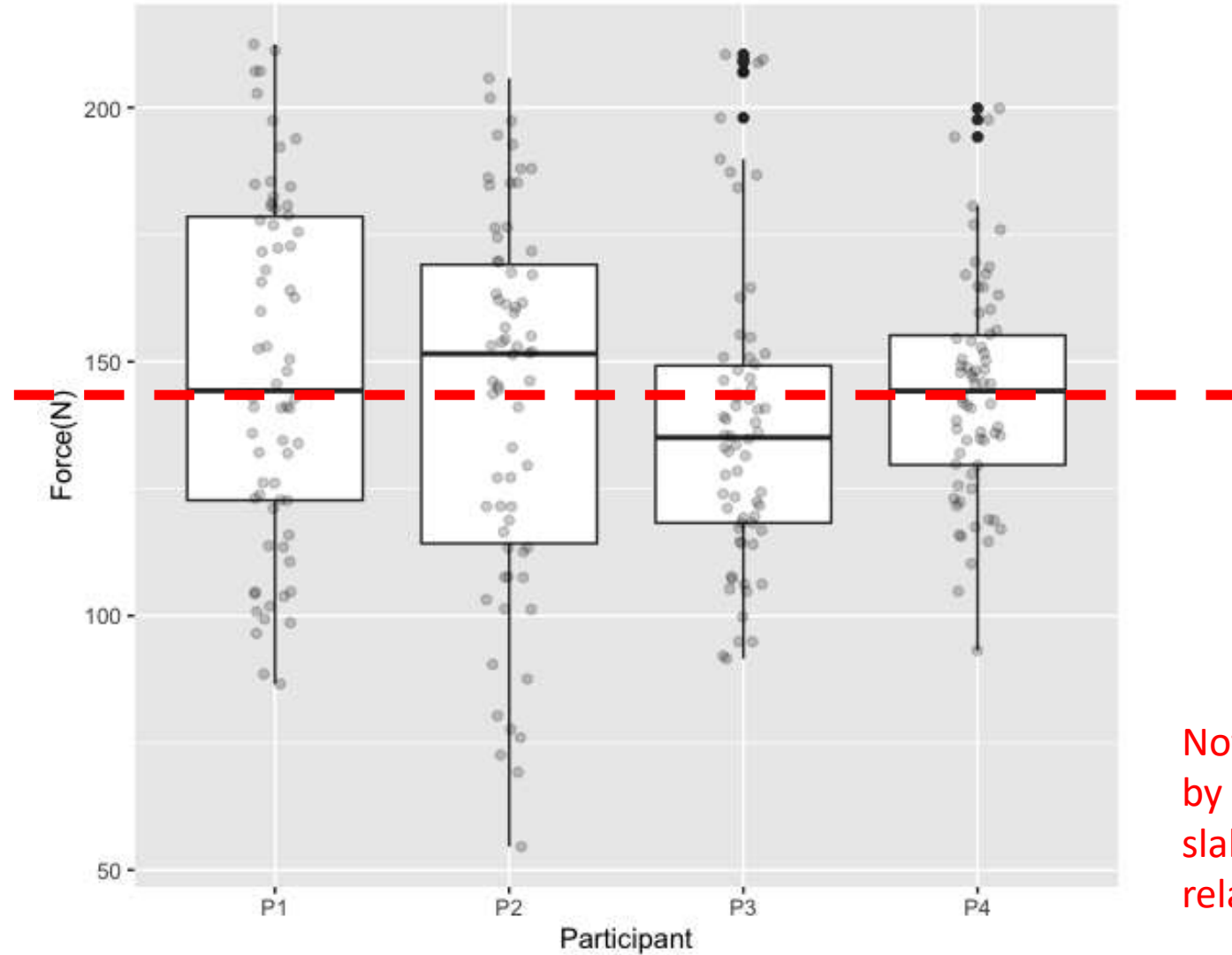
- Not equally distributed
- P1 large and greater variability (why?)



N= 6 participant for each of P1-P4
- 22 trials included

Note: the x-axis is organized by participant position on slab (or corner) rather than relative to dropper

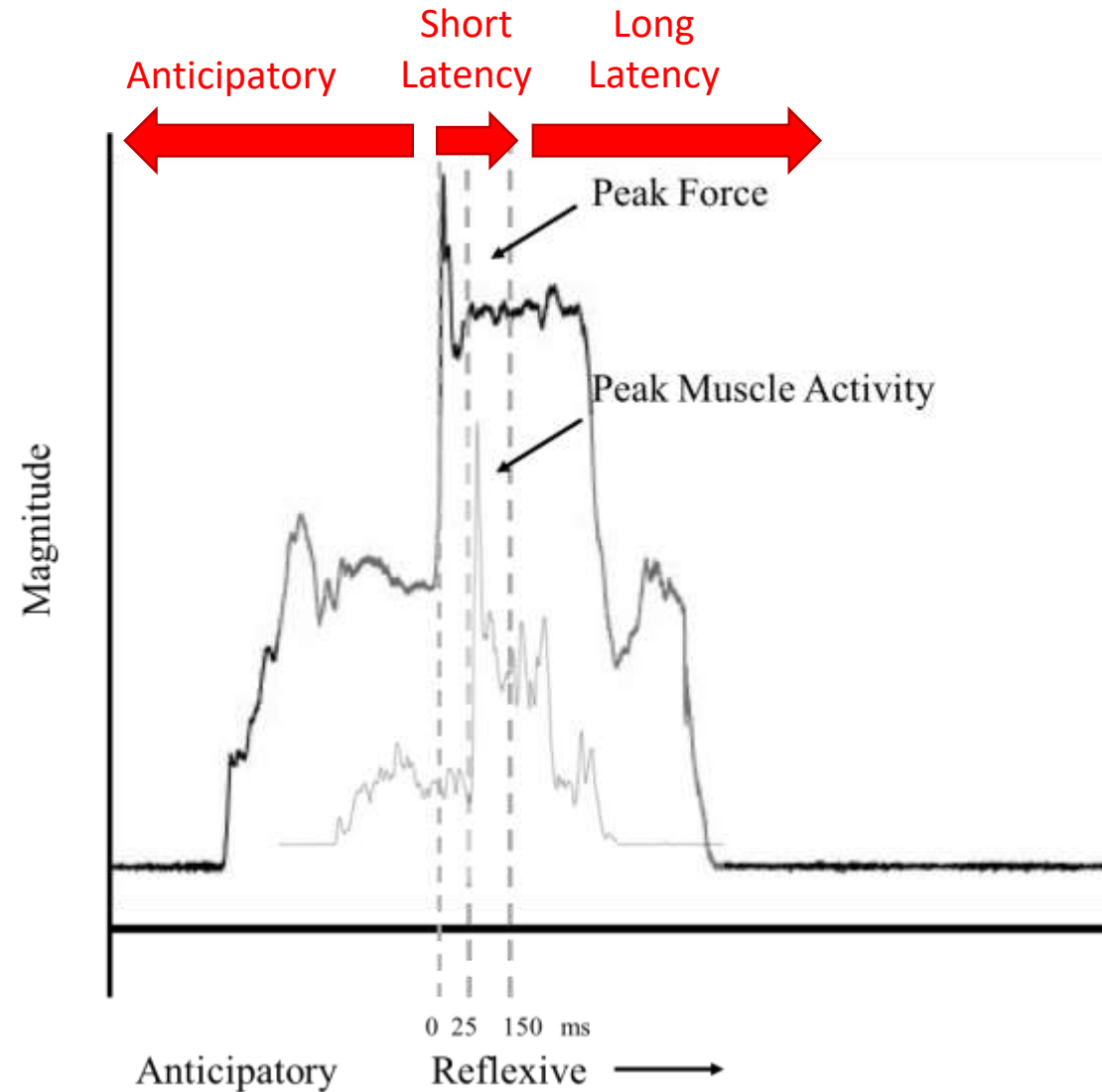
Steady State Forces for Non-Drop Trials (Rectangle)



N= 6 participant for each of P1-P4
- 22 trials included

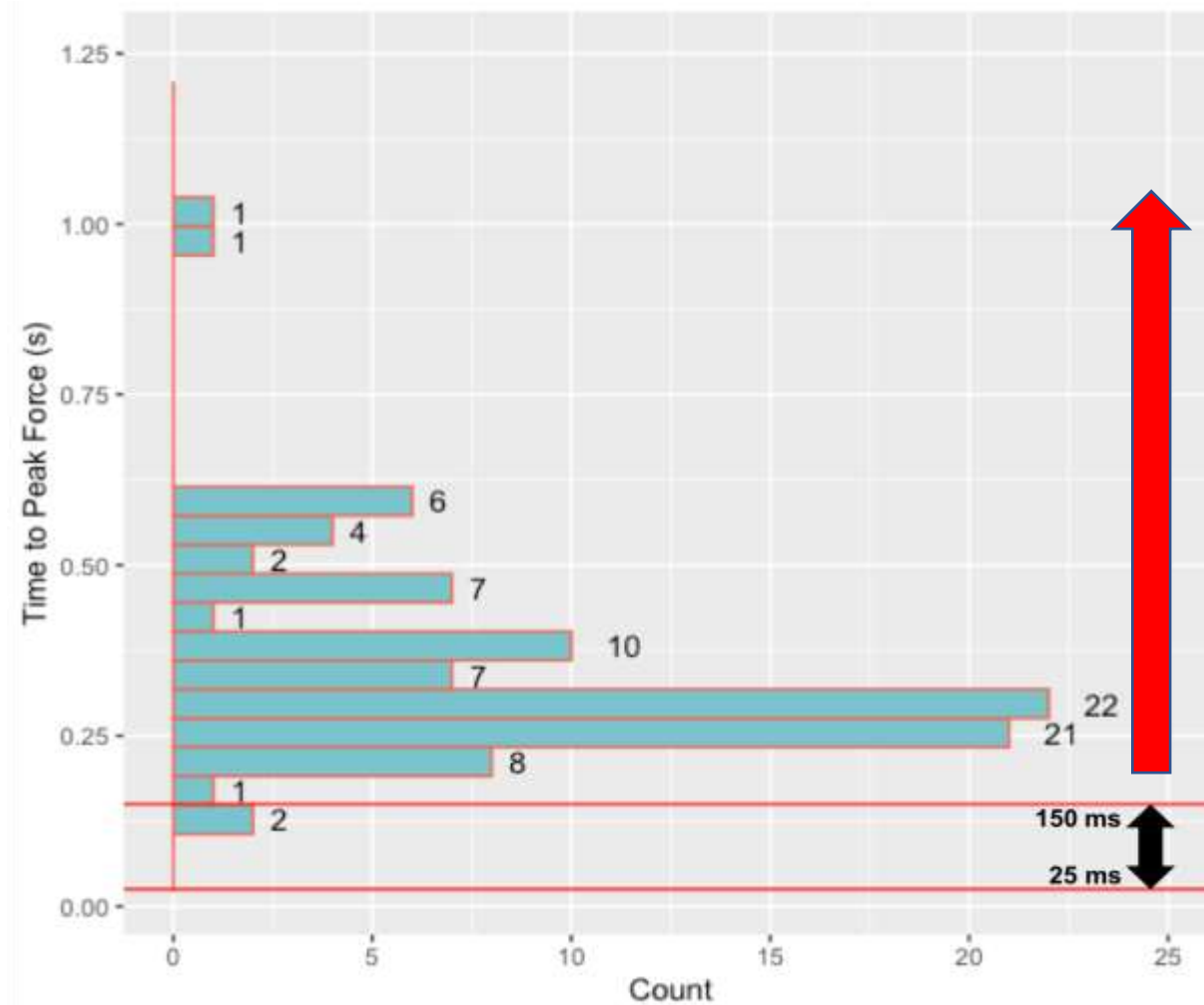
Note: the x-axis is organized by participant position on slab (or corner) rather than relative to dropper

Reflex vs. Anticipatory Actions (Timing)



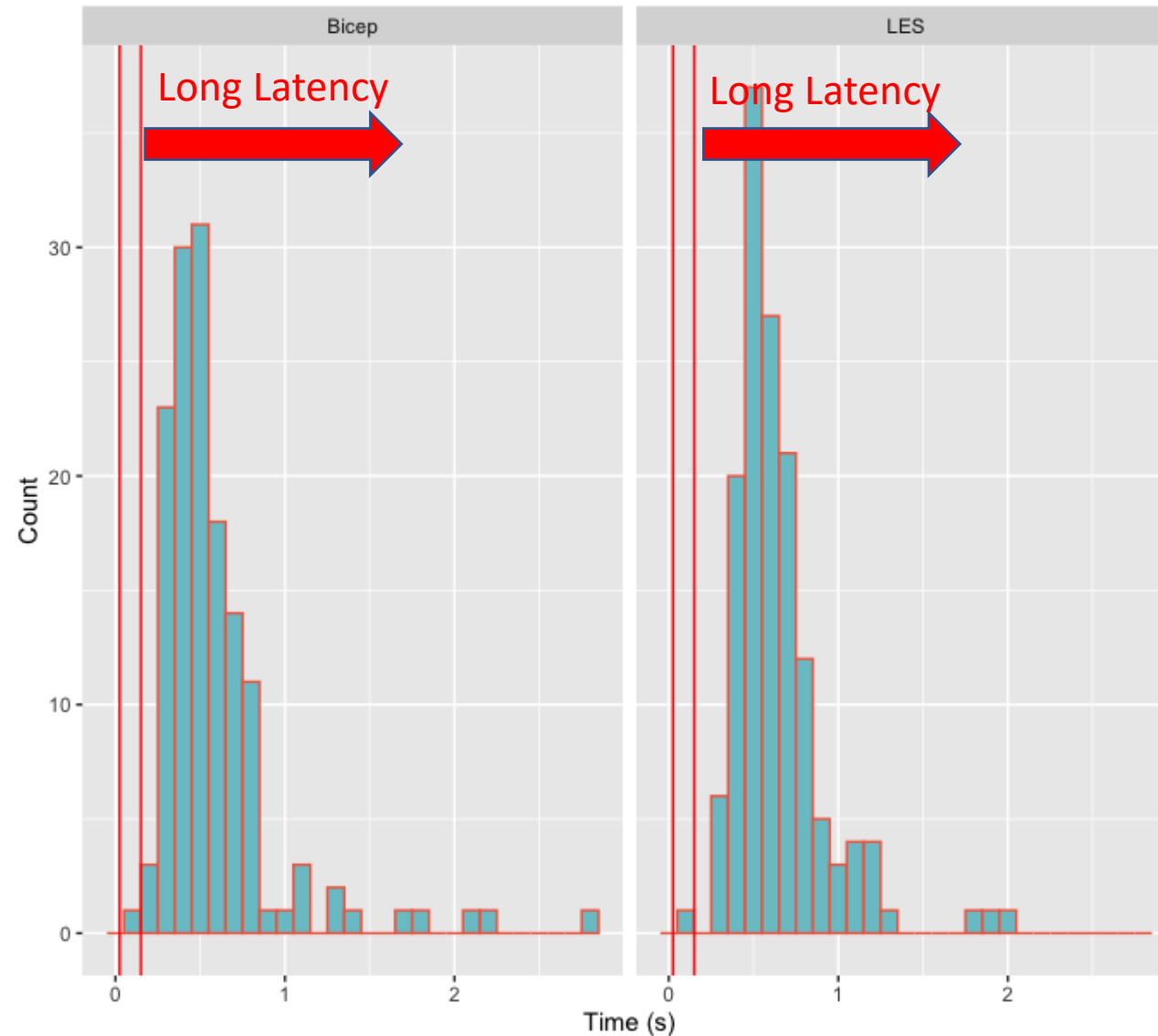
(Holmes and Keir, 2012)

Time to Peak Force – from initiation of drop



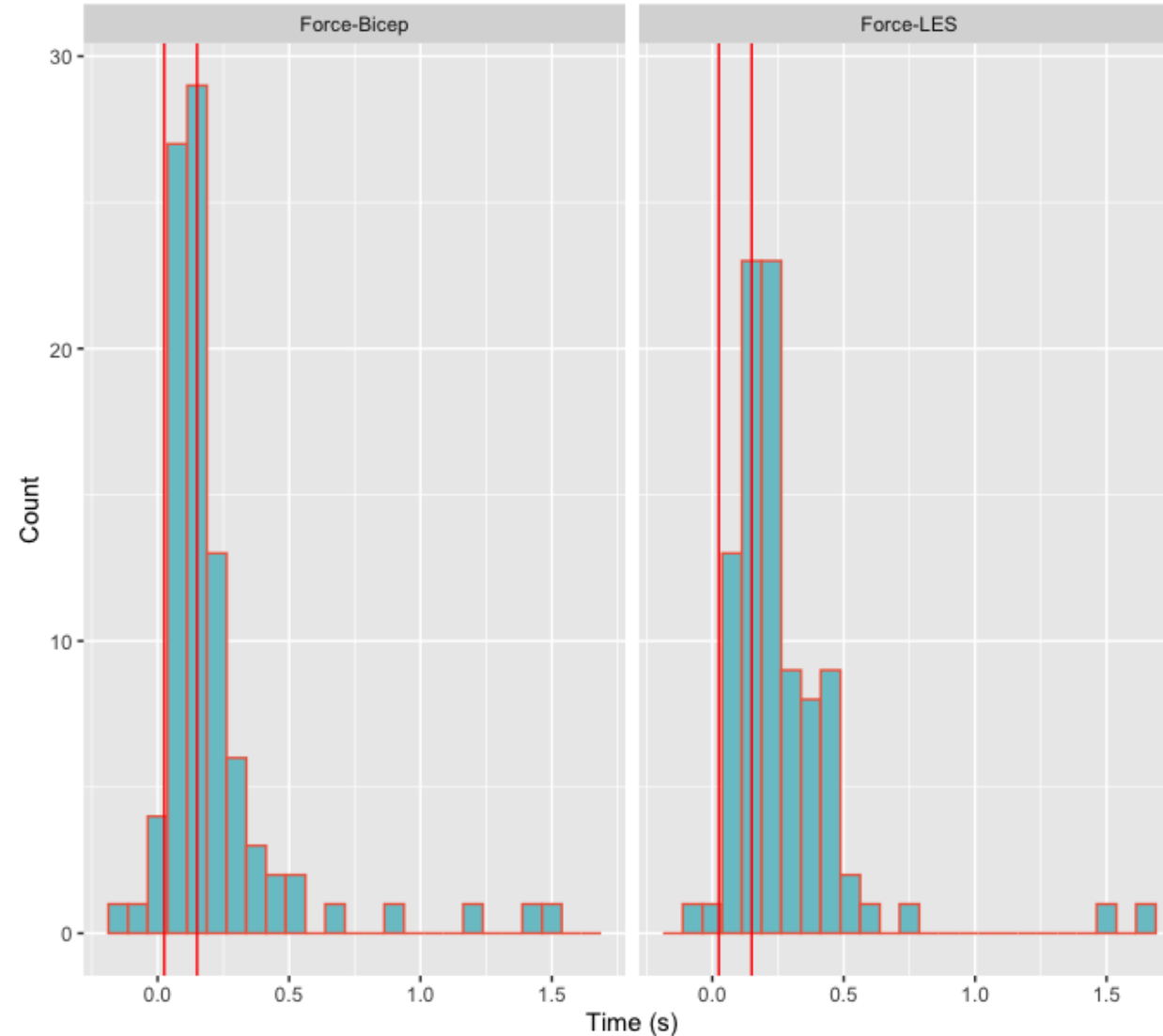
**Most well
above reflexive
Long Latency**

Time to Peak Muscle Activity



**Most well
above reflexive
Long Latency**

Time to Peak Force vs. Time to Peak Muscle Activity for Adjacent Lifters



Reaction timing dependent on proximity of muscles

Discussion - Joint Action

- Data did not show that dropper's force and muscle activity differed between drop & non-drop trials
- Few anticipatory muscle activity outcomes
- Original study design was effective
 - No evidence of “tells” by dropper or anticipatory actions by others

Limitations

- Original intention of the study
- Very light weight – due to drop safety considerations
 - Not representative of loads in the field
- Small sample size
- Right-side only EMG
- No training
 - Not Masonry workers

Future Directions – Multi-person lifting

- Compare matched vs. mismatched individuals
 - height, weight, strength, experience
- Task specific lifts
 - 2-person lifts
 - Knee to shoulder height transfer lifts
 - Lift and carry
 - Elevation & angle changes
- Industry specific lifts

Future Investigation on Joint Action

- Bilateral EMG
- Eye tracking
- Training

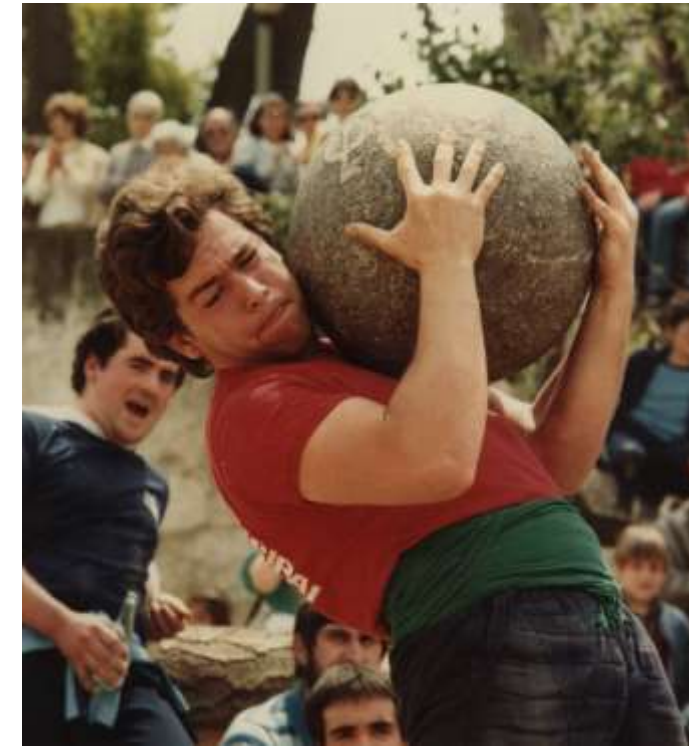
Solutions (?)

- Devices, lift assists
 - No universal solution



Solutions (?)

- Devices, lift assists
 - No universal solution



Hiring Strategies?



Specialized tools

Take home points

- In four person lifts –
 - Lifter closest to dropper bears heaviest burden on drop
 - Force and muscle activity higher (BB, AD, UT)
 - Opposite lifter is “unloaded”
- **Load shape & position** alter force contribution following sudden load release
 - With rectangular load
 - Short adjacent lifter = Peak force contribution of up to 43% of total team load
 - Drop trial exceeded NIOSH lifting recommendations
- Sudden load release in team lifting possible mechanism of injury for masonry workers

Thank You!

- McMaster Occupational Biomechanics Laboratory
- CRE-MSD
 - Seed grant - Dr. Colin McKinnon (PI)
 - Co-Investigator – Dan Mulla
- Masonry and Allied Trades Labour Management Committee (IHSA)



Thank You!

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CRE-MSD

