Development of Data-Driven, Individual-Specific Interventions for WMSD Prevention

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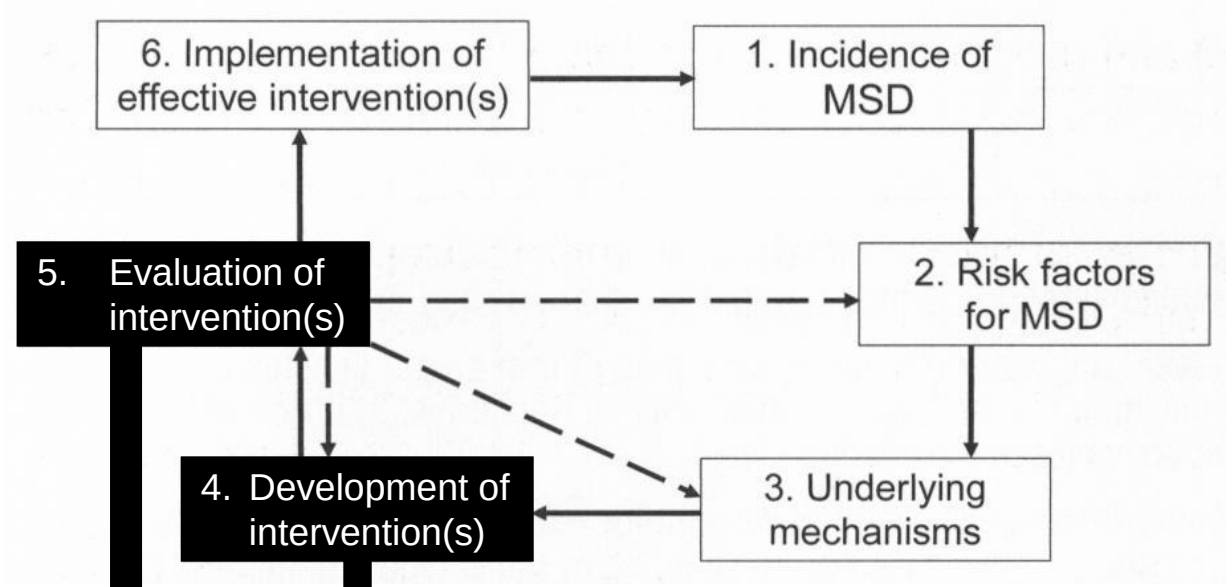
Work-related Musculoskeletal Disorders (WMSD)

Oranye & Bennett, Ergonomic, 2018; Sarkar et al., Int. J. Occup. Environ. Health, 2016

Primary WMSD Prevention



- Identifying effective approaches for interventions
- Evaluating intervention efficacy

van der Beek et al., Scand J Work Environ Health, 2017

Engineering Controls

Powered Ambulance Cot
Stryker

Automated Medication Crusher
Powder Crush

Patient Transfer Board
SafetySure

Armstrong et al., Appl Ergon, 2017; Lavender et al., Appl Ergon, 2003

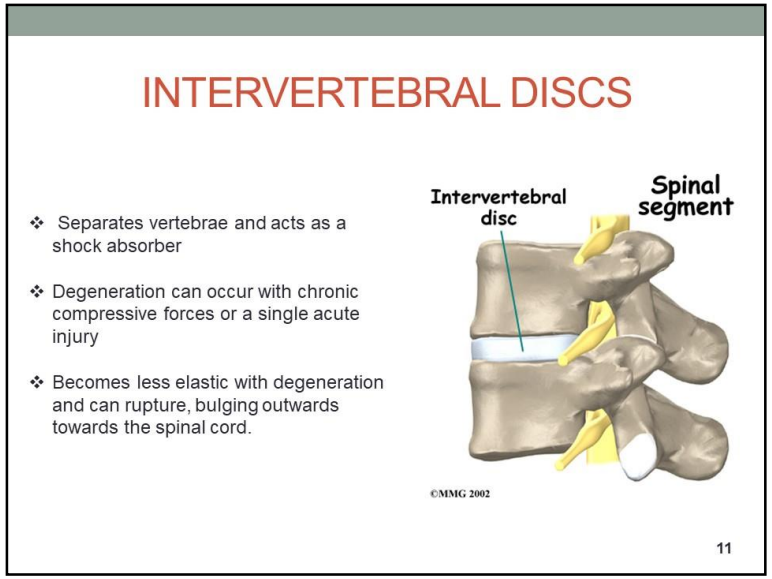
Movement Training

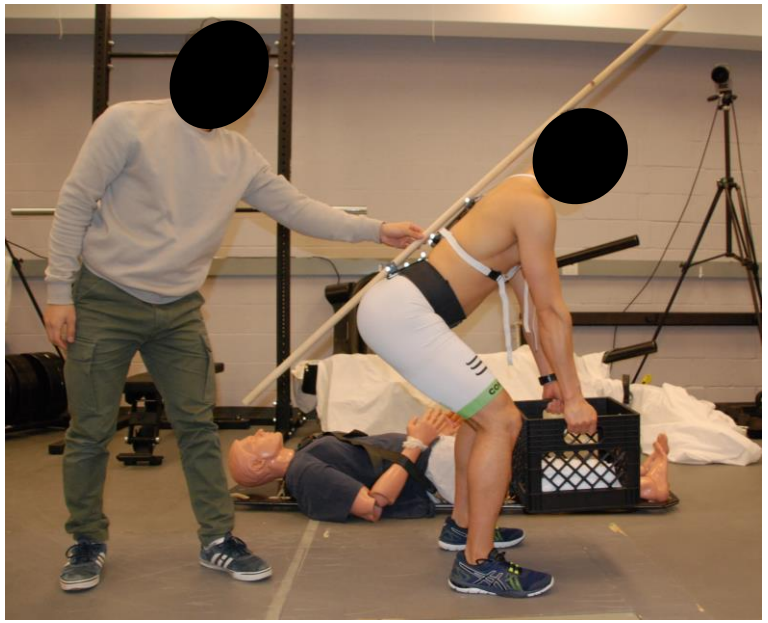
Training Methods Elicit Spine-Sparing Movement

Visual Aids for Safe Lifting

From StateFoodSafety

Education

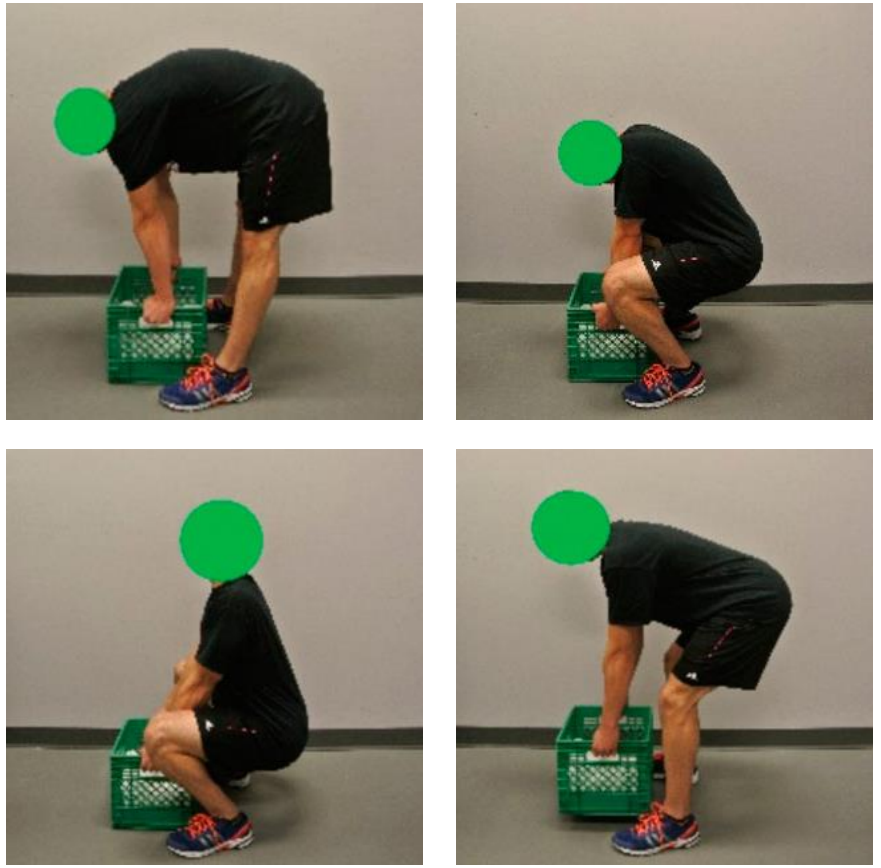




Augmented Feedback

Can visual aids elicit changes in spine motion during lifting?

- Asked to replicate postures in lifting images
  - Displaying different amounts of knee & spine flexion
- Significant differences in spine kinematics between image conditions
- Greatest reduction in peak spine angles & velocities *did not correspond* to image with "best" spine position



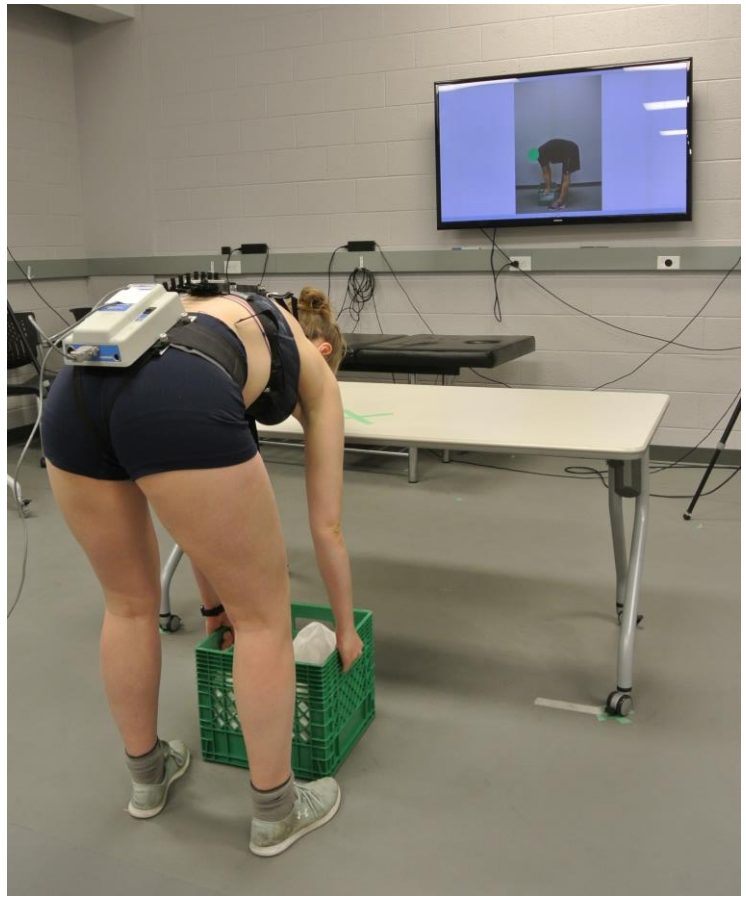
Chan et al., Int J Occup Saf Ergon, 2019

Can visual aids elicit changes in spine motion during lifting?

Yes, but images may not elicit the desired effect on their own.

Perhaps due to limitations in:

- Awareness
- Strength
- Mobility
- Coordination



Chan et al., Int J Occup Saf Ergon, 2019

Education-based Manual Handling Training

Safe Lifting Principles

SAFE PRINCIPLES OF LIFTING

Situation
Prepare
Interact
Neutral spine
Execute
Smooth

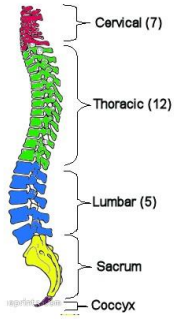
- Decreased load on the structures of the spine and its supporting muscles
- Keep core muscles tight to maintain stable spine

25

Anatomy

THE SPINE

- Composed of bones, discs, nerves, muscles and ligaments
- When an injury occurs, one or more of these structures are damaged and the spine is unable to function properly



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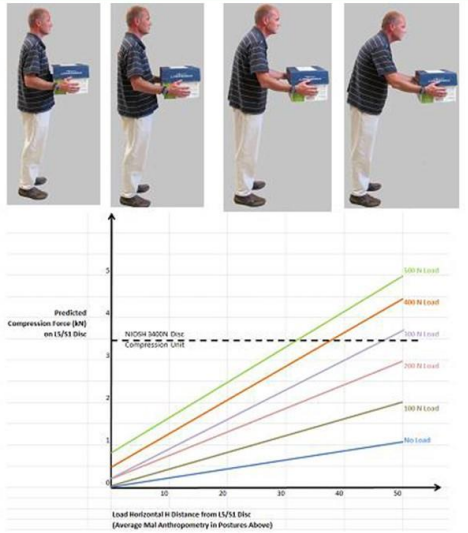
Biomechanics



19

Chan et al., in review

Feedback-based Manual Handling Training

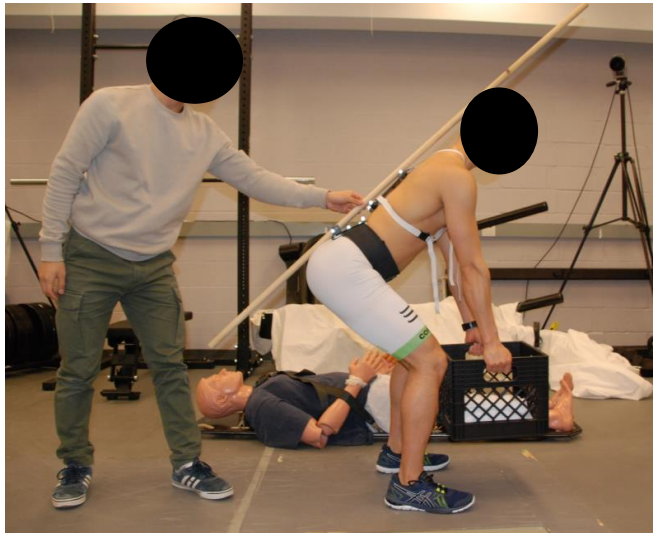
The 7 'Key' Features

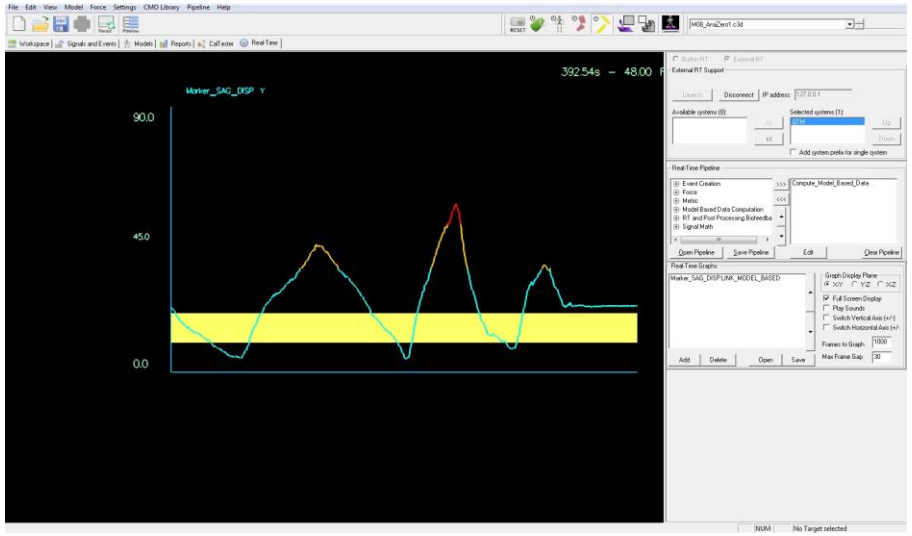
From Performance Redefined

Neutral Spine

Comparison of Approaches to Movement Training

- Didactic (DID) compared to augmented feedback (AUG) interventions
- Both interventions had 5 sets of 10 practice lifts



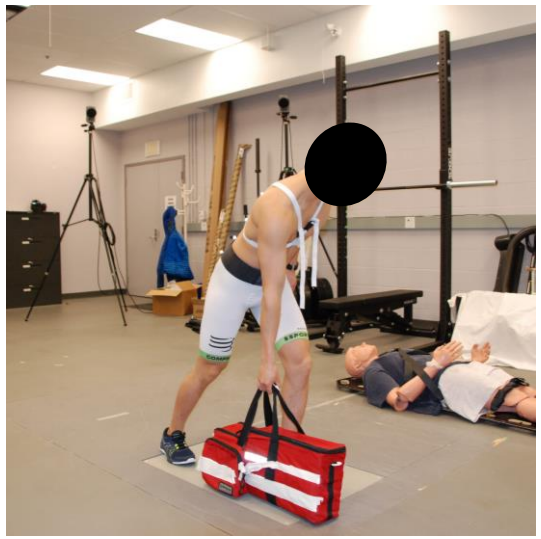


Chan et al., in review

Comparison of Approaches to Movement Training

- Tested immediately after and one-week after interventions

6kg



8.7kg

82.5kg shared

Chan et al., in review

Both interventions elicited reductions in spine motion after one-week

Number of significantly reduced LBD risk factors with after 1-week

Lifting Task	DID	AUG
Box	2 of 4	4 of 4
Medication Bag	4 of 4	4 of 4
Backboard	0 of 4	1 of 4

Chan et al., in review

AUG elicited equal or greater reductions in spine motion compared to DID

Lifting Task	Absolute peak spine flexion angle	Relative peak spine flexion angle	Peak spine flexion velocity	Peak spine extension velocity
Box	**AUG**	×	**AUG**	**AUG**
Medication Bag	×	×	×	×
Backboard	×	×	**AUG**	**AUG***
**Difference found immediately post-intervention only*				

× = no difference between DID and AUG

AUG = AUG elicited significantly larger reduction compared to DID

Chan et al., in review

Real-time WMSD Risk Monitoring

Inertial Measurement Units (IMUs)

Xsens DOT

Insole Plantar Pressure Monitoring System

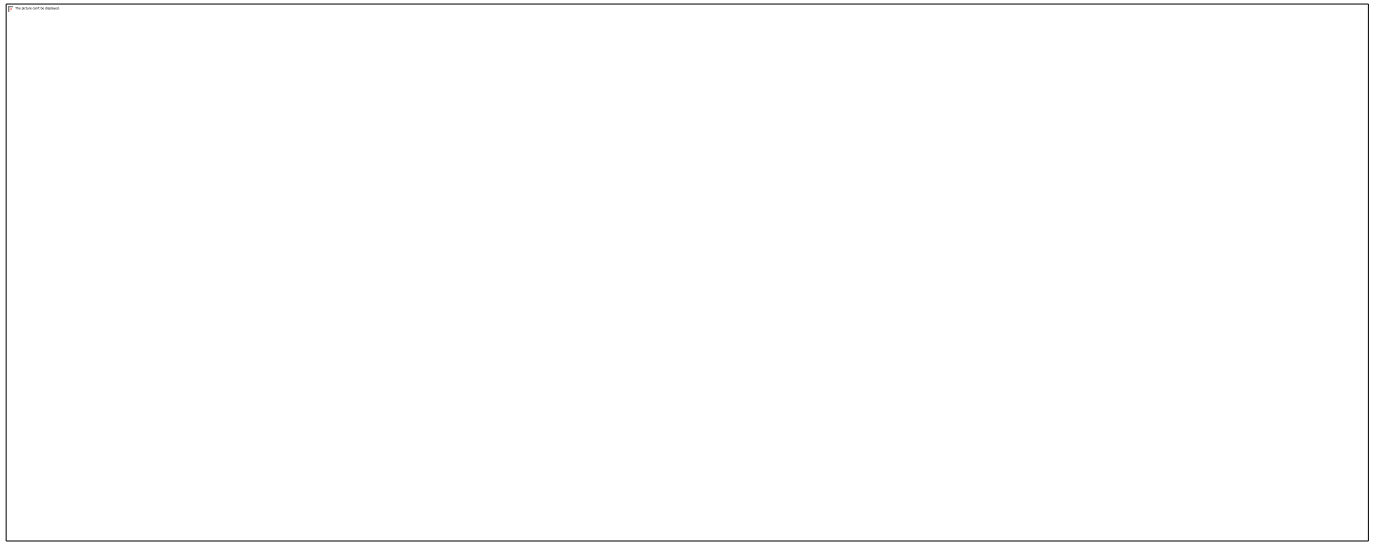
Tekscan F-Scan System

Lee et al., Automat Constr, 2020

Chan et al., in review

Individual-specific method to recognize atypical spine motion using wearable sensors

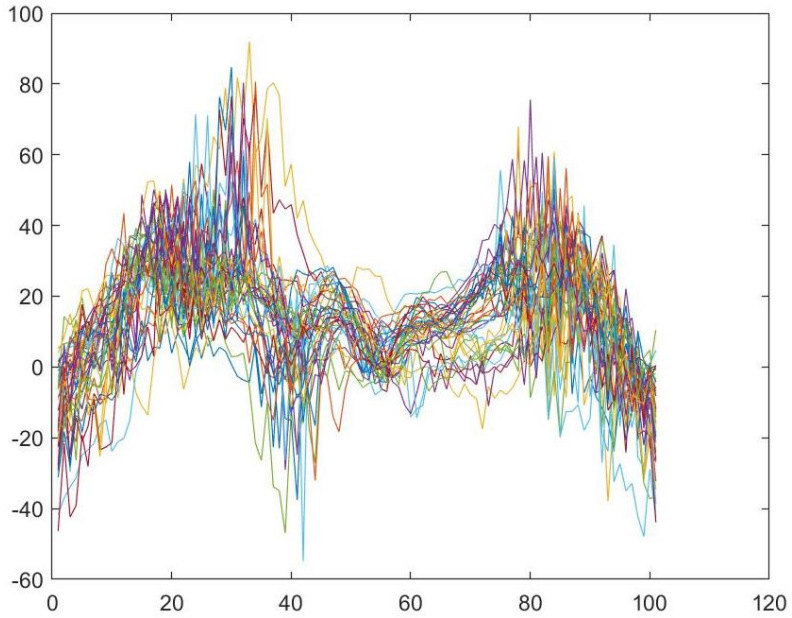
- Asked to perform 50 spine flexion-extensions
  - 11 sets or until fatigued
  - Assessed using visual analogue scale & maximal lift strength
- 2× IMUs: Pelvis & T8 vertebrae



Chan et al., Sensors, 2020

10-feature spine motion composite index (SMCI)

- Peak thoraco-pelvic continuous relative phase (CRP)
- Repetition time
- Pelvis & T8 vertebrae:
  - Orientation range
  - Peak orientation
  - Peak angular velocity
  - Peak angular acceleration



Thoraco-pelvic CRP

Chan et al., Sensors, 2020

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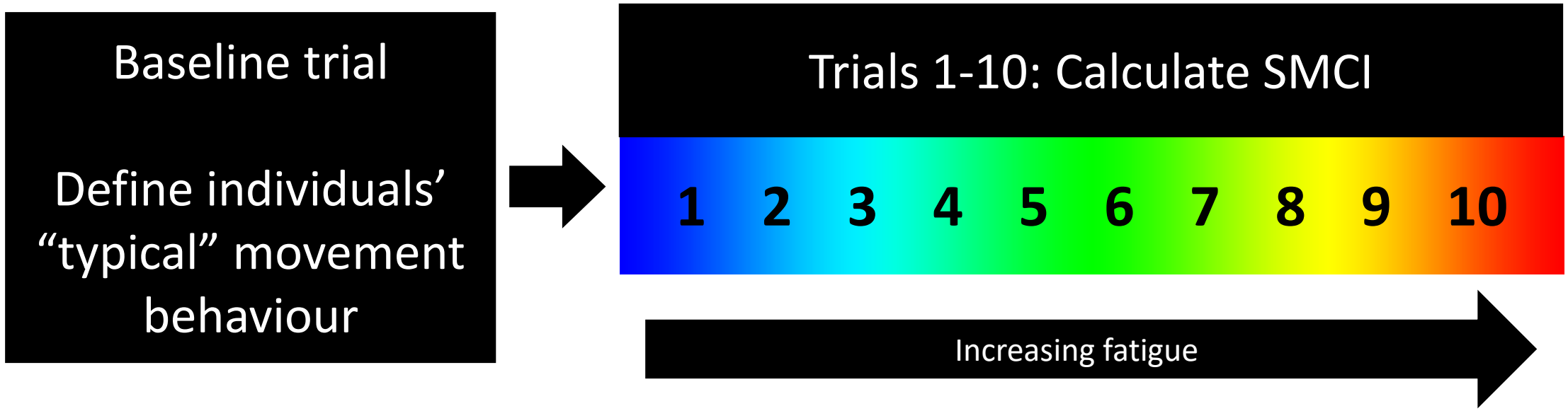
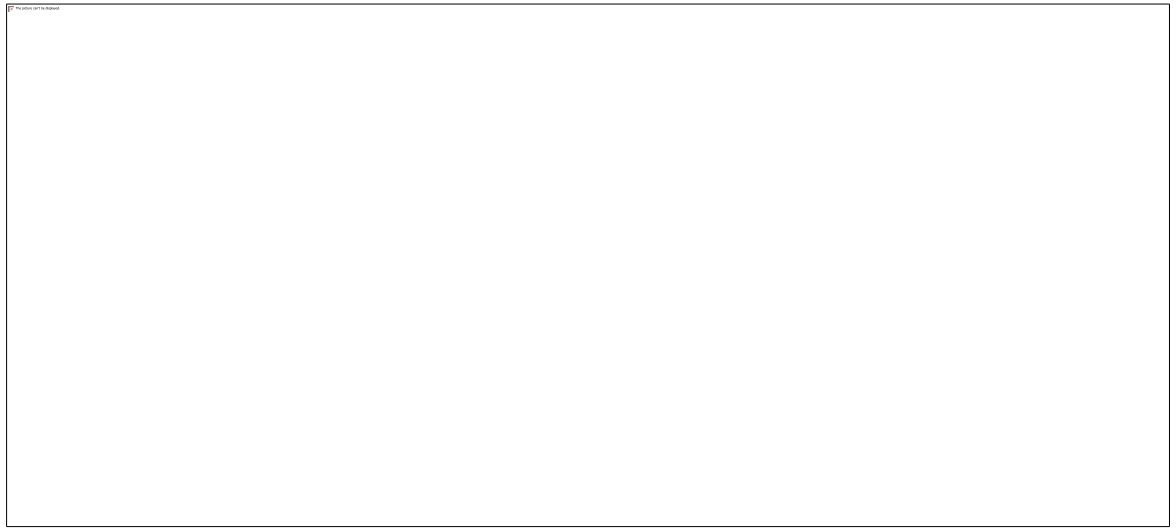
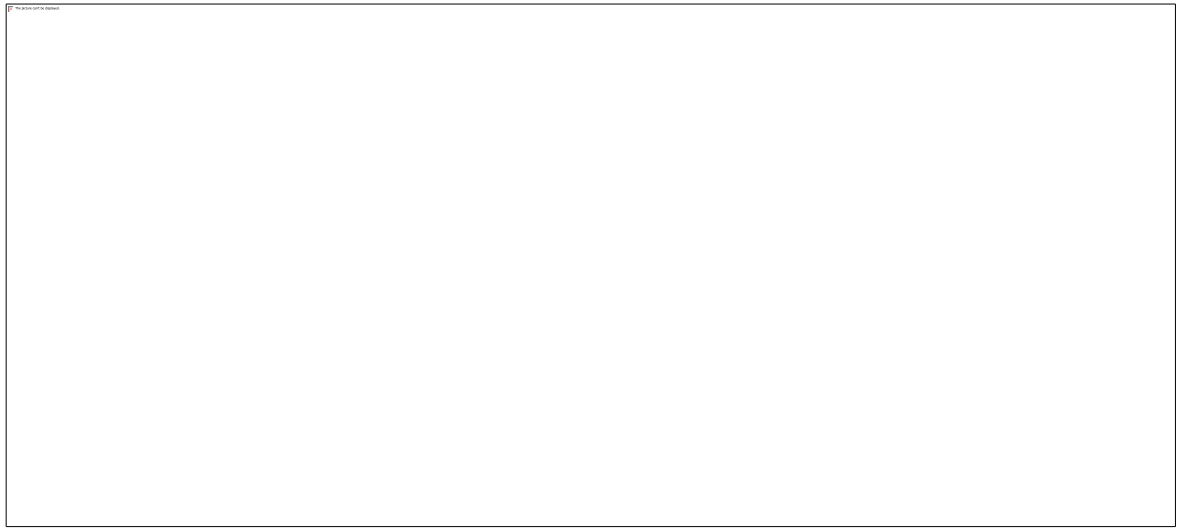


Chan et al., Sensors, 2020

SMCI correlated with increases in fatigue



SMCI & Fatigue visual analogue scale



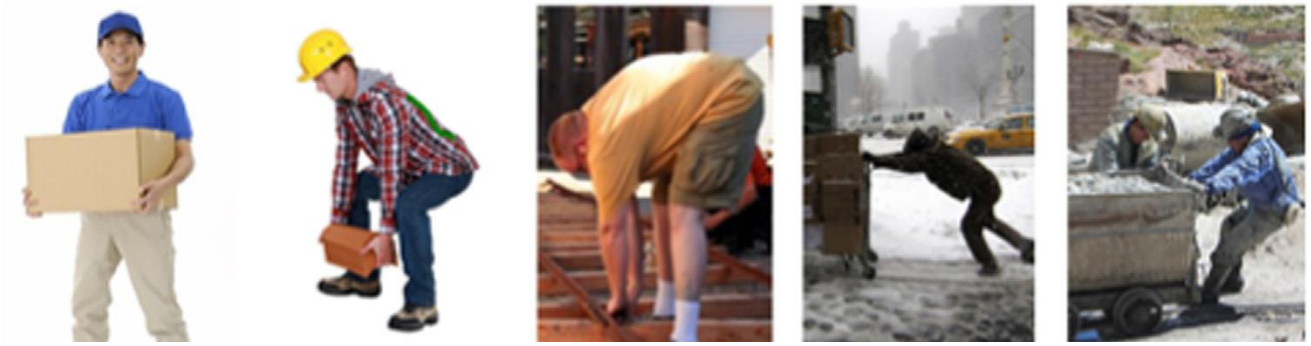
SMCI & Maximal lift strength

- Strong correlations when averaged
- Moderate repeated measures correlations

Chan et al., Sensors, 2020

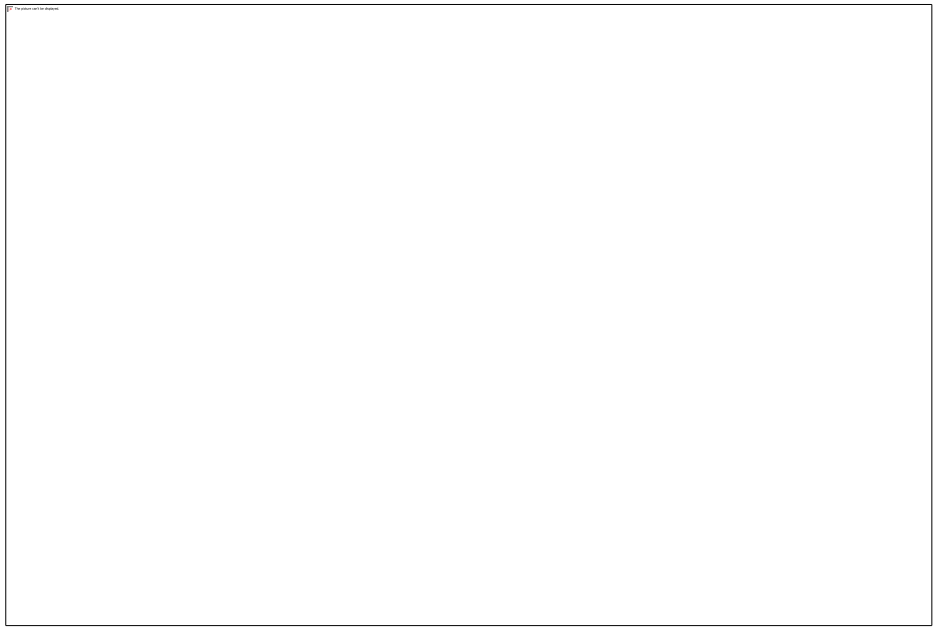
Practical Significance

- Wearable sensors can detect atypical movement associated with fatigue
- Feedback or cues can be automated & individual-specific
- Widely applicable for repetitive tasks



Chen et al., Smart Health, 2018

Chan et al., Sensors, 2020



Beange et al., 2017

Thank you for attending!

PhD, Human Kinetics (2019 - present)

- Supervisor: Dr. Ryan Graham
- Spine and Movement Biomechanics Laboratory
- University of Ottawa

MSc, Exercise Sciences (2016 - 2018)

- Supervisor: Dr. Tyson Beach
- Musculoskeletal Biomechanics and Injury Prevention Laboratory
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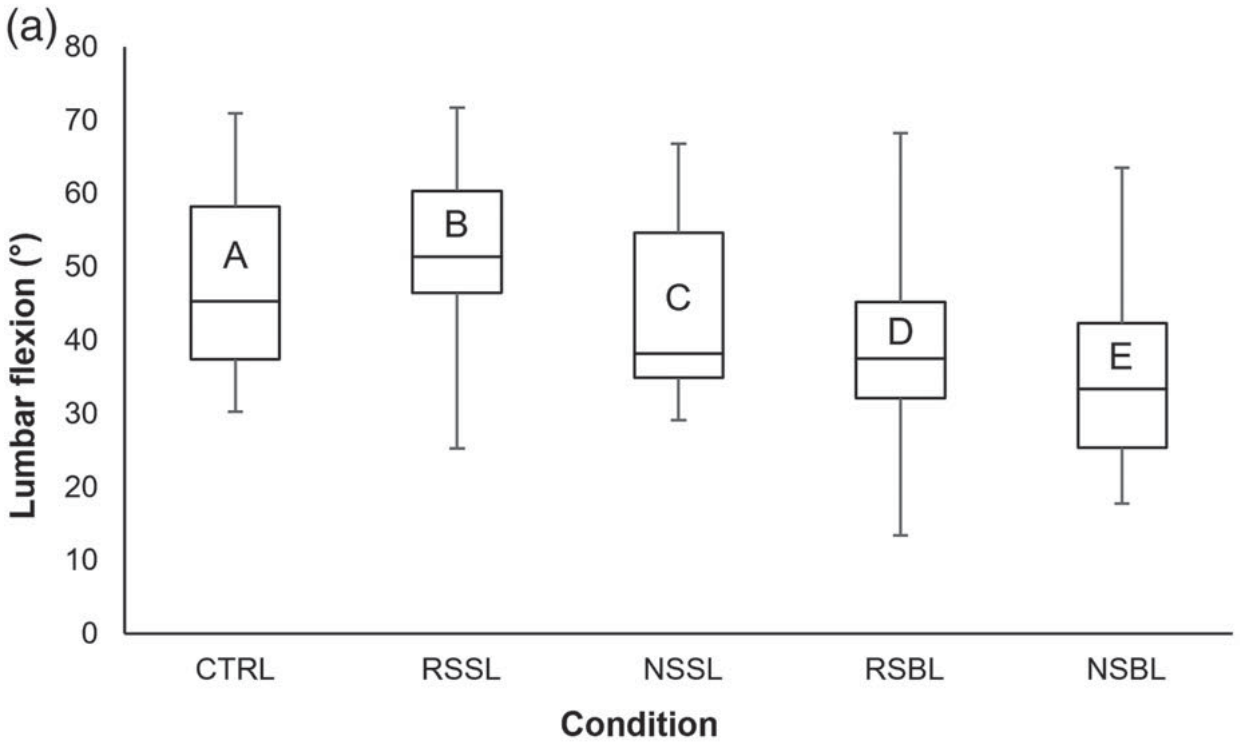

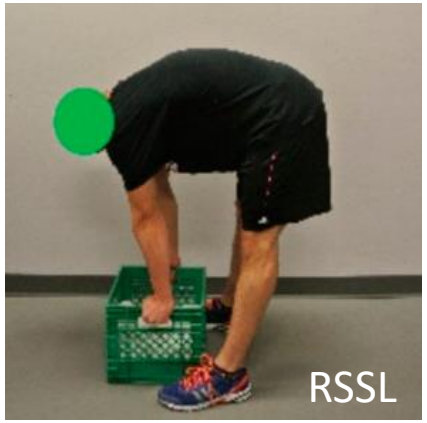

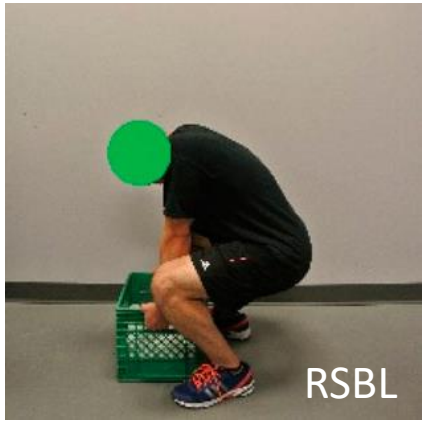

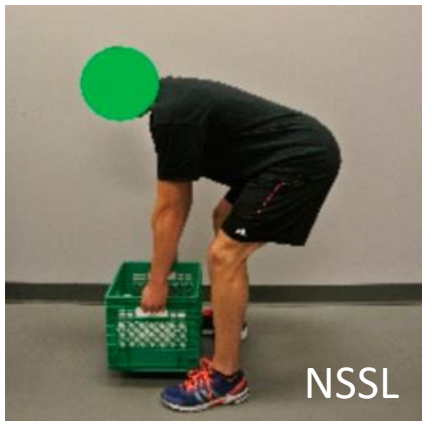

Chan et al., Int J Occup Saf Ergon, 2019

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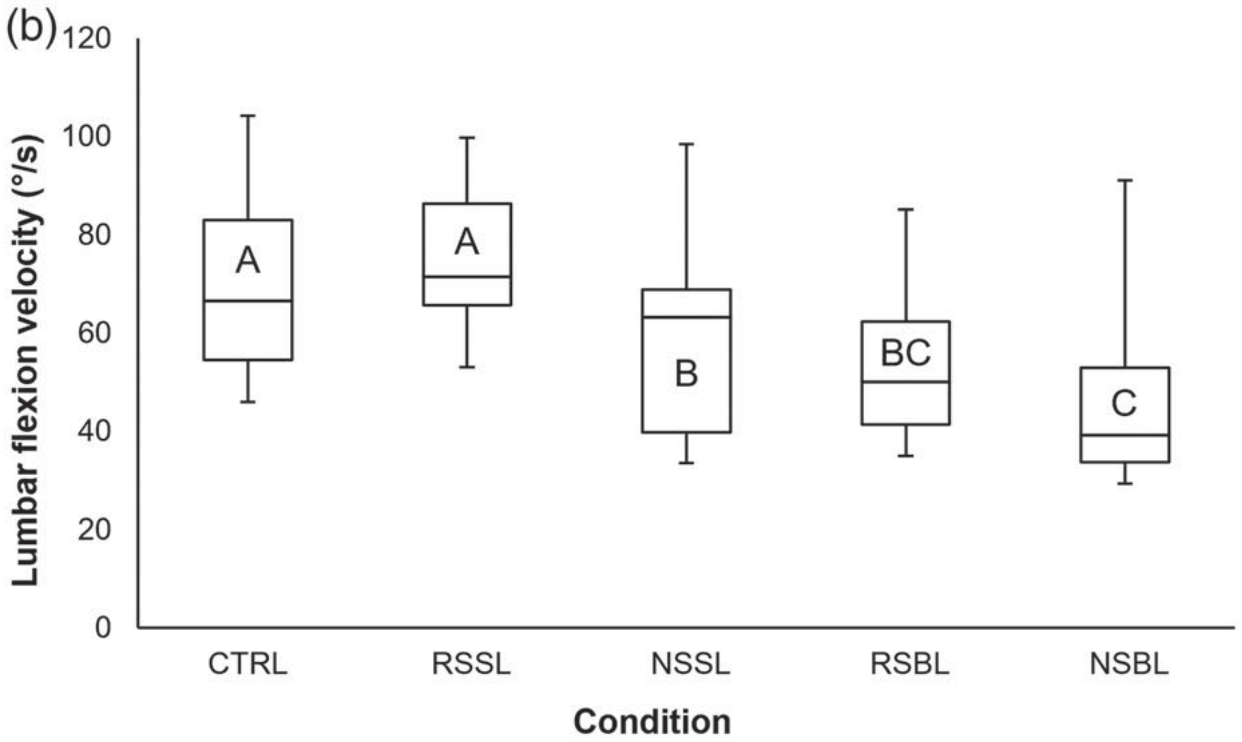

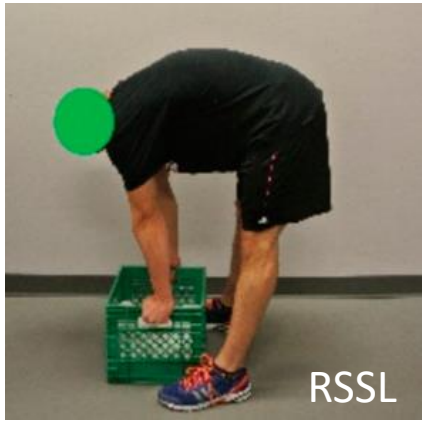

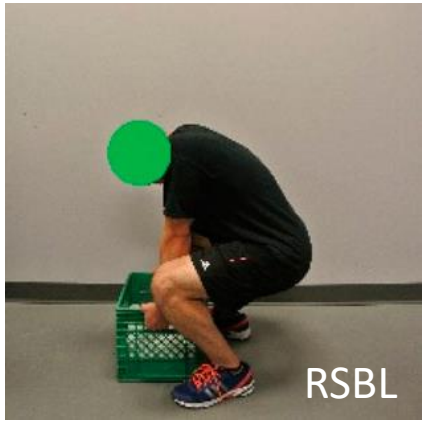

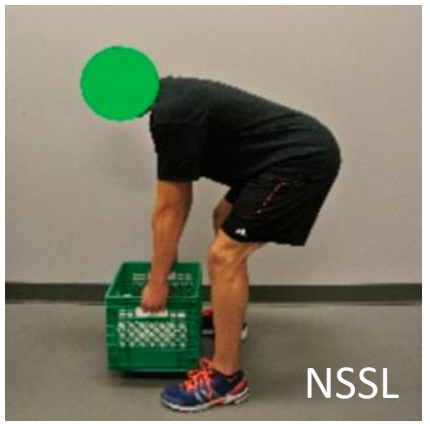

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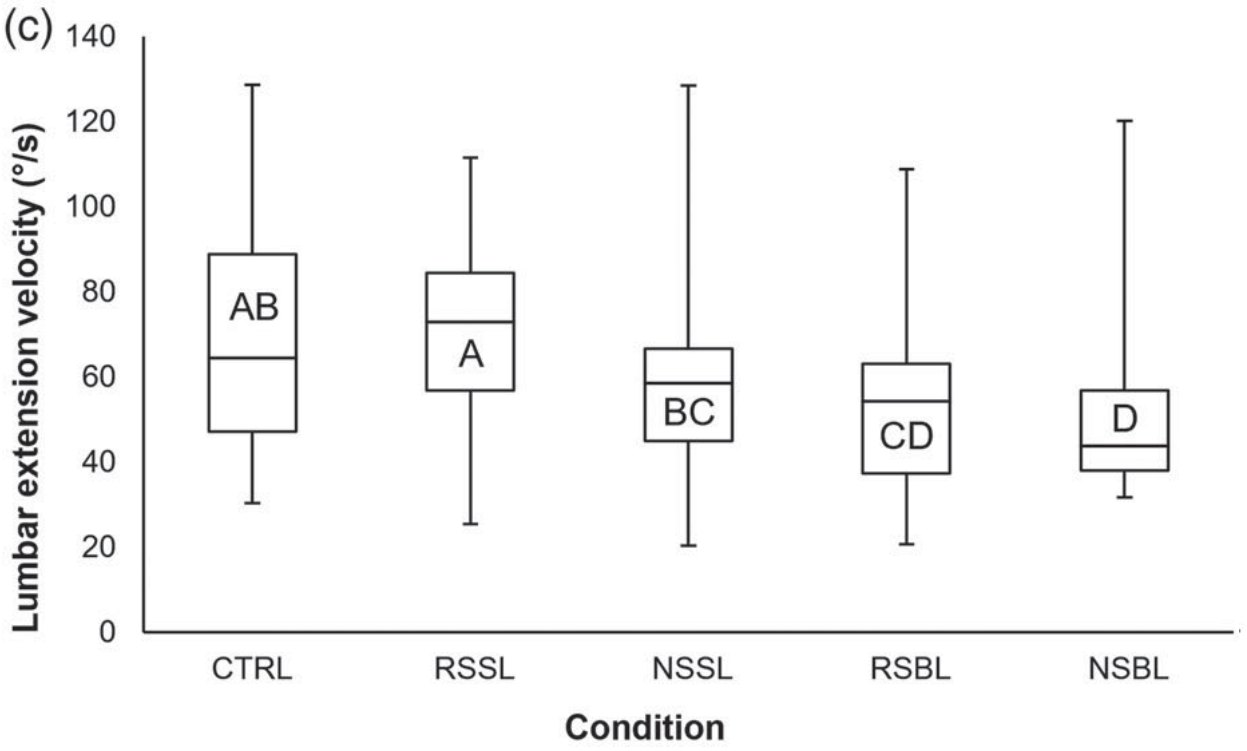
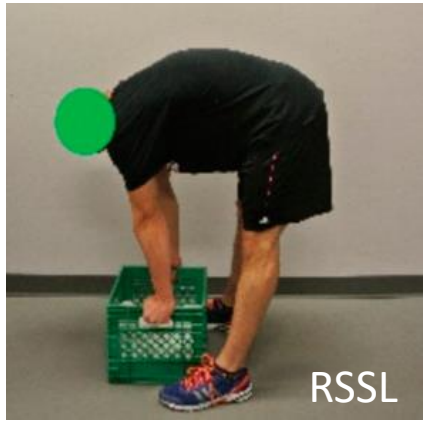
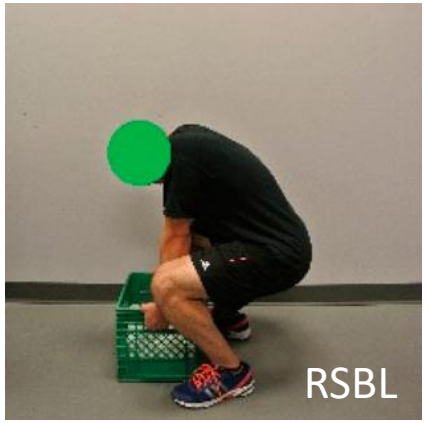
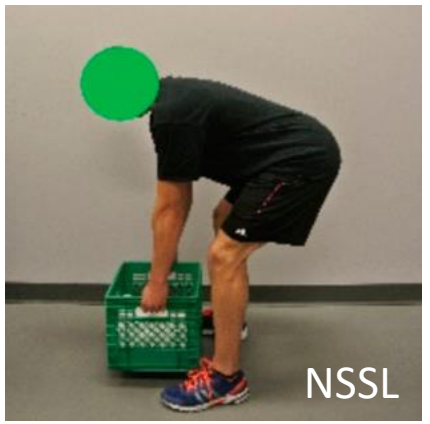








Chan et al., Int J Occup Saf Ergon, 2019

AUG Intervention

Feedback Schedule

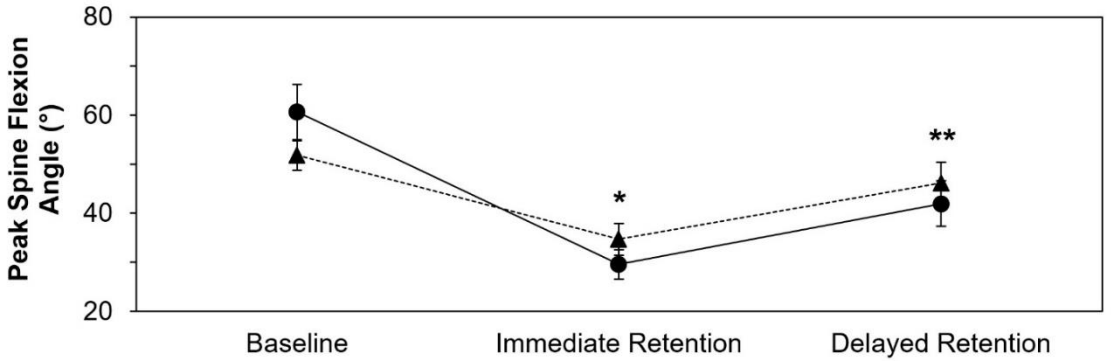
Set #	Augmented Feedback Administered
1	All 10 lifts with dowel + individualized coaching cues
2	5x opportunities for KP Feedback
3	4x opportunities for KP Feedback
4	3x opportunities for KP Feedback
5	2x opportunities for KP Feedback

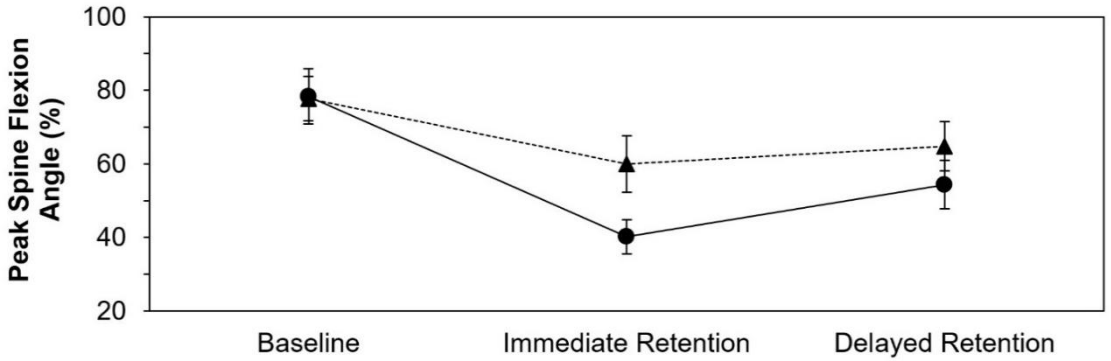
Standardized phrases provided

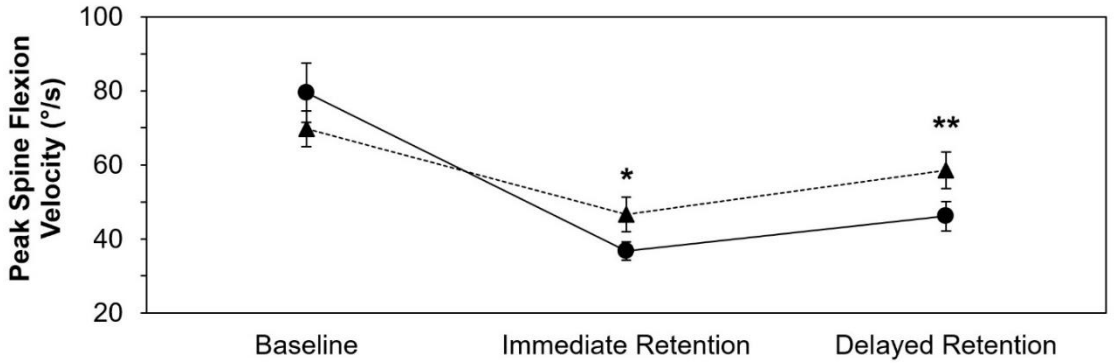
Spine flexion angle (°)	Qualitative feedback given
< 10	"Excellent. Keep this up!"
10-20	"This was good and there is still room to improve."
21-35	"Not bad but keep trying to resist flexion even more."
36-50	"Your spine was flexed during that lift."
> 50	"There was a lot of spine flexion during that lift."

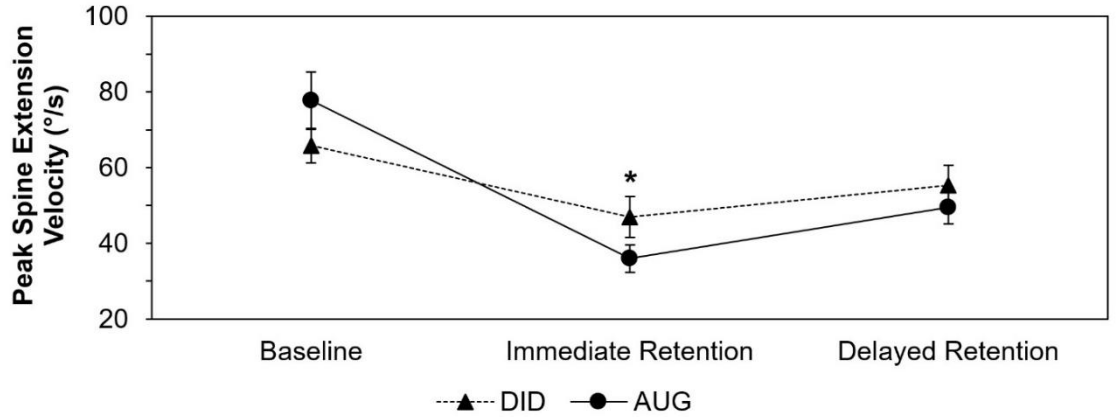
Chan et al., in review

Retention: Box Lifting Task



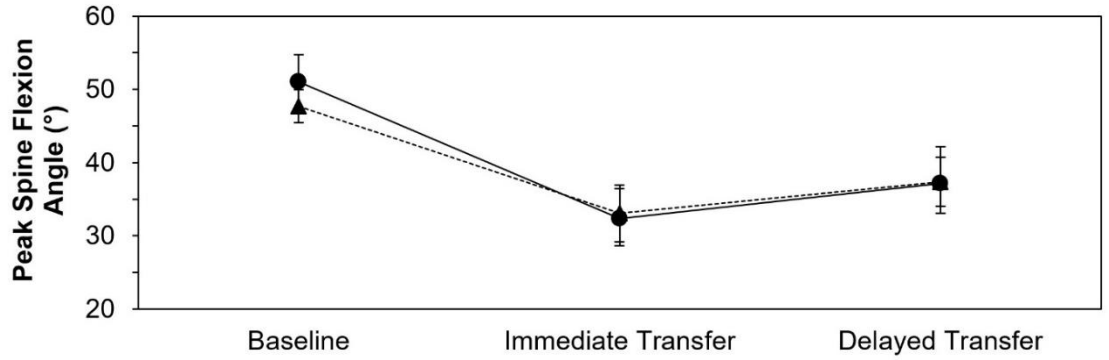


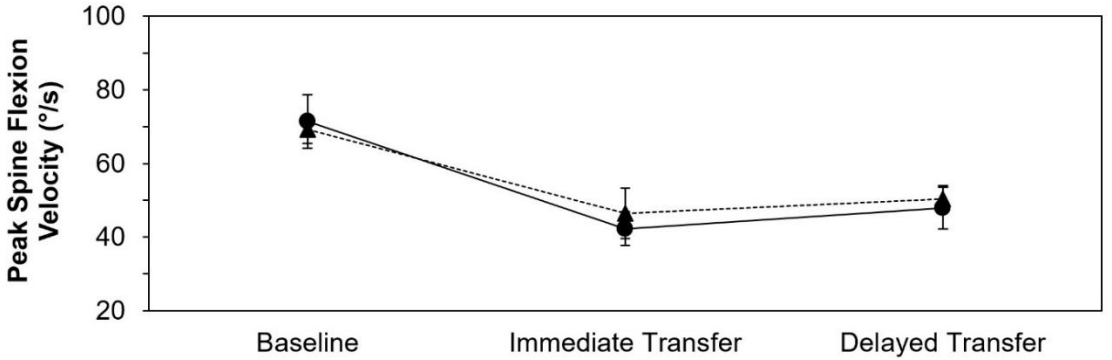


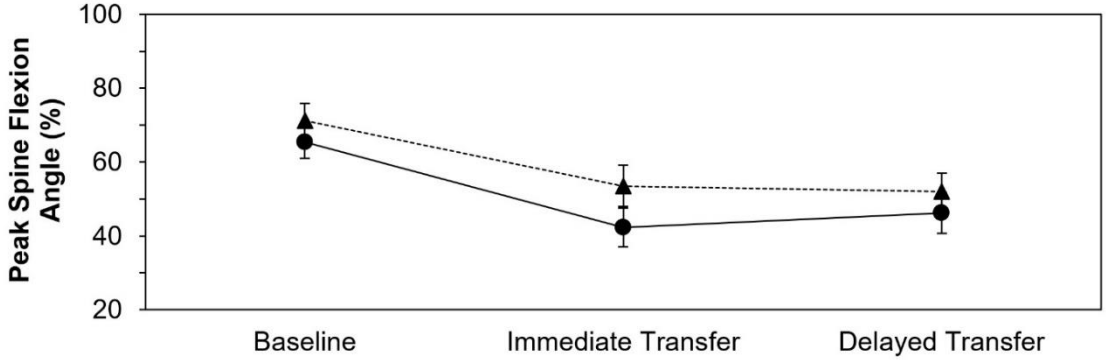


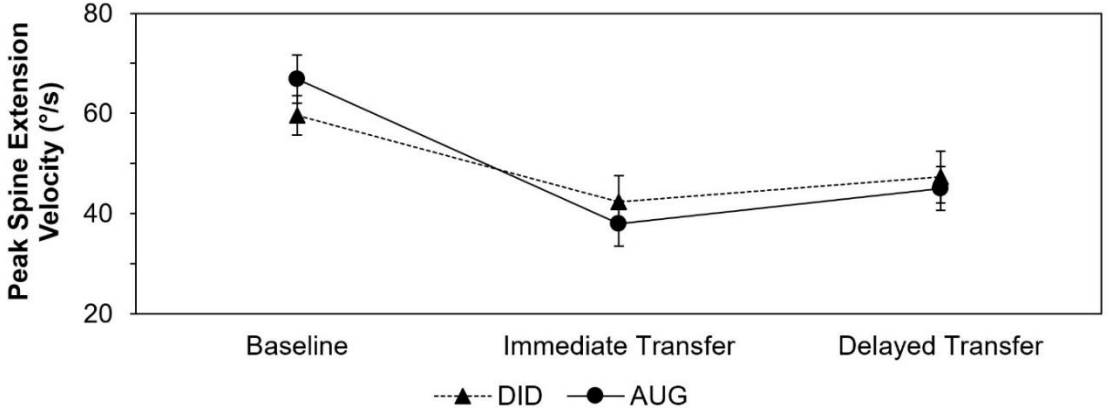
Chan et al., in review

Transfer: Medication bag lifting task



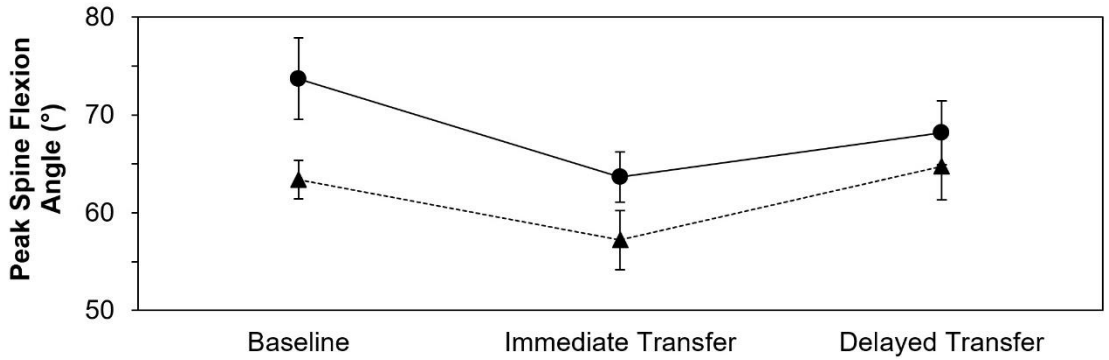


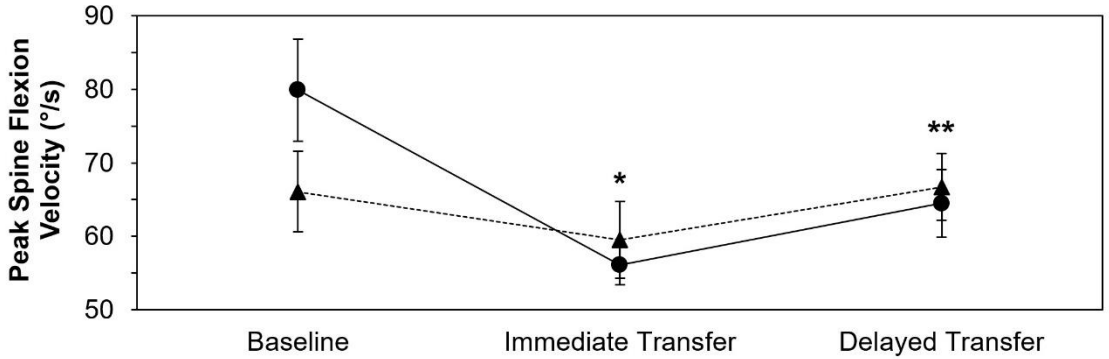


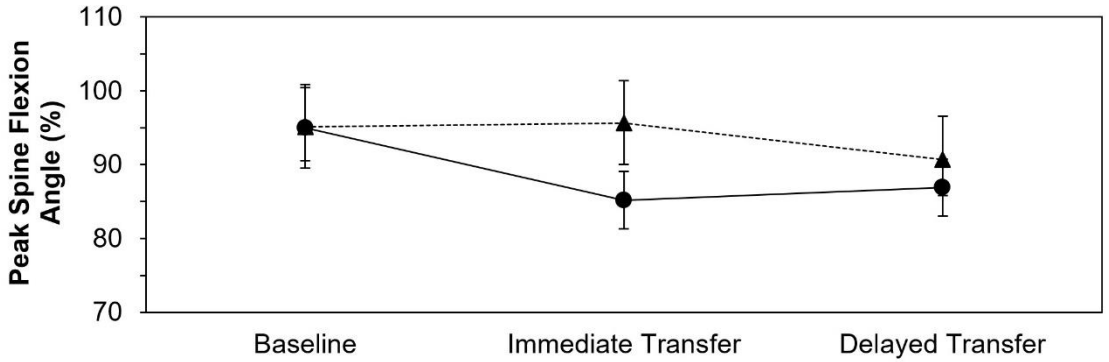


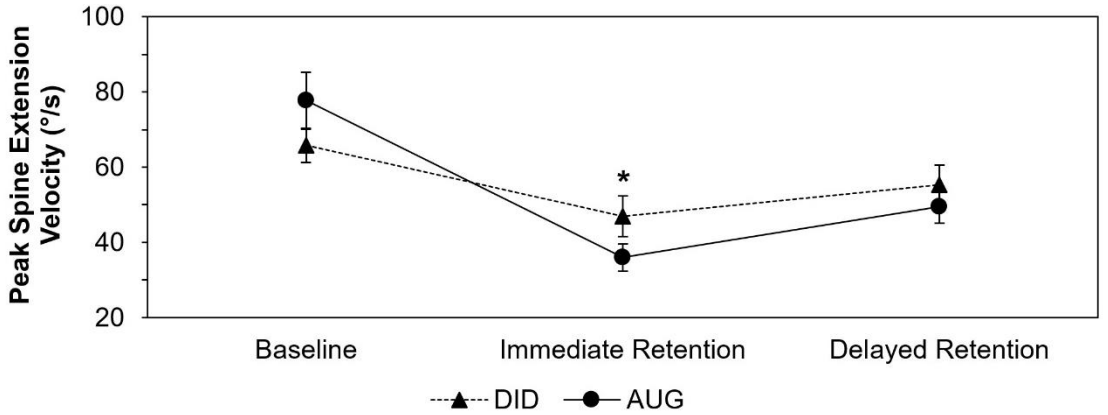
Chan et al., in review

Transfer: Paramedic backboard lifting task



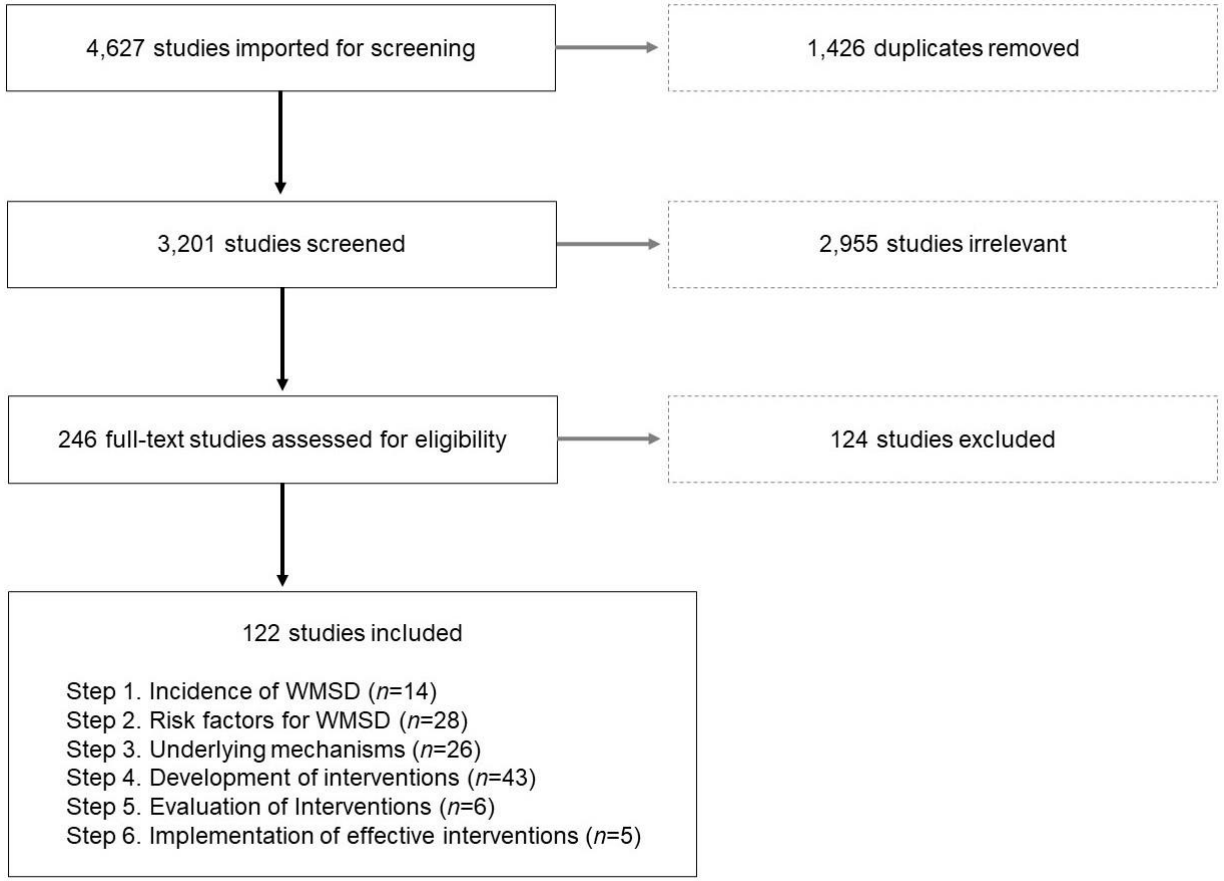






Chan et al., in review

ML Scoping Review



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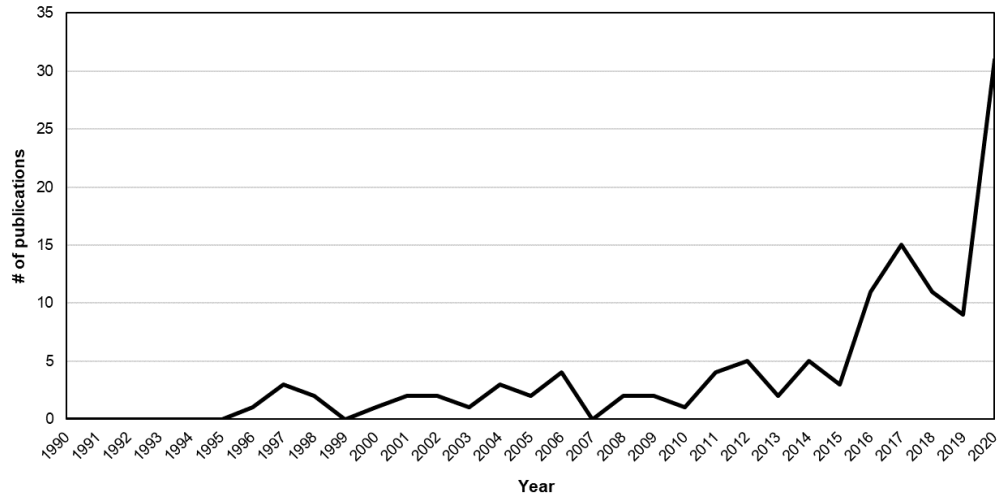
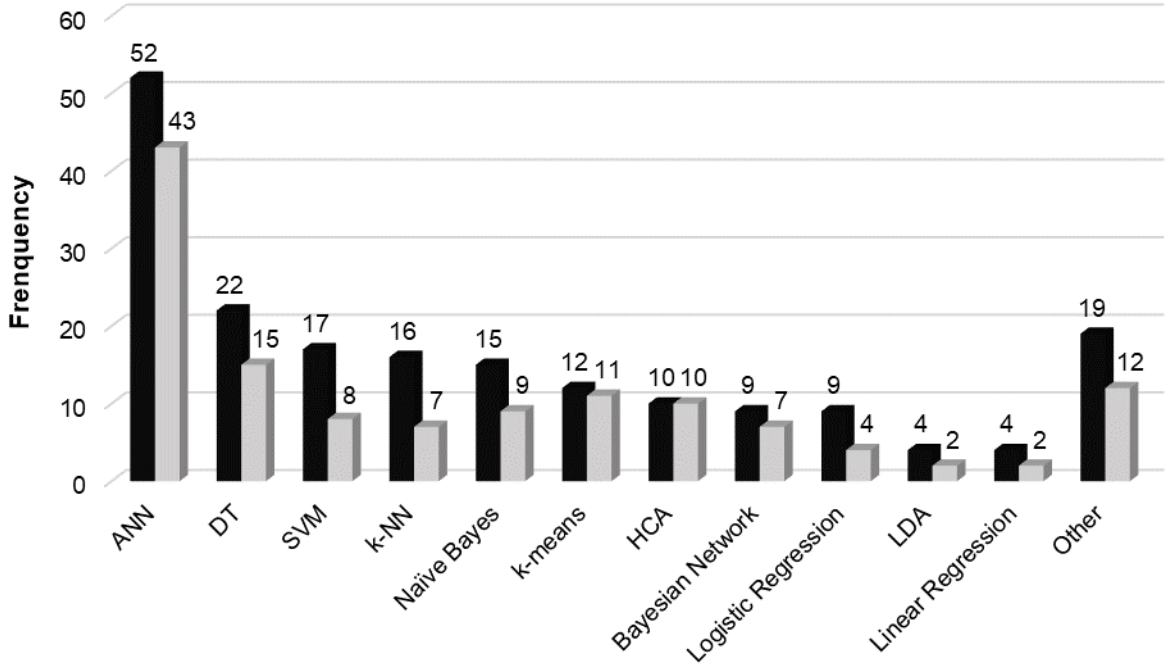
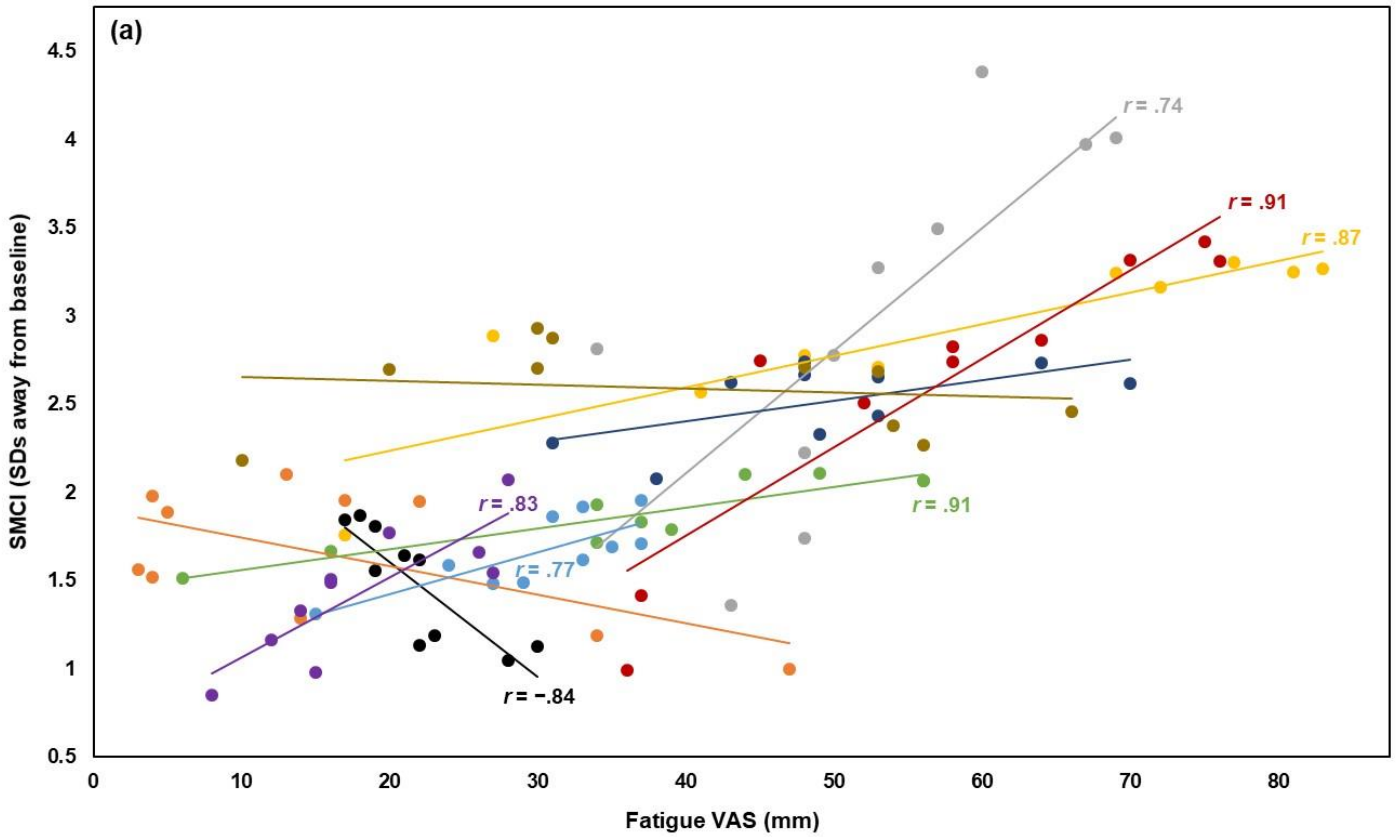




Chan et al., in review

Individual Correlations for SMCI & Fatigue



Chan et al., Sensors, 2020

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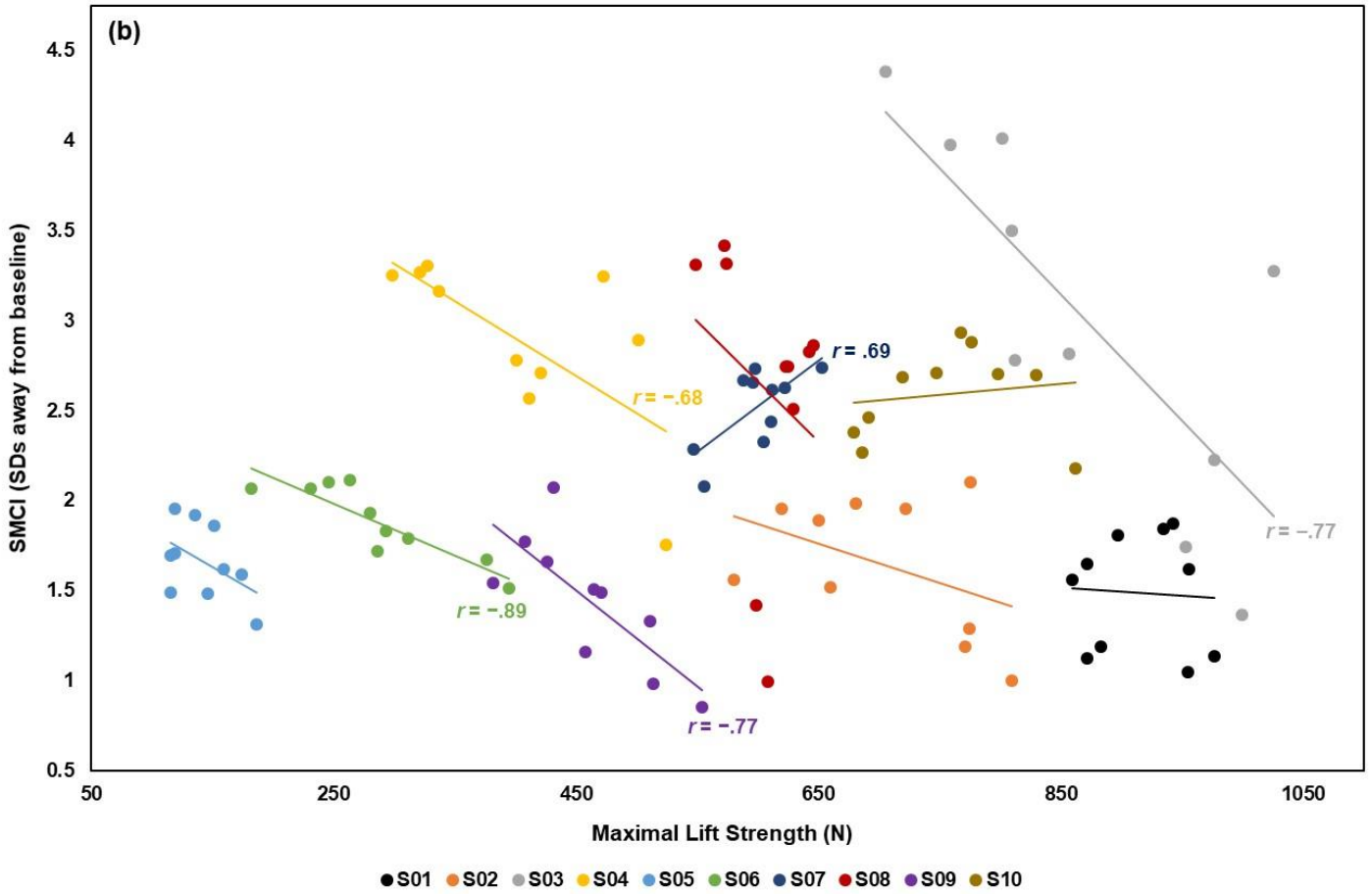

Chan et al., Sensors, 2020