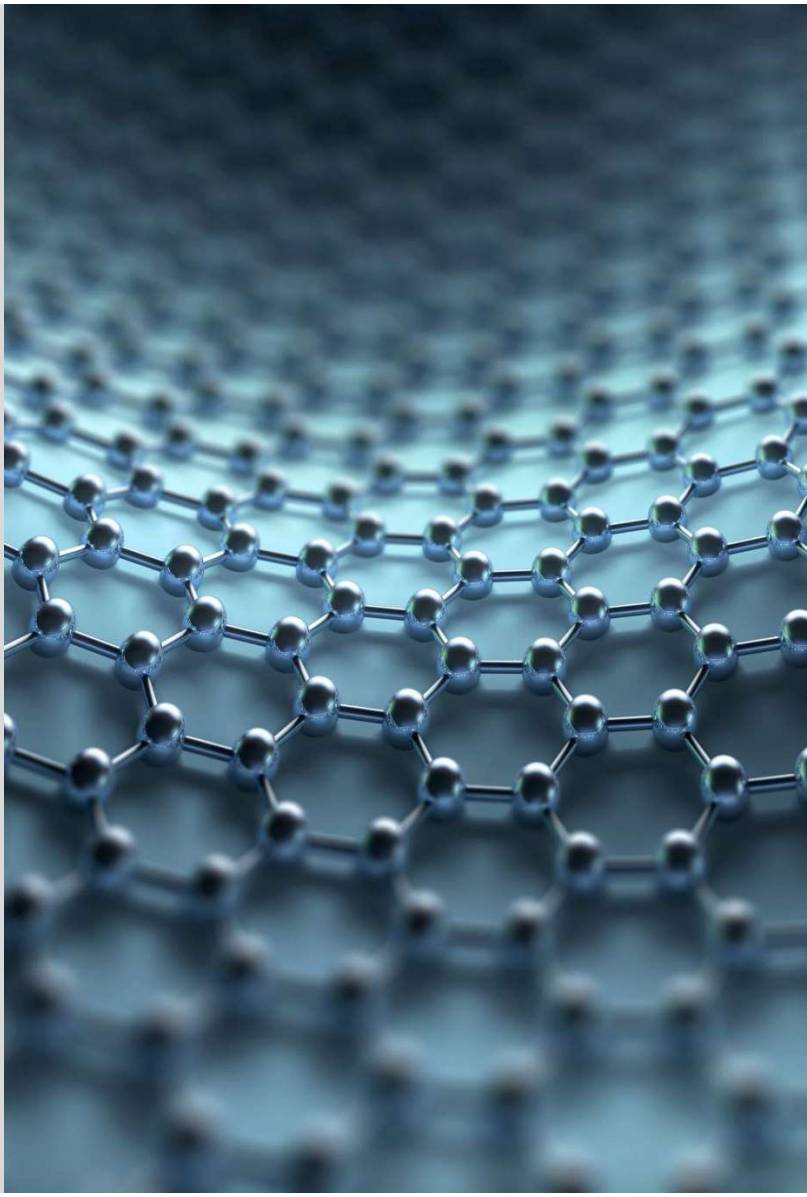
Proposal



Research Question

Can we perform ergonomic cumulative assessment using computer vision with deep learning without wearing any equipment to learn the ergonomic characteristics of expert masons?

Justification:
This research direction is meaningful because in the paper written by *JuHyeong Ryu, A.M.ASCE1; Bennett Banting2; Eihab Abdel-Rahman3; and Carl T. Haas, F.ASCE4*, titled as **'Ergonomic Characteristics of Expert Masons'**, we can tell from the data that the working posture of an expert mason causes the lowest compression force and moments at the respective body parts. However, the expert may not realize that their certain postures are proper postures, therefore they cannot efficiently teach the apprentices. Hence, a scientific analysis can help us to collect proper postures and train the beginners in a more systematic way.

Background

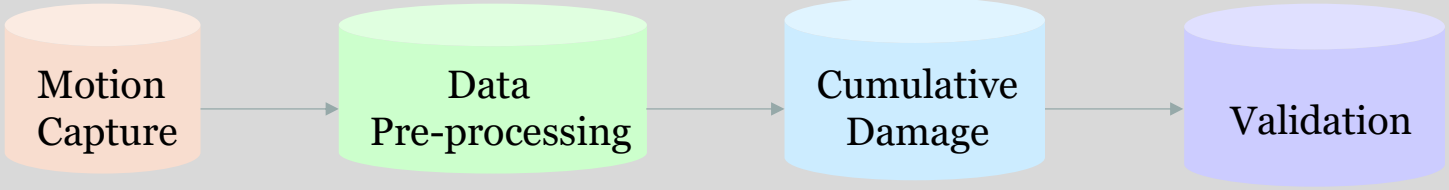
To develop from paper written by *JuHyeong Ryu, A.M.ASCE1; Bennett Banting2; Eihab Abdel-Rahman3; and Carl T. Haas, F.ASCE4*, titled as **'Ergonomic Characteristics of Expert Masons'**.

We would like to introduce cumulative damage ergonomic assessment to the same experiment conducted in the paper mentioned previously. Cumulative Damage is an important risk indicator in ergonomics because some posture might not be considered as risky at that moment, but it causes serious musculoskeletal disorder in a long run.

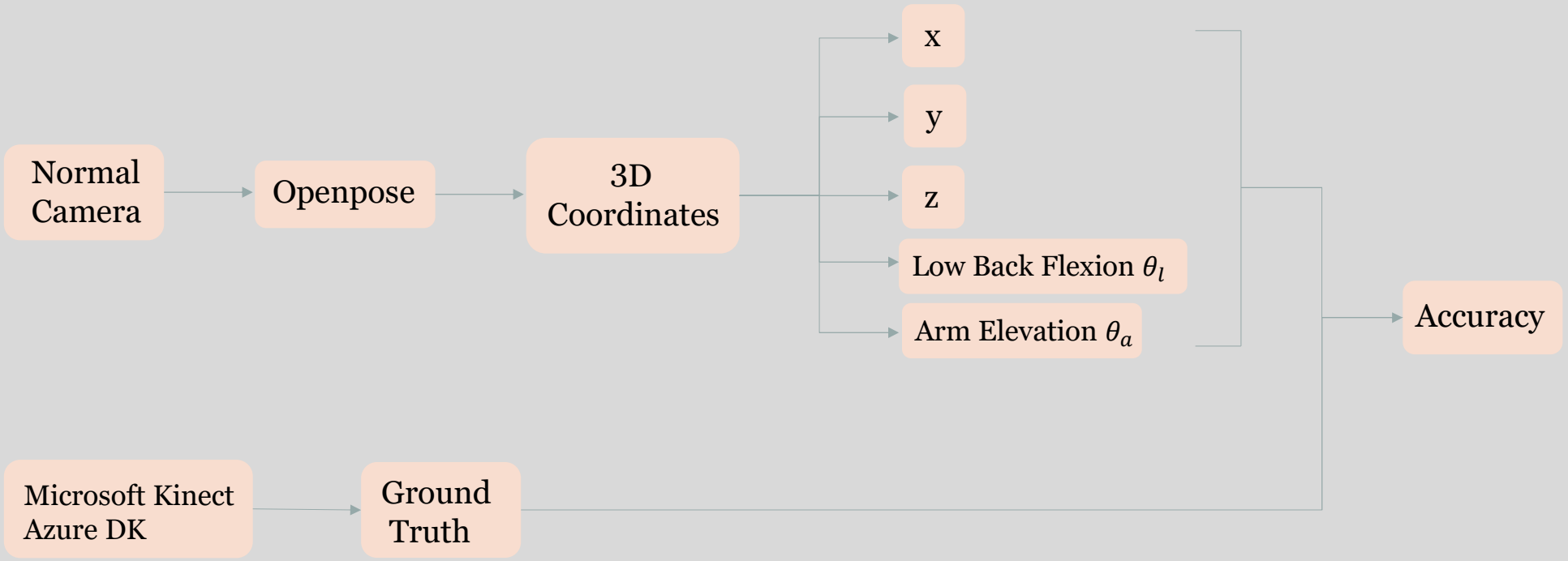
Another thing we would like to introduce is using only computer vision with deep learning to perform the posture estimation without wearing any suit such as IMU. Wearing a suit while working in construction site is less convenient and less comfortable for workers. In addition, to purchase the suit, the budget is higher compared to only using camera for posture estimation.

In the end, we can compare our outcome in terms of cumulative damage to the outcome in the paper mentioned above. We expect our outcome has some similarity to the outcome in the reference paper, but some differences occur due to the consideration of cumulative damage assessment.

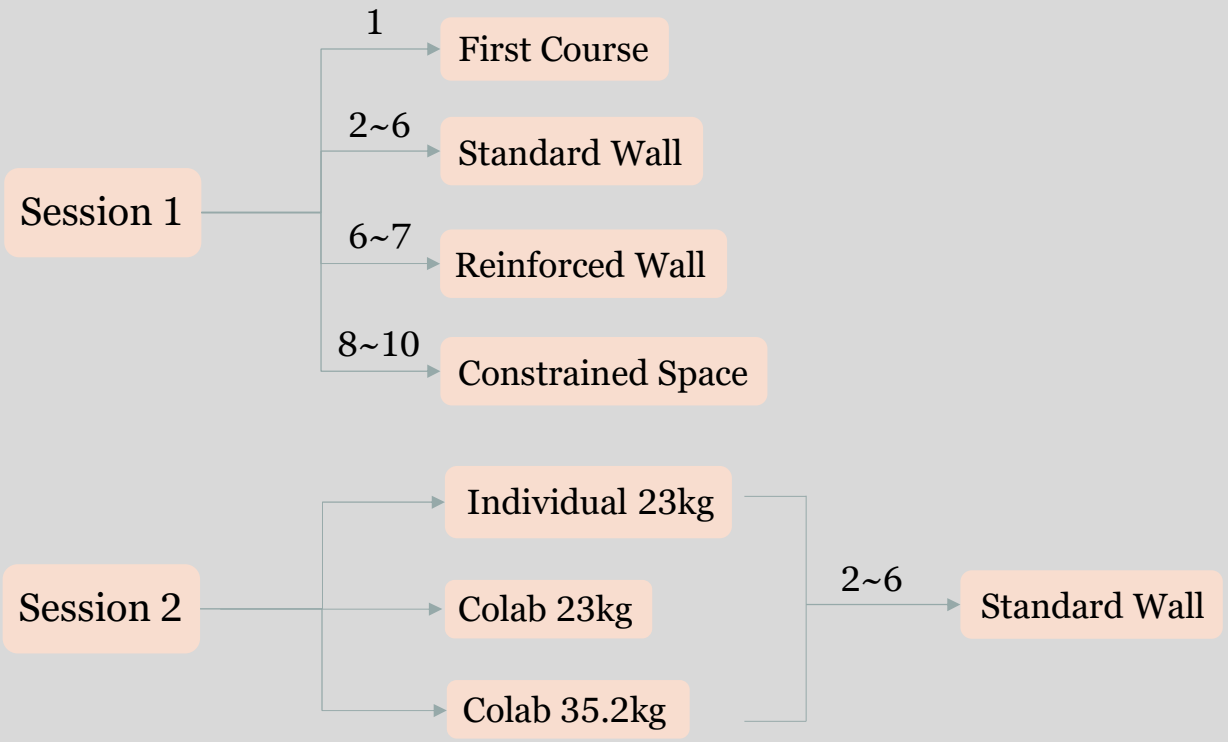
Technical Framework of CD



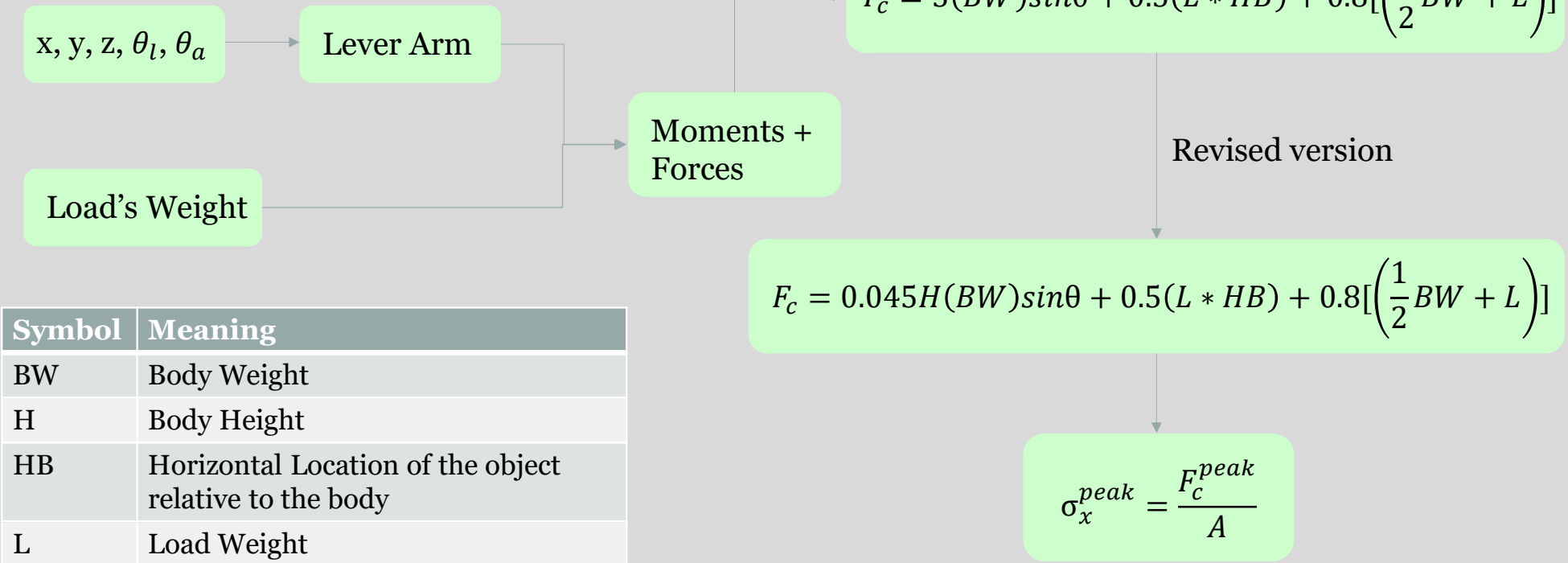
Motion Capture



Experiment for Motion Capture

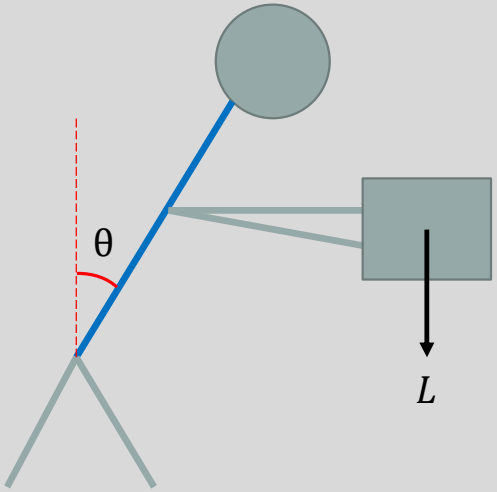


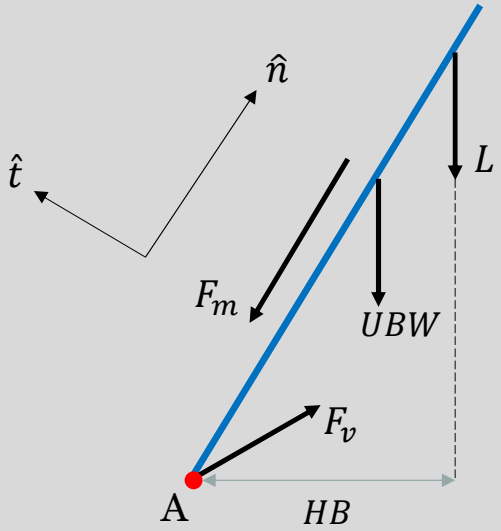
Data Pre-processing (Low Back)

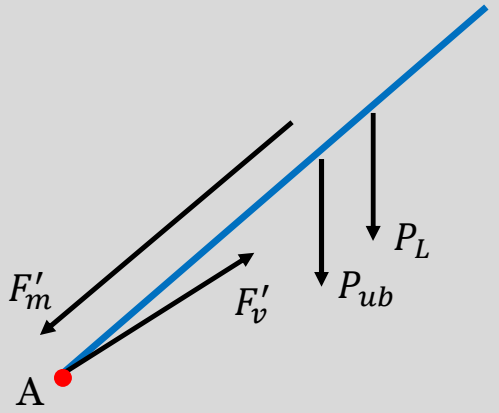


Symbol	Meaning
BW	Body Weight
H	Body Height
HB	Horizontal Location of the object relative to the body
L	Load Weight

Data Pre-processing (Low Back)







https://health.usf.edu/publichealth/tbernard/~/media/D7F7CFCBC5EF43EBB9A23E592BC84411.ashx

https://www.researchgate.net/publication/40785995_A_revised_back_compressive_force_estimation_model_for_ergonomic_evaluation_of_lifting_tasks

By $\Sigma M_A = 0$

$$(UBW)\boldsymbol{d_{ub}} + (L)(\boldsymbol{HB}) = (\boldsymbol{F_m})d_m$$

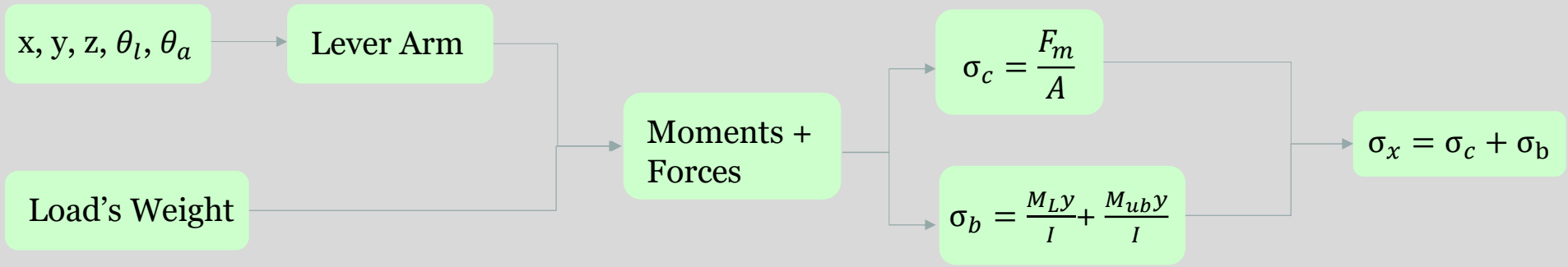
$\boldsymbol{d_{ub}}$, $\boldsymbol{HB}$ ↑ → $\boldsymbol{F_m}$ ↑

By $\Sigma F = 0$

$$\boldsymbol{F_v^n} = UBW^n + L^n + \boldsymbol{F_m}$$

$\boldsymbol{F_m}$ ↑ → $\boldsymbol{F_v^n}$ ↑

Data Pre-processing (Shoulder)



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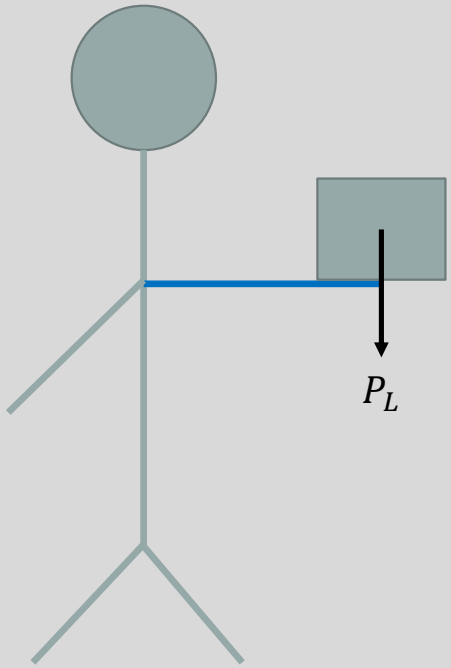
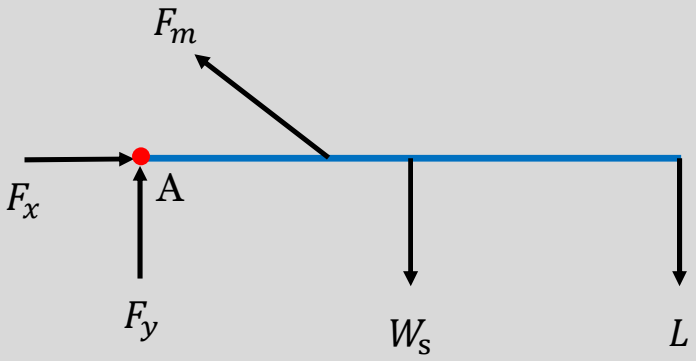
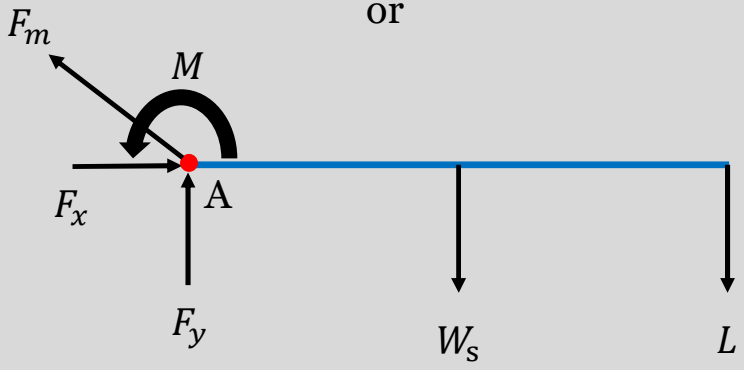
σ_x is total axial stress
σ_c is centric axial stress
σ_b is axial stress caused by bending moment

Data Pre-processing (Shoulder)





or



Cumulative Damage

$S = \frac{\sigma_x^{peak}}{\sigma_u^{avg}}$

- Low Back → $N = 902416 * e^{-0.162*S}$
- Shoulder → $S = 101.25 - 14.83 \log N$

→ CD = DPC * Number of Repetitions

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σ_u is average axial stress per cycle
σ_u is mean ultimate axial stress
S is normalized axial stress wrt σ_u

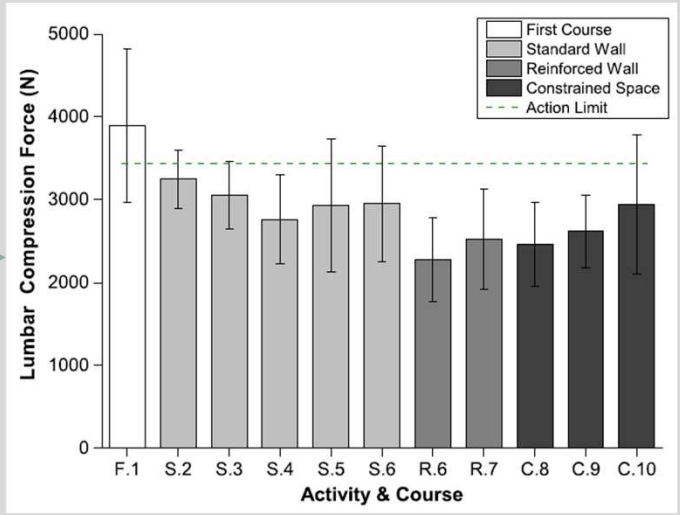
Validation – 1st Session

Lumbar Compression Force

Cumulative Damage

Observe and Compare

Benchmark



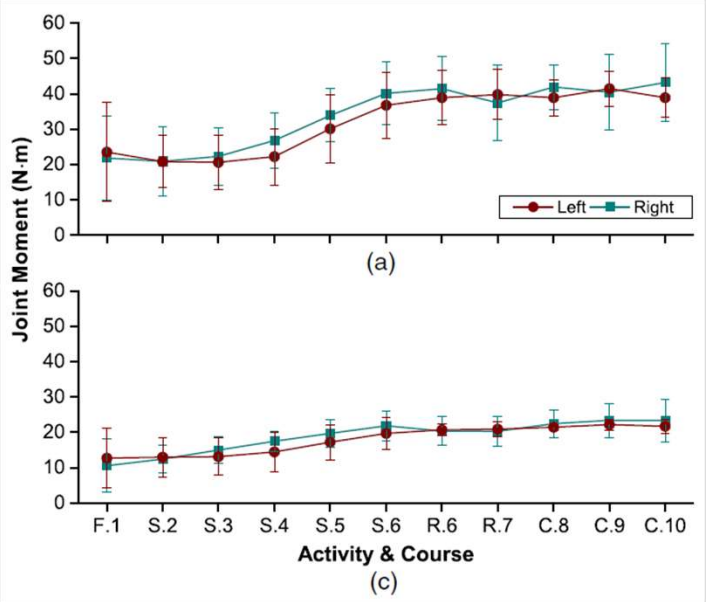
Validation – 1st Session

(a) Shoulder Moment
(c) Elbow Moment

Cumulative Damage

Observe and Compare

Benchmark



*The author made a mistake, (c) is elbow moment not hip moment

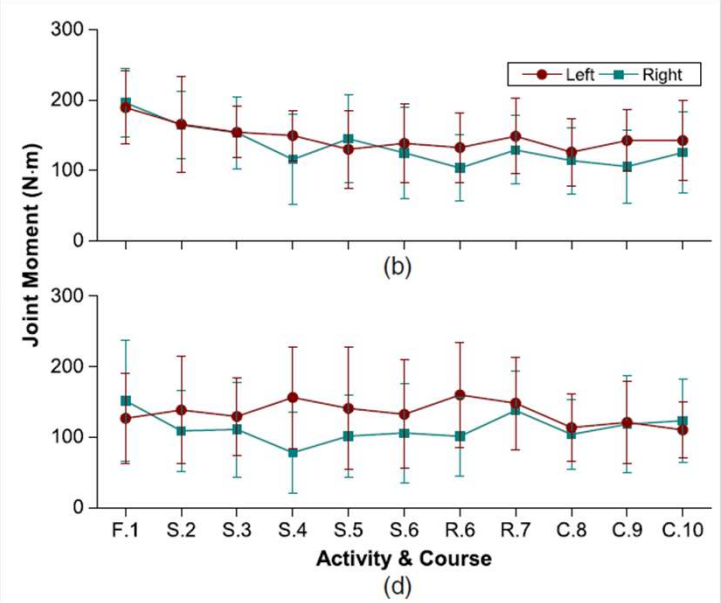
Validation – 1st Session

(b) Hip Moment
(d) Knee Moment

Cumulative Damage

Observe and Compare

Benchmark



*The author made a mistake, (b) is hip moment not elbow moment

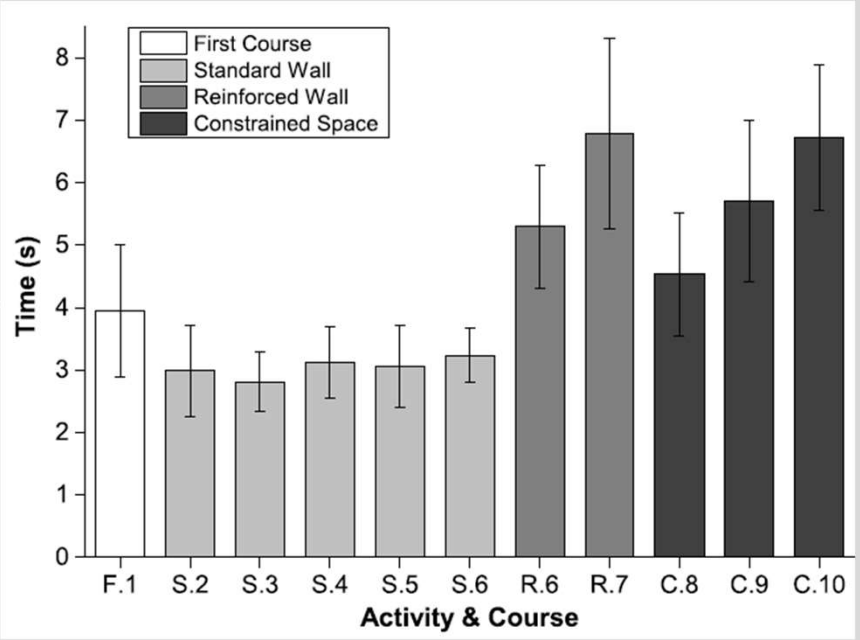
Validation – 1st Session

All 1st - session activities

Efficiency

Observe and Compare

Benchmark



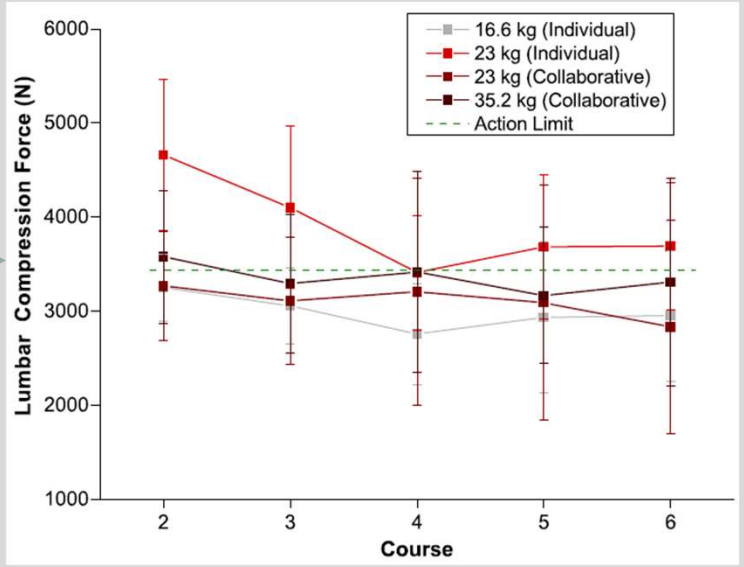
Validation – 2nd Session

Lumbar Compression Force

Cumulative Damage

Observe and Compare

Benchmark



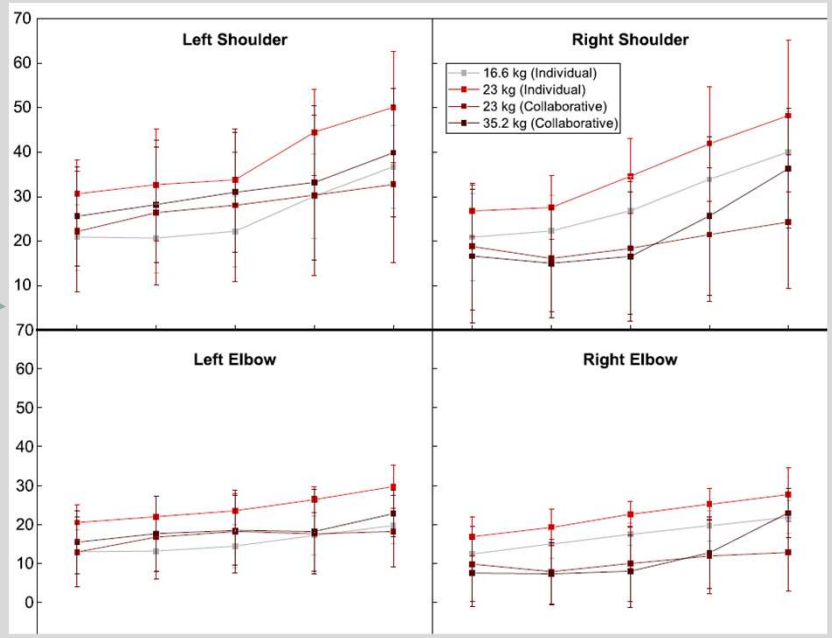
Validation – 2nd Session

(a) Shoulder Moment
(c) Elbow Moment

Cumulative Damage

Observe and Compare

Benchmark



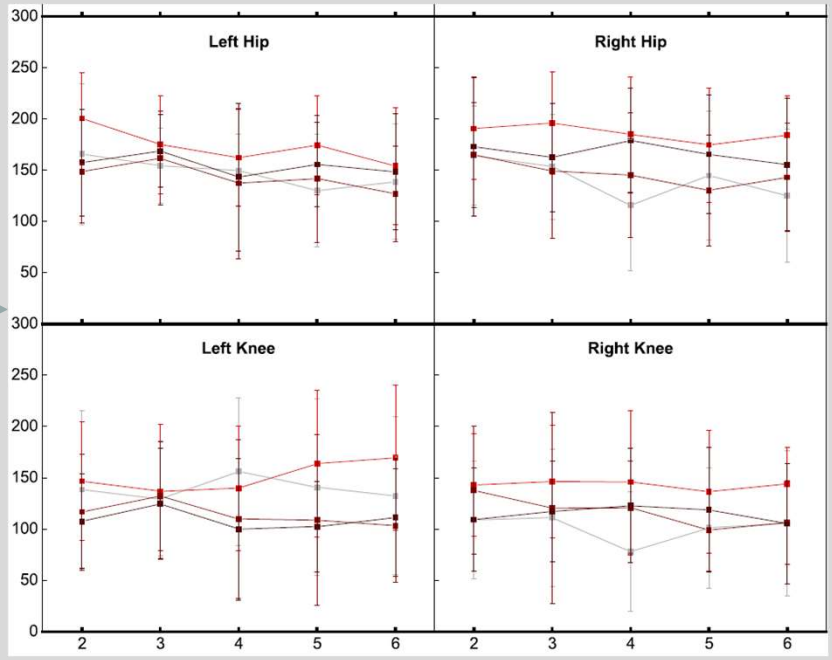
Validation – 2nd Session

(b) Hip Moment
(d) Knee Moment

Cumulative Damage

Observe and Compare

Benchmark



Validation – 2nd Session

All 2nd - session activities

Efficiency

Observe and Compare

Benchmark