Neural, Muscular, and Perceptual responses with Shoulder Exoskeleton use over days
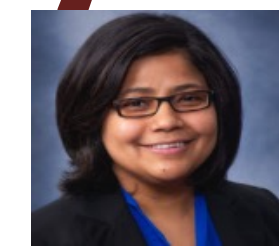
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BACKGROUND

A majority of the cases of Musculoskeletal Disorders in the United States involve workers employed in manufacturing, and social assistance workforce. Repetitive overhead work, that is work done over the acromion level, is one of the leading causes of work-related MSDs [1]. This causes increased absenteeism but also affects the worker's wellbeing and health [2, 3]. Passive shoulder exoskeletons have been widely introduced in the industry to aid upper extremity movements during repetitive over head work. As an ergonomic intervention it is important to understand how users adapt to these devices over time and if these induce external stress while working.

- Does adaptation to exoskeleton happen over days?
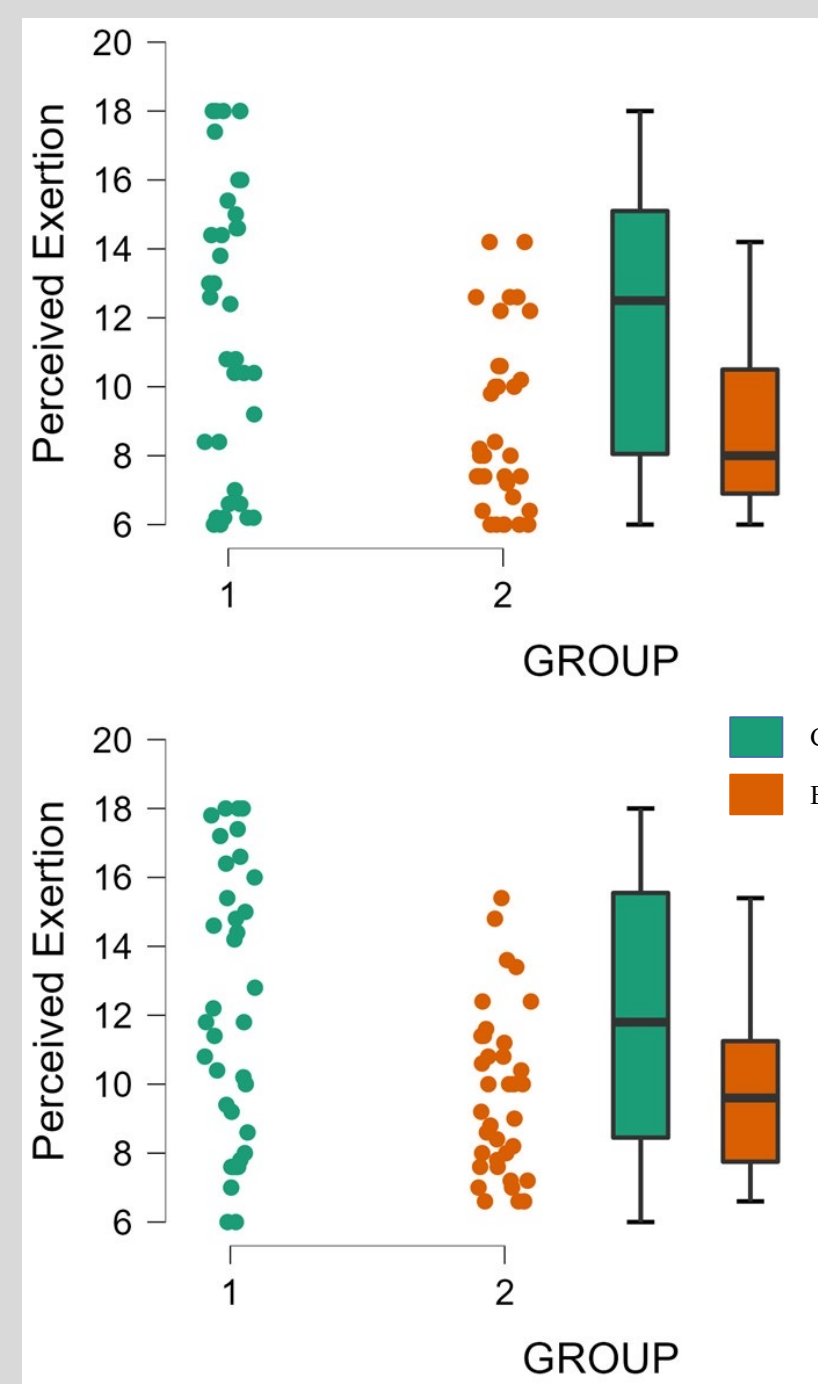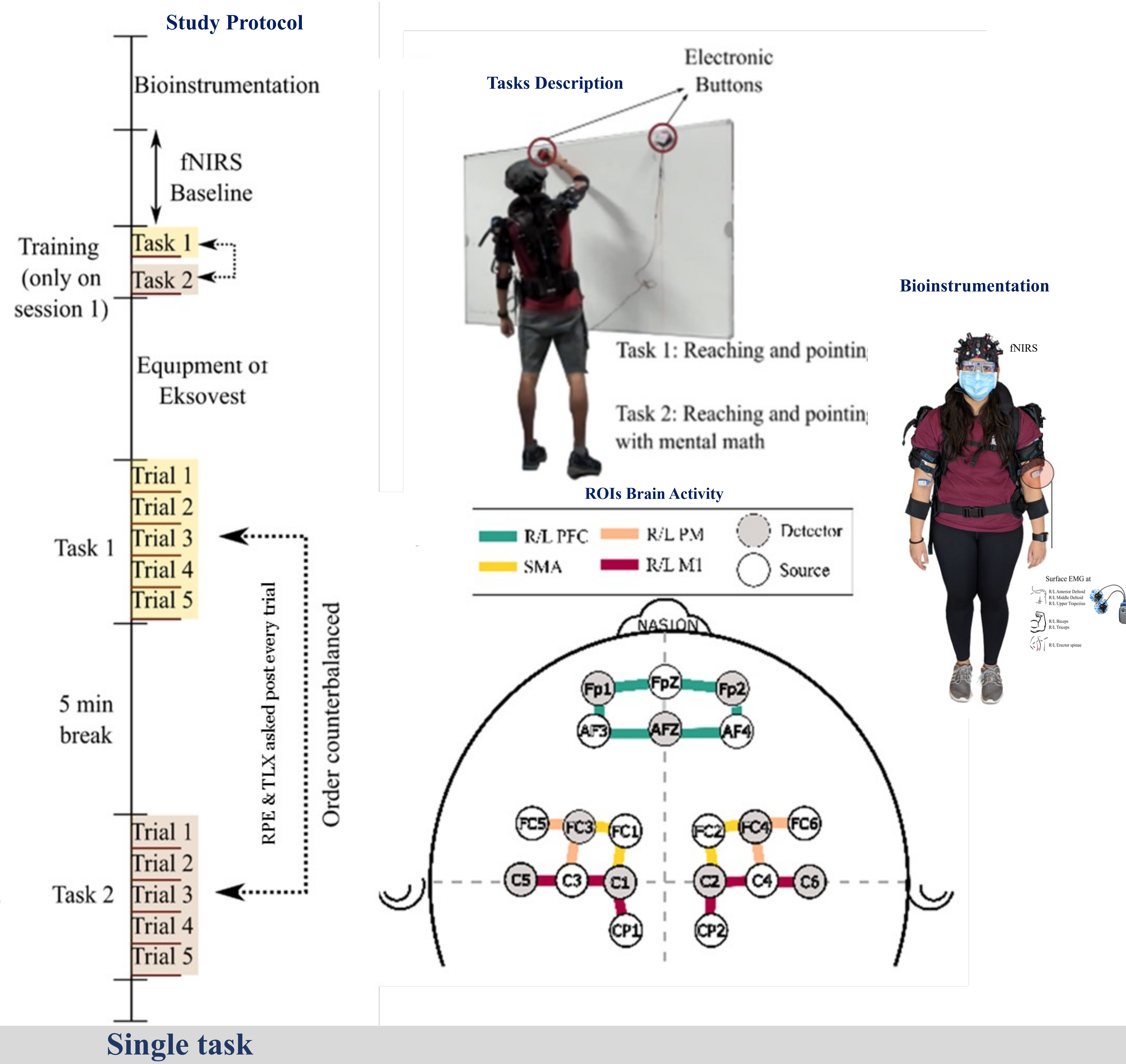- Can we capture it?
- Studied over 3 days

Over days

- Do exoskeletons account for sex differences?
- Sex balanced population
- 24 participants

Sex difference

- Shoulder Exoskeletons are proved beneficial for overhead task
- BUT, how are they still effective when perturbation is introduced ?
- Compared Physical task with physical task induced with cognitive workload
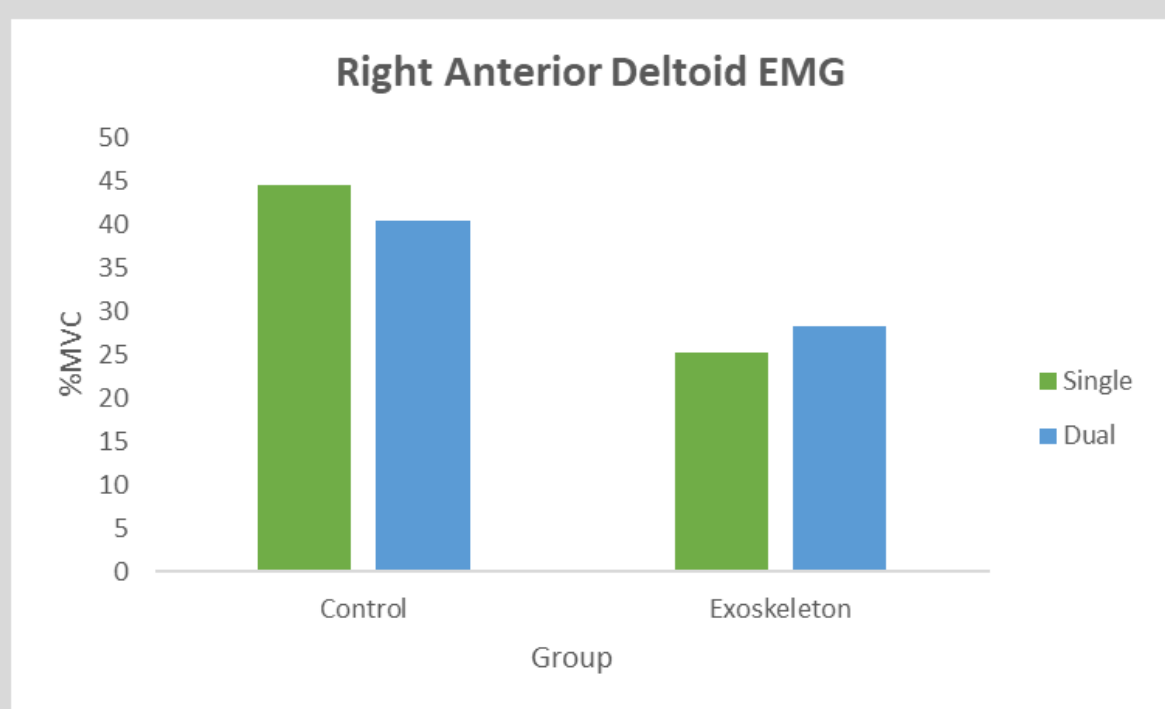
Induced Mental Workload

OBJECTIVES

➢ Motor & Neural Adaptation over time
➢ Gauge benefits based on task
➢ Evaluate gender equity

Study Protocol

Bioinstrumentation

fNIRS Baseline

Training (only on session 1) — Task 1, Task 2

Equipment of Eksovest

Task 1 — Trial 1, Trial 2, Trial 3, Trial 4, Trial 5

5 min break

Task 2 — Trial 1, Trial 2, Trial 3, Trial 4, Trial 5

RPE & TLX asked post every trial
Order counterbalanced

Tasks Description — Electronic Buttons

Task 1: Reaching and pointing
Task 2: Reaching and pointing with mental math

Bioinstrumentation — fNIRS

ROIs Brain Activity
- R/L PFC
- SMA
- R/L PM
- R/L M1
- Detector
- Source

Single task

Single task

Lower perceived exertion in the EXO group across both single and dual tasks

Females - Control   Males - Control
Females – Exoskeleton   Males - Exoskeleton

R... be... in EXO condition during single t...

Exoskeleton reduces shoulder EMG in single task and in females
EXO benefit diminishes in dual tasks

...on between frontal and motor ROIs in EXO condition particularly in ...ks
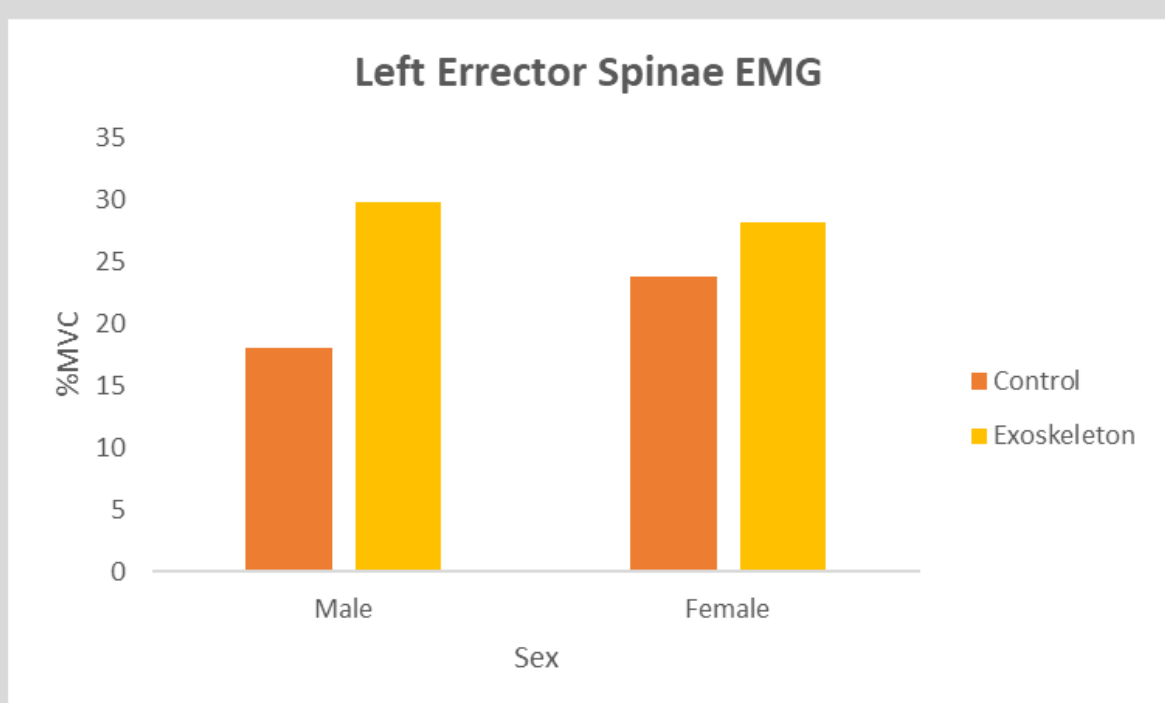
Exoskeleton reduces low back EMG for males
No EXO benefits observed in females

Females - Control   Males - Control
Females – Exoskeleton   Males - Exoskeleton
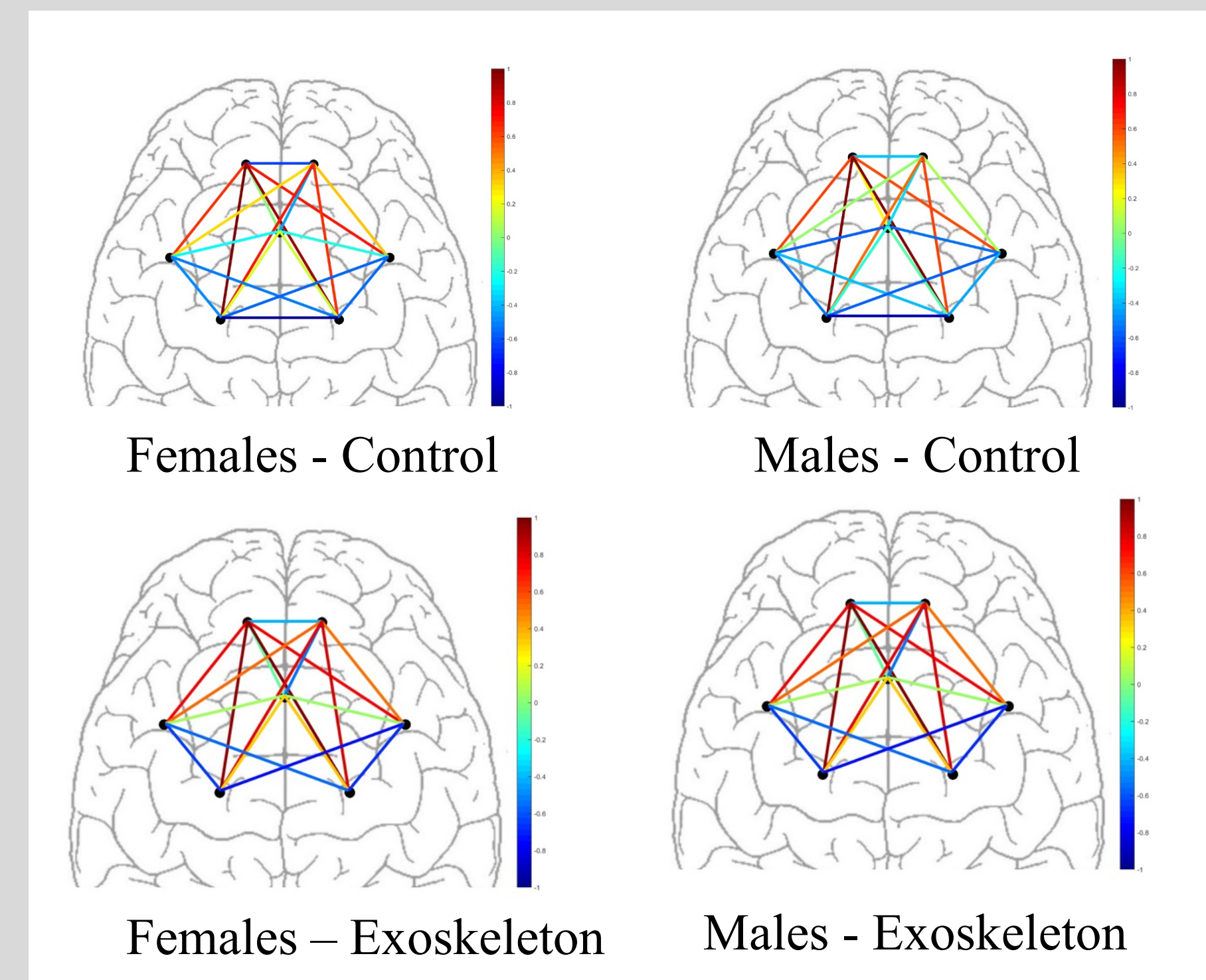
Why is this important?

❖ To assess if exoskeletons can help in domains requiring not just physical strength but also cognitive situation awareness
❖ Sex differences identified can be used as a fundamental basis to develop design metrics to built exoskeletons to aid both sexes based on physiological differences
❖ Based on perception, trust in technology can be improved helping masses adopt to better ways of working to safe guard themselves

Future Work

❖ Passive shoulder exoskeletons need to be evaluated for longer range of motion
❖ Based on brain activity behavior, neural metrics need to be developed to assess impact of exoskeletons
❖ Evaluation of motor adaptation for more cognitively challenging tasks over longer trials

References

1. Grieve, Jason R., and Clark R. Dickerson. "Overhead work: Identification of evidence-based exposure guidelines." Occupational Ergonomics 8.1 (2008): 53-66.

2. Alexopoulos, E.C., et al., Musculoskeletal disorders in shipyard industry: prevalence, health care use, and absenteeism. BMC musculoskeletal disorders, 2006. 7(1): p. 1-10.

3. De Bock, S., et al., Passive shoulder exoskeletons: more effective in the lab than in the field? IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2020. 29: p. 173-183.

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