Collaborative Research NRI: Understanding Underlying Risks and Sociotechnical Challenges of Powered Wearable Exoskeleton to Construction Workers

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This project synergistically integrates wearable robotics, immersive technologies, physiological sensing, artificial intelligence, and socio-technical system theory to understand the underlying physical and psychological risks and socio-technical challenges of incorporating powered back-support exoskeletons (BSEs) on construction sites.

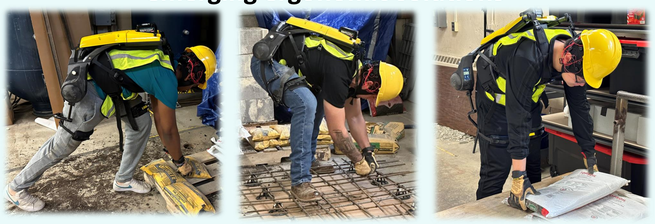
Powered Exoskeletons in Construction Sector

Construction work involves physically intensive tasks and repetitive tasks, often performed in unusual postures, exposing workers to **Work-related muscoskeletal disorders (WMSDs).**

Back-related WMSDs are the most prevalent of all musculoskeletal disorders in construction industry.

Incidence of back-related WMSDs in construction sector is two times than all industries combined.

Powered Back-Support exoskeletons (BSEs) are emerging ergonomic solutions



Key Problems to be Addressed in Research

Limited knowledge to support widespread implementation of powered BSEs in the construction industry **due to lack of understanding in** :

- Social technical challenges (perceived usefulness and ease of use, trust, and risk perception) of using exoskeletons under real working conditions.
- Physiological consequences (changes in postures and movement control mechanisms) for construction workers in using exoskeletons.
- Impact of exoskeletons on workers' psychology (changes in cognitive load and attention cost).

Overview of the Research Project

Understanding the Sociotechnical Challenges of BSEs in Construction

Interactive and Immersive Virtual-reality Testbed for Task Execution with BSEs

Worker-centered Physical and Physiological Risk Assessment

Identification of Barriers in Adoption of BSEs

Survey was sent to construction professional nationwide to assess facilitators and barriers influencing adoption of BSEs in construction.

200 experts were contacted, and 105 completed questionnaires were received.

Most Significant Barrier for Adoption of Exoskeleton

Usability of exoskeletons

Willingness to use (team buy-in)

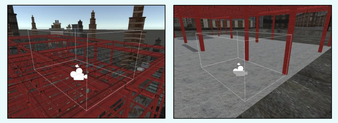
Productivity gains for exoskeletons

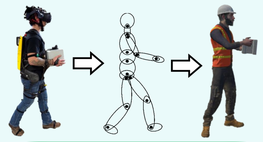
Least Significant Barrier for Adoption of Exoskeleton

Hygiene issues with exoskeleton

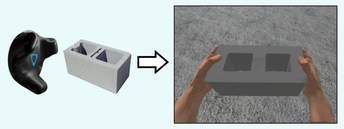
Developing an Interactive Immersive Simulated Workplace

Scenario Creation





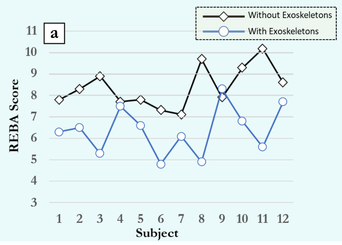
Tangible Object



Assessment of Ergonomic Risks while Using Powered BSEs

Joint angle were calculated using computer vision technique, and Rapid Entire Body Assessment (REBA) was used to evaluate the ergonomic risk.

REBA score for subjects with BSEs was lower, pointing decrease in ergonomic risk.



Key Innovations of the Research

Provides awareness of the relationship between construction tasks, organizational structure, stakeholders, and wearable robotics technology.

Generates a user-centered, simulated workspace to examine interactions with emerging technologies for safe and feasible evaluation of pertinent physical and psychological risks.

Develops a new interpretive pipeline between physiological and psychological data with local muscular fatigue, fall risk, joint hyperextension, cognitive workload, trust, and vigilance of individuals.

Broader Impacts (Impact on Society)

Improves the safety and productivity of 7.5 million workers in the U.S. construction industry.

Provides evidence for manufacturers to design more adaptable exoskeletons, promoting occupational health equity in the construction workplace.

Broader Impacts (Education and Outreach)

- Engaging Underrepresented Workers and Students
- K12 Outreach
- Demonstration and K12 Outreach
- Videos for Public
- Workshops for Industry

PI Jebelli organizing a workshop for this project

2023 FRR & NRI Principal Investigators' Meeting
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