CHARACTERIZING FATIGUE DYNAMICS INDUCED BY EXTENDED USE OF EXOSKELETAL SYSTEMS IN MILITARY AND OCCUPATIONAL ENVIRONMENTS

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Background

Fatigue is a significant issue for individuals engaged in physically demanding tasks, such as military personnel and patients undergoing rehabilitation. Exoskeletal devices, like exoboots, are designed to provide external support and reduce fatigue by aiding in movement and load distribution. This study explores the potential of exoboots to reduce fatigue in fit individuals during extended physical exertion, with applications in both rehabilitation and military settings. Understanding their effectiveness can lead to improved performance, faster recovery, and reduced injury risk in these populations.

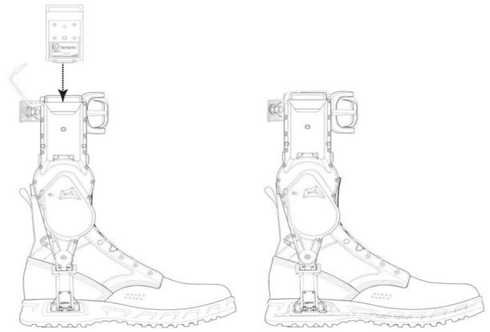
Study Objective

The objective of this study was to evaluate the effectiveness of exoboots in reducing fatigue during extended physical tasks in fit individuals. Specifically, it aimed to assess the impact of exoboots on endurance, recovery, and overall performance in both controlled and potential real-world settings.

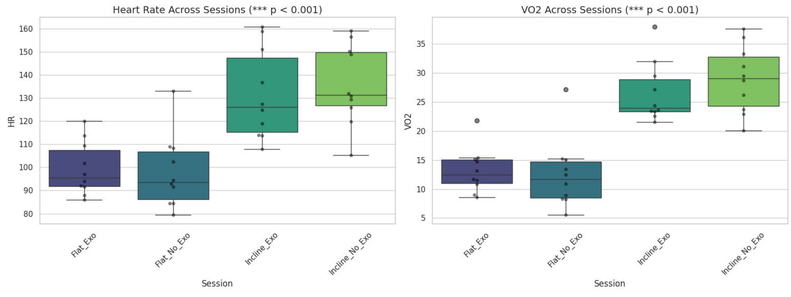
Methods

Ten participants (ASU ROTC, aged 18-25) completed four walking conditions: (1) No exoboots + incline, (2) Exoboots + incline, (3) No exoboots + no incline, and (4) Exoboots + no incline, each with a 50 lb weighted vest. Endurance duration, heart rate (HR), R-R intervals, and oxygen consumption (VO2) were measured using motion capture, force plates, Inertial Measurement Units (IMUs), and ECG. Trials were spaced over 2-3 weeks, with walking speed adjusted to maintain manageable exertion levels. Data analysis focused on comparing endurance, cardiovascular responses, and metabolic demands under different conditions, providing a comprehensive evaluation of fatigue reduction and performance.

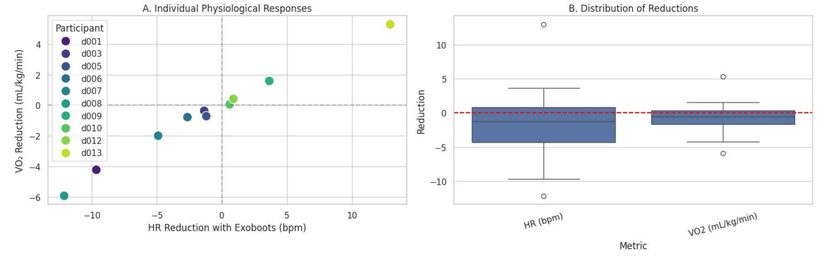
Exoboot Design



Results



Heart rate (left) and VO_2 (right) across four walking conditions: Flat_Exo, Flat_No_Exo, Incline_Exo, and Incline_No_Exo. Both measures increased significantly with incline ($p < 0.001$). Exoboots did not reduce fatigue and sometimes slightly increased effort.



Effects of exoboot use on heart rate and VO_2. (A) Individual changes show mixed responses; points left/below zero indicate reduced effort. (B) HR slightly decreased on average, while VO_2 changes were minimal and inconsistent, highlighting varied effects.

Discussion

- Key Findings:
  - Exoboots did not consistently reduce physiological fatigue, with some participants showing slight decreases in heart rate or VO_2, while others showed increases.
  - On average, heart rate slightly decreased with exoboot use, but VO_2 changes were minimal and varied, indicating limited overall impact on metabolic demand.
  - Individual responses to the exoboot varied widely, suggesting its effectiveness may depend on user-specific factors such as physiology or gait mechanics.
- Study Limitations:
  - Limited sample size and focus on fit individuals, restricting generalizability.
  - Short-term design, lacking long-term effect or wear analysis.
  - Controlled tasks may not reflect real-world conditions.
  - User experience, including comfort and psychological impact, was not explored.
- Future Research Suggestions:
  - Include a diverse cohort to assess broader applicability.
  - Investigate long-term effects and device wear.
  - Test exoboots in real-world settings, considering task complexity and stressors.
  - Examine user comfort and compare with other fatigue-reducing devices.

Acknowledgments

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