

Effect of Hydration Pack Load Carrying Configuration on Trail Running Energetics and Performance

Ryan Giglio | Cal Poly Humboldt

Introduction

- Running performance is influenced by biomechanics and metabolic efficiency, often referred to as running economy.^{18 19}
- Trail running presents additional challenges due to:
 - Uneven terrain⁴
 - Variable grade¹⁸
 - Increased neuromuscular demand
- External load carriage (hydration packs) alters:
 - Mechanical work (joint coordination, leg stiffness)^{10 11 17}
 - Energy expenditure (cost of transport increases with load)^{7 16}
- Problem: Limited research compares hydration pack configurations in real trail environments.^{12 16 20}
- Research Purpose: Identify which hydration pack design minimizes metabolic cost and performance decline.



Methods

- All searches were conducted using Google Scholar, ScienceDirect, and SPORTDiscus as search engines.
- Used keywords included running, trail running, metabolic cost, uneven terrain, energetics, load carriage, performance, hydration pack, running economy, biomechanics, kinematics, energy expenditure.

Results

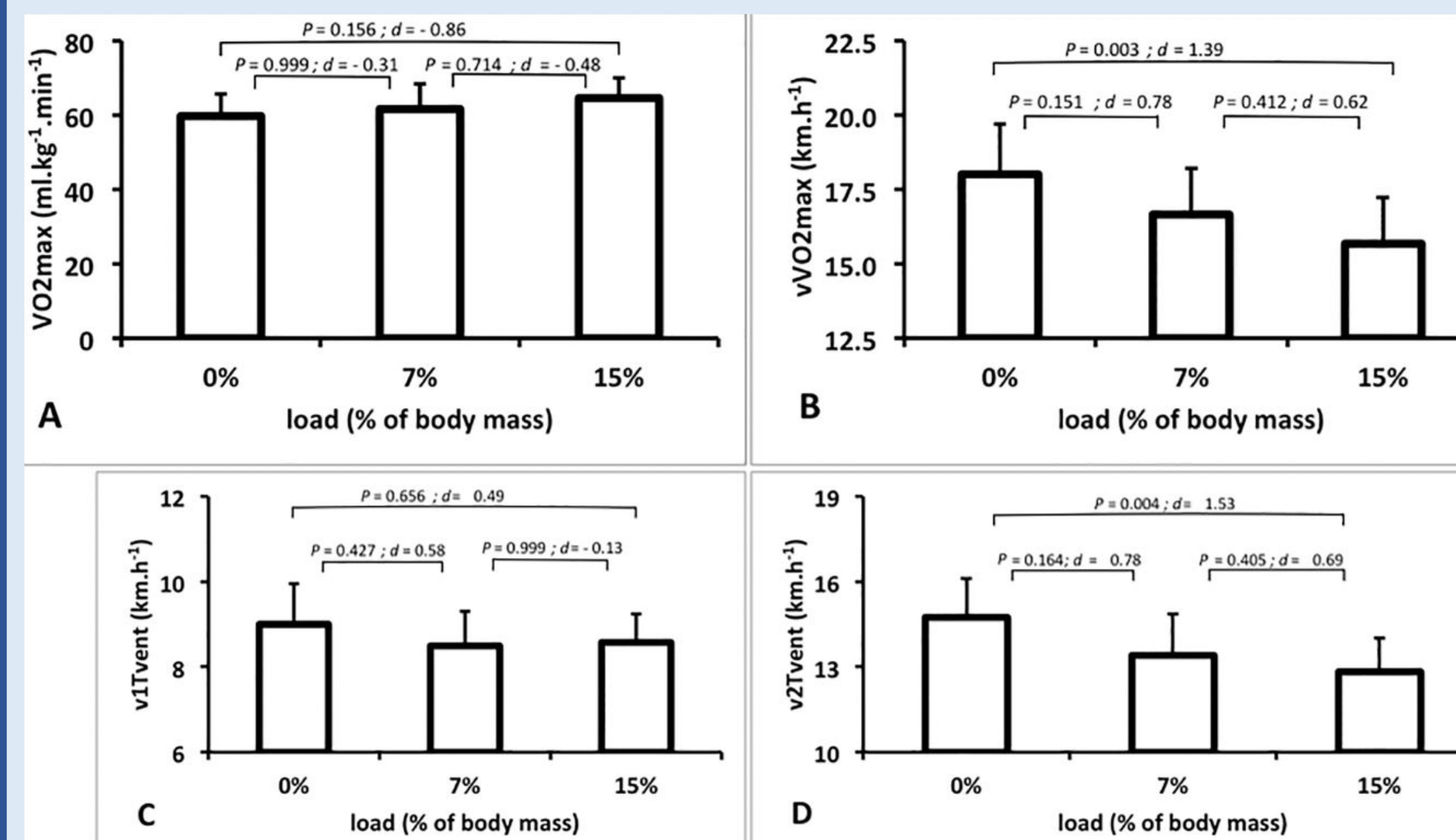


Figure 1: VO2max and ventilatory thresholds with varying load (Fagundes et al, 2017)

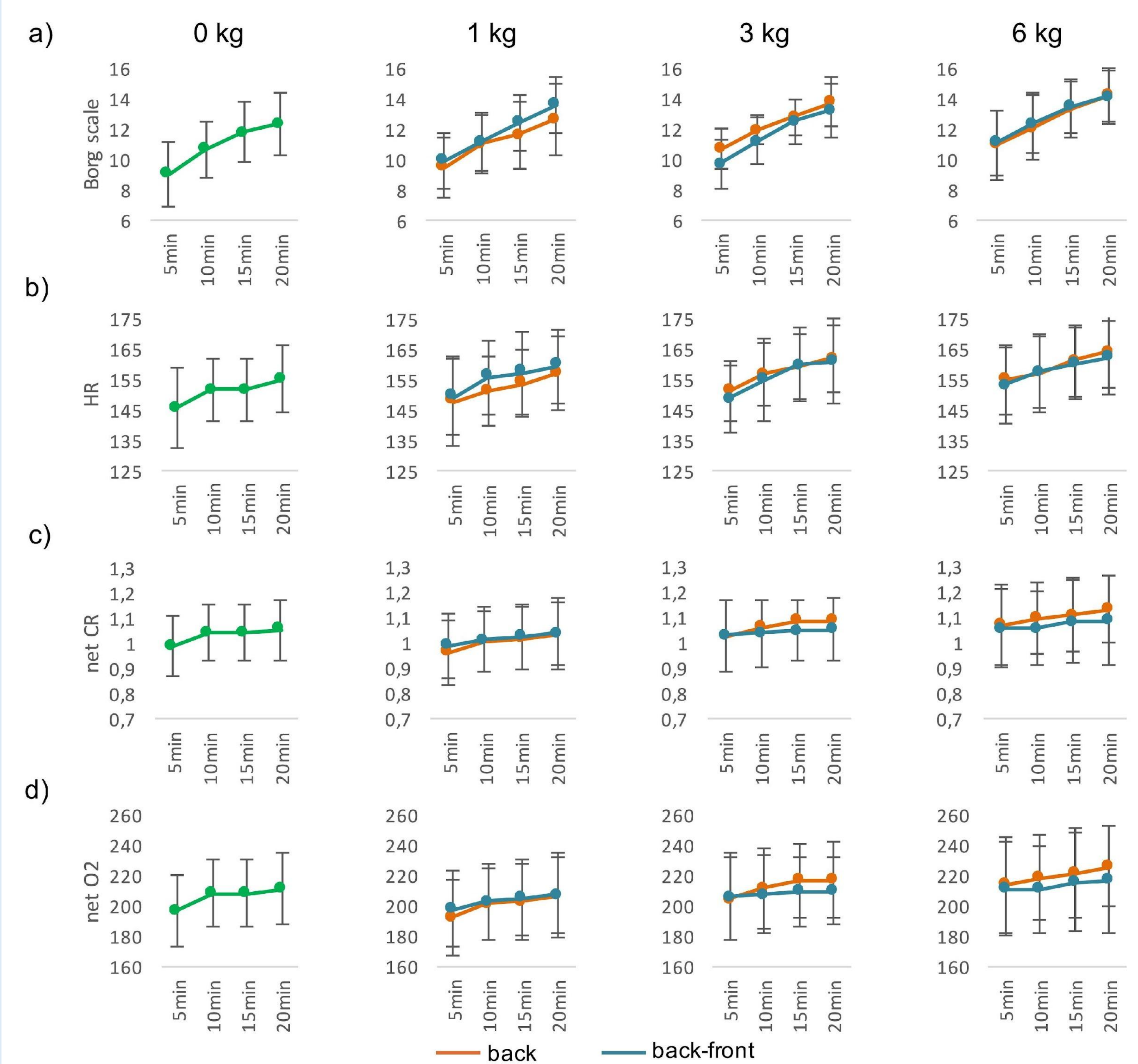


Figure 2: Metabolic cost comparisons between backpack designs and weights (Scheer et al, 2020)

Conclusion

- External load carriage consistently increases metabolic cost, even when running mechanics appear largely unchanged.^{7 10 16}
- Biomechanical adaptations (e.g., increased leg stiffness, altered coordination) help maintain performance but may increase energetic demand.^{11 17}
- Hydration systems show minimal differences in kinematics, suggesting that load placement and distribution are key factors.^{12 16}
- Current evidence is limited by controlled laboratory settings, reducing real-world applicability to trail running.^{4 12 16}

Future Directions

- Conduct field-based studies on actual trails to capture terrain variability and ecological validity.^{4 15}
- Directly compare common hydration pack configurations (vest, backpack, waist belt, handheld).^{12 16}
- Incorporate performance and physiological measures^{13 8}
 - Cost of transportation
 - Running power
 - Time-to-completion
- Examine long-duration fatigue effects and comfort over ultra-endurance distances.^{9 15}
- Identify an optimal load distribution strategy that minimizes energy cost while maintaining performance.^{12 16}

References



Cal Poly
Humboldt.