



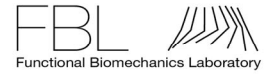
# Hip-belt Load Sharing Reduces Peak Shoulder Pressure Across Walking Slopes During Heavy Load Carriage

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## Objective

Quantify how pressure under backpack shoulder straps is affected by using a hip belt during heavy load carriage

## Introduction

50% of active-duty military personnel experience a load-related musculoskeletal injury each year [1]

Heavy loads (30-40 kg) increase strain on upper-body nerves, reducing motor function and control of upper limbs and hands [2]

30% of vertical forces from backpack can be offloaded by a hip-belt attachment [3]

Little is currently known about the effect of using a hip belt on offloading shoulder strap pressure and the influence that walking slope has on shoulder pressure during load carriage.



U.S. Marine Corps photo by Capt. Jeffrey Belovaras/Released

## Methods

### Participant Demographics

Military Service Personnel

N = 4 (3M,1F)

Height: 1.66 ± 0.05 m

Weight: 65.2 ± 9.0 kg

Age: 28 ± 6 y

### 2 Load Conditions

Hip Belt Assisted (Hip Belt)

- Body armor, helmet, and backpack
- 40% body weight total

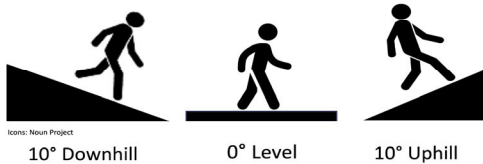


Shoulder borne

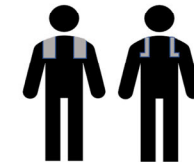
- Body armor, helmet, and backpack
- 40% body weight total



### 3 Slope Conditions (treadmill walking, 1.15 m/s)



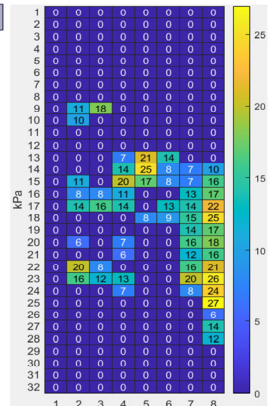
### Pliance Sensor Orientation



Front View Back View

- Pressure data from two Pliance<sup>®</sup> sensors (Novel, Inc) collected at 20Hz

- 256 sensing sites (1cm<sup>2</sup>, 8x32 grid) from each sensor. Cells are arranged in an 8x32 grid and oriented lengthwise to align with shoulder straps



Visualization of pressure magnitude over sensor area

### Outcome metrics

1. Peak Point Pressure
2. Average Total Pressure

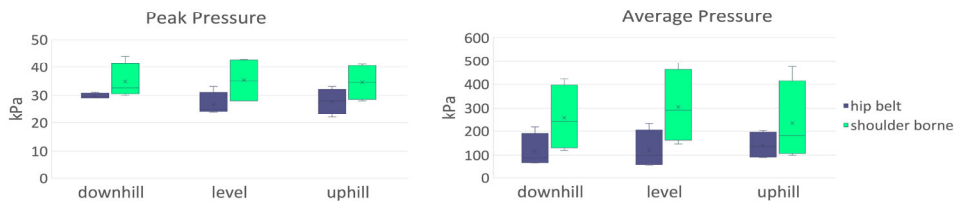
Computed in MATLAB

### Linear Mixed Effects

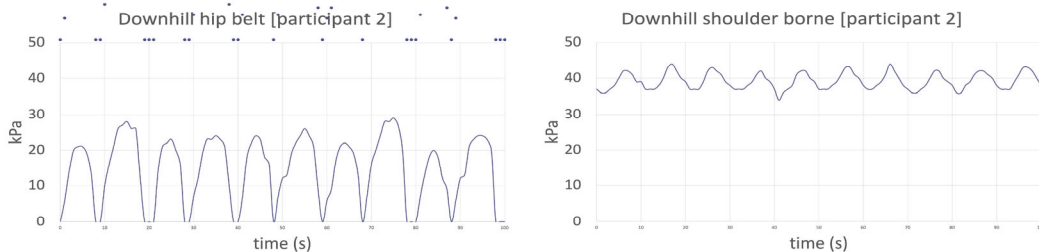
- Backpack, Slope, Backpack × Slope, participants as random intercepts
- ANOVA ( $\alpha = 0.05$ ), Pairwise comparisons using Tukey's HSD
- Analysis performed using R (R Core Team (2022). <https://www.R-project.org/>)

## Results

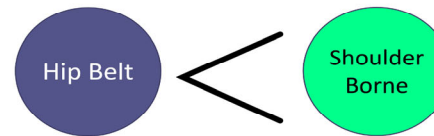
### Average and Peak Pressure for all slope conditions (n=4)



### Peak pressure over time between load conditions

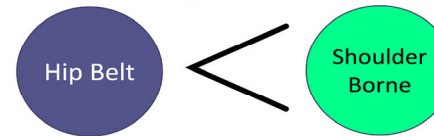


Peak Pressure  
p = 0.004



25.9% decrease

Average Pressure  
p = 0.001



120.7% decrease

## Conclusions

- Hip-belt configuration effectively reduced peak and average shoulder pressure in all participants under all slope conditions.
- Both shoulder and hip-belt conditions resulted in peak pressure below the recommended maximum, 45 kPa [4].
- Lower peak and greater range of pressure occurred when participants wore hip belt, resulting in a decrease in average pressure on all slopes.
- Future work will examine asymmetry between shoulders and analyze relationship between load condition and backpack kinematics.

## Acknowledgments

Colorado School of Mines Undergraduate Research Fellowship

## References

- [1] U.S. Army Public Health Center (2018)
- [2] Hadid et al. (2015) *J Biomech*, 48(15)
- [3] Lafandra et al. (2004) *Med Sci Sports*, 36(3)
- [4] Bryant et al. (2004) *Ergon Des*, 12(Winter)

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