The effects of military load carriage on torso segment acceleration local dynamic stability during walking

L. Eduardo Cofré Lizama[1,2], Kane Middleton[3] **Jon Wheat**[4]
[1]School of Health Sciences, Department of Allied Health, Swinburne University of Technology, Melbourne, Australia
[2]Department of Medicine (Royal Melbourne Hospital), University of Melbourne, Melbourne, Australia
[3]School of Allied Health, Human Services and Sport, La Trobe University, Melbourne, Australia
[4]School of Science and Technology, Nottingham Trent University, Nottingham, United Kingdom
Email: jon.wheat@ntu.ac.uk

Summary

We investigated the effects of load carriage on torso segment acceleration local dynamic stability (LDS) - estimated by the short-term local divergence exponent (LDE) - in male and female soldiers walking at several military-relevant speeds. For both males and females, greater loads led to decreased LDS of sternum, but increased LDS of sacrum, acceleration. These findings suggest that participants prioritised pelvis over thorax stability in adapting to the task of carrying heavier loads.

Introduction

Soldiers are routinely required to carry heavy loads during walking and marching, which has been associated with high incidence of musculoskeletal injuries [1]. The LDS of torso segments is related to injury risk and risk of falling [2]. In a group of older adults, carrying a load of 15% body weight resulted in decreased LDS of markers attached to the sternum [2]. On the other hand, in young adults, carrying a relatively light load (11 kg) led to an increase in the LDS of the sacrum – assumed to be a proxy for whole-body centre of mass (COM) [3]. More work is needed on the effects of load carriage on torso LDS in military personnel with heavier, military-relevant loads, to better understand injury risk in this population.

Methods

This study was approved by the DDVA and LTU HREC (302-20 and 302-20 DDVA HREC, respectively). Active-duty male Australian Army soldiers (n=23 25 ± 5 years; 175.3 ± 9.3 cm; 78.0 ± 15.6 kg) completed six 10-minute walking trials at each of three speeds (3.5, 5.5, 6.5 km/h) and three load conditions (7.2 kg, 23 kg, 35 kg). Torso segment LDS was calculated on 3D acceleration data from inertial measurement units (IMU: XSens DOT) attached to the sternum and sacrum. A further IMU attached to the heel was used to determine foot contacts. LDS of the 3D accelerations was quantified using LDE (Rosenstein's algorithm with a 9D state space and τ=10). Mixed-model analyses were used to assess between-load differences in LDS, with speed and sex also included as fixed effects and participant as a random effect (intercept).

Results and Discussion

There was a significant interaction between load and speed for the sacrum (p=0.007) but not the sternum (p=0.152), and no significant interaction between load and sex for both the sacrum (p=0.08) and sternum (p=0.09). There was a significant main effect of load for both the sacrum and sternum (p<0.001). *Post-hoc* tests indicated that at the sacrum, LDE was lower for 35 kg than 7.2 kg at 5.5 and 6.5 km/h. At the sternum, LDE was greater for 23 kg and 35 kg than 7.2 kg.

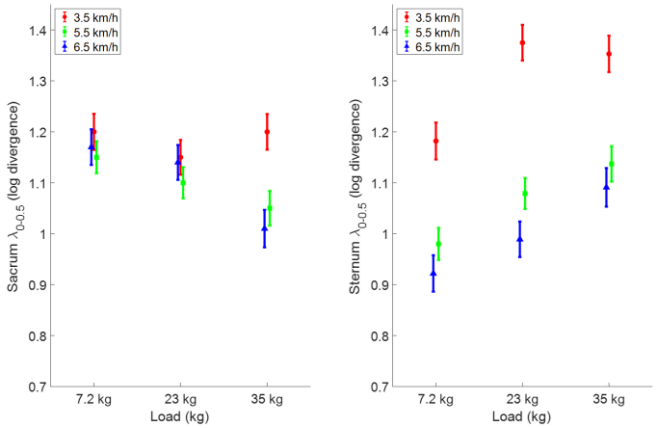

Figure 1: 3D LDE for sacrum (left) and sternum (right) in the three load conditions at each speed. (bars = standard error)

Like older adults carrying relatively light loads [2], load carriage led to a decrease in the LDS of the thorax segment (sternum). Conversely, participants increased LDS of the pelvis (sacrum) when carrying heavier loads, which is similar to the response reported in military cadets carrying only 11 kg [3]. As the pelvis (sacrum) is often considered a COM proxy, this suggests participants adopted a strategy to prioritise COM LDS to cope with the added demands of carrying load, but more work is required to understand how this was achieved.

Conclusions

Soldiers prioritised the stability of the pelvis over thorax stability in adapting to the task of carrying heavier loads.

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