Soldiers' stability over 2-hours of load-carriage walking

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Summary

We investigated gait stability in soldiers walking for 2 hours at 5.5 km/h while carrying 23 kg of external body-borne load. Stability was assessed using the Local Divergence Exponent (LDE) from 3D torso acceleration data. Significant increases in exertion, temperature perception, and pain were observed, but no significant changes in LDE occurred, indicating stable gait patterns. These findings highlight the development of adaptations, which may reflect a healthy, adaptable sensorimotor system. The latter may not be seen in soldiers at risk of musculoskeletal injuries and should be further studied.

Introduction

Load carriage over long walking periods is a routine task amongst soldiers' duties and has been associated with high incidence of stress injuries [1]. Fatigue-related changes in sensorimotor control of walking may lead to this heightened injury risk, which may be reflected in the stability of soldiers' gait. The LDE quantifies soldiers' motor control responses to load carriage, potentially indicating whether these responses reflect a healthy neuromuscular system or suggest a higher injury risk [2].

Methods

Nineteen active-duty male Australian Army soldiers (25 ± 5 years; 180.5 ± 7.6 cm; 83.9 ± 12.5 kg) walked for 2 hours at 5.5 km/h while wearing an 18-kg vest and holding a 3.2-kg replica rifle. Rating of perceived exertion (RPE), OMNI-Resistance Exercise Scale (OMNI-RES), temperature perception (TP), and pain were assessed every 13 minutes using validated scales. Inertial sensors (XSens DOT) placed on the sternum (STR), sacrum (SAC), and heel captured 3D accelerations. Stability was quantified through the LDE (Rosenstein's algorithm) in 3D, vertical (VT), mediolateral (ML), and anteroposterior (AP) directions over 9 periods (512 strides each). Mixed-model analyses assessed temporal LDE, RPE, TP and pain changes across periods, with *post-hoc* tests exploring between-period differences. This study was approved by the DDVA and LTU HREC (302-20 and 02-2021, respectively)

Results and Discussion

Sixteen of 19 participants completed the 2-hour trial; three withdrew due to: shoulder pain (67'), a fallen chest strap (41'), and shin pain (40'). Significant time effects were observed for RPE, OMNI-RES, TP, and pain ($p<0.001$). No significant stability changes were detected across periods for the LDE measures from SAC and STR sensors for all 3D and directional (VT, ML, and AP) with p values ranging from $p=0.27$ to $p=0.85$ (Figure 1), suggesting stable locomotor patterns despite increasing exertion/discomfort.

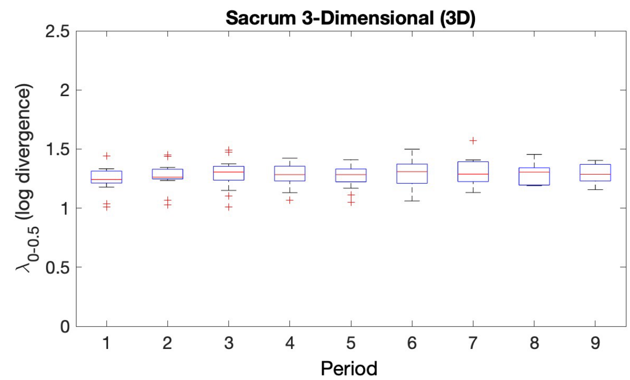

Figure 1: 3D LDE evolution over the 9 time periods assessed.

Slower strides during a 3-hour walk have been linked to increased fatigue perception, stride time variability, and ankle muscle fatigue, reflecting efforts to maintain stability [3]. In our study, similar physiological changes may have occurred during the shorter, loaded walk. Maintaining center of mass stability is a primary goal of the central nervous system, and significant stability changes could indicate neuromuscular challenges to achieve the aims of a loaded walking task.

Conclusions

Soldiers' stability is maintained throughout a 2-hour treadmill walk, reflecting their neuromuscular adaptability to fatigue.

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