SOLDIERS' LOADS AFFECT RANDOM WALK OF CENTER OF PRESSURE AND EMG ACTIVATION DURING POSTURAL SWAY

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INTRODUCTION

Carrying loads may contribute to poor balance resulting in falls when soldiers perform marches, negotiate obstacles, and maneuver during operations. We investigated the effects of carrying loads on soldiers' center of pressure trajectories during postural sway using a general stochastic model; we also examined EMG activity changes as a function of load carried.

METHODS

Fourteen Army enlisted men (mean: 19.6 yr, 1.75 m, 74.11 kg) participated after giving informed consent. We tested the soldiers under three load weight configurations: 6, 16, and 40 kg. At the heaviest load, soldiers wore/carried: M16A1 rifle, boots, minimal clothing (6 kg), plus a helmet and armor vest with ammo, grenades, and canteen (+10 kg), plus a backpack containing a 20-kg steel block (+24 kg). The 20-kg block was located either high on the back and close to the shoulders (h&c) or low on the back and away from the body (l&a) to create two unique backpack center of mass positions.

We recorded postural sway as the volunteers stood comfortably on a force plate for ten trials of 30-s each. Foot placement on the force plate was controlled. The presentation order of the load configurations was based on a Latin square. Force plate outputs were recorded and converted to physical units (mm). From a stabilogram diffusion analysis (SDA), we determined Hurst scaling exponents for short-term and long-term regions for axial and planar movements [1]. Percent of EMG on-time activation for 8 bilateral muscle pairs (Tibialis Anterior, Vastus Lateralis, Rectus Femoris, Gluteus Medius, Biceps Femoris, Erector Spinae, Upper Trapezius, Paraspinals) was calculated as described elsewhere [2].

For each configuration, each measure was averaged over the ten trials. A one-way repeated measures ANOVA with three levels was run on each averaged measure to determine the effects of weight (6 kg, 16 kg, 40 kg h&c). A significant ANOVA finding was followed up with a trend analysis using a within-subjects polynomial contrast. A paired samples t-test was used to determine the effects of load position (h&c vs. l&a) on the measures. Alpha was set at .05 and we corrected for multiple comparisons.

RESULTS AND DISCUSSION

SDA--For the medio-lateral Hurst exponent over the short-term time intervals, a significant linear trend for weight was found, with the heaviest load being the least random with values ranging from 0.81 to 0.85. The l&a load position was significantly less random than the h&c position, 0.84 vs. 0.85. For both the planar and anterior-posterior Hurst values (both with similar means) over the long-term time intervals, a significant linear trend for weight was found (Figure 1): The lightest load was the most random. Also, the l&a position was significantly more random than the h&c position, about 0.20 vs. about 0.12.

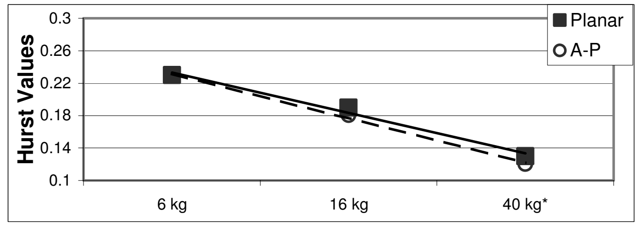

Figure 1: A-P and planar long-term mean Hurst values results. (H < 0.5, correlated anti-persistent motion)

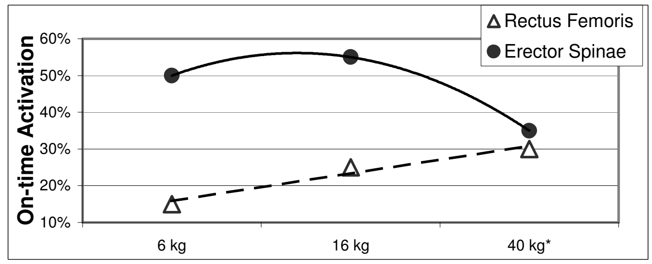

Figure 2: Rectus Femoris and Erectors Spinae mean on-time activation results.
*40 kg load includes pack with block in h&c position.

EMG—For bilateral Rectus Femoris, a significant linear trend was found: On-time percentage increased with an increase in load weight from 15% mean on time at 6 kg to 20% at 16 kg to 30% for 40 kg (Figure 2). For Erector Spinae, a significant quadratic trend was found: on-time percentage increased with an increase in load carried from 50% at 6 kg to 55% at 16 kg, but then decreased to 35% at 40 kg (Figure 2). The Paraspinals increased significantly in on-time percentage as a function of load position, from 65% for h&c to 80% average on-time for the l&a position.

Postural sway became less random as load weight increased. However, as the load position was changed from high and close to low and away from the body at the heaviest load, postural behavior became less structured. Thus, a load placed low and away in the backpack may be quite difficult for a load carrier to control precisely. In contrast, a load placed close and high on the back required more control to balance, but was easier and more predictable to manage.

At the heaviest load, Rectus Femoris activity continued to increase while Erector Spinae activity decreased. These muscular changes at the heaviest load may be attributable to forward lean of the trunk when the backpack was worn. The changes may reduce the efficiency of the muscular control scheme, which aims to maintain posture while minimizing fatigue.

REFERENCES

1. Collins JJ, et al. *Exp. Brain Res* **95**, 308-318, 1993.
2. Laughton CA, et al. *Gait Posture* **18**, 101-108, 2003.