ASSESSMENT OF POSTURAL SWAY DURING MULTIPLE LOAD AND VISUAL CONDITIONS

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INTRODUCTION

This study investigated the effect of variations in applied load (weight and size) and visual condition on quiet-stance postural sway. Occupations such as structural firefighting are often performed in conditions with poor lighting and smoke. A self-contained breathing apparatus (SCBA) that includes a face mask and shoulder pack with air bottle is used in these situations. There is controversy as to what type of air bottle should be used based on weight, size, and cost. Previous studies have examined the effect on balance of wearing personal protective equipment (PPE) with SCBA packs for firefighter (Punakallio 2003) and hazardous material workers (Kincl 2002); however, no systematic assessment has been done on multiple load carrying bottle configurations and visual conditions and their effect on postural stability.

Therefore, in this study, we investigated how modest changes in applied load weight and size would affect quiet-stance postural sway under eyes open and eyes closed conditions, while wearing PPE used by firefighters.

METHODS

Four air bottles were tested: An aluminum bottle (AL) representing current low-budget, low pressure, heavy and large designs: 9.1kg, 53.3cm (L), 17.2cm (dia). A carbon fiber bottle (CF) representing current expensive, high pressure, light and small designs: 5.4 kg, 47.0 cm (L), 14.0 cm (dia). To assess the effect of weight, a fiberglass bottle (FG) with similar size as CF but weight of AL was constructed: 9.1kg, 49.5cm (L), 14.0cm (dia). To examine center of mass location effect, a novel redesigned bottle (RD) was constructed, by cutting a 60-min CF bottle in half, to provide a light and short design that was lower on the back: 5.4 kg, 31.8cm (L), 19.0cm (dia).

Twenty-one male firefighters (age 28±5 yrs, height 177±8 cm, and mass 89±21 kg) participated in this study. Each wore his own PPE (bunker coat, pants, and boots). Helmet and SCBA pack (Scott Air-Pak Fifty 4.5) were provided.

For each bottle configuration, three 60 s trials of quiet stance were conducted for either of two visual conditions (eyes open and looking ahead at a target, or eyes closed). The subject stood on a force plate (AMTI, BP600900) with arms crossed at the chest. For all trials, subjects stood within foot tracings that were created during the first trial of each bottle condition. (No significant differences in stance width were noted between bottle conditions.) The presentation order of bottles and visual conditions were randomized between subjects. Center of pressure (COP) data were sampled at 1000 Hz.

Average COP measures were determined from data based on three trials per condition. Traditional parameters (Prieto 1996) included

Angular Deviation (*AngDev*) from the anterioposterior (AP) axis; and AP, mediolateral (ML), and radial (RAD) components of Maximum Distance (*MaxDist*), Displacement Standard Deviation (*SD*), Range (*Range*), and Mean Frequency (*MeanFreq*). Two-way repeated measures ANOVA tests examined whether bottle configuration and visual condition affected these parameters. The level of significance was set to $\alpha = 0.05$. Statistical analyses were run on SPSS (SPSS Inc., Chicago, IL; v15).

RESULTS AND DISCUSSION

In general, body sway decreased as different bottle configurations were used in the order of AL, FG, CF, and RD (i.e., heavy and large to light and small); however, only ML components were found to be statistically significant differences. There were significant main effects for bottle configuration on $MaxDist_{ML}$ (p=0.025), SD_{ML} (p=0.006), $Range_{ML}$ (p=0.015), and $MeanFreq_{ML}$ (p=0.006). Post hoc tests showed heavy bottles (AL, FG) had significantly larger values than light bottles (CF, RD). This suggests that weight significantly affected sway response.

There were no significant differences between AL and FG or CF and RD, suggesting that size and COM location did not significantly affect postural sway.

Significant main effects for visual condition were found in all parameters except $MeanFreq_{ML}$ and *AngDev*; however there was a significant bottle × vision interaction for $MeanFreq_{ML}$. No other interaction effects were noted. When eyes were open, the values of parameters decreased significantly.

We found that postural sway increased significantly in the ML direction with weight, but not load size, and lack of vision. Schiffman (2006) found that path length in both AP and ML direction increased as carrying weight increased with soldiers. Punakallio (2003) found that sway velocity increased when PPE was used, compared to sportswear, and between eyes open to eyes closed conditions.

SUMMARY/CONCLUSIONS

From the results above, we can conclude that reducing load weight significantly increases postural stability, whereas reducing load location might not. Visual condition also significantly affects postural stability of individuals wearing added load.

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ACKNOWLEDGEMENTS

Funding from Illinois Homeland Security Research Center. Thank you to Seiji Naito for testing assistance, and Jason Thomas for bottle construction.