Effects of Heat Stress on Firefighters' Postural Balance During Live Fire Fighting

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Objective: Measure the effect of physically demanding tasks performed under hot environment on postural balance characteristics.

Design: This balance study is a continuation of the study that has been performed in October 2011 where heart rate and core body temperature were recorded during a live burn. A second study was also performed in October 2012 to assess the development of postural balance recording of firefighters during live burn activities.

The design of the balance study is to evaluate the impact of heat stress on postural balance of firefighters during live burn (with and without live fire) training using wearable wireless/remote sensing multi-dimensional gyroscope and accelerometers. The heat stress and physical exertion levels will be quantified using a wearable sensors system "Bioharness" and an FDA approved ingestible radio pill (CoreHQ). These wearable sensors collectively will provide firefighters' heart rate, core body temperature and skin temperature during live burn training. Collectively, these outcomes will be used to determine an accurate assessment of the physiological effects of heat strain on firefighters. In the long term this data can be used to develop an algorithm that can notify others of the hazards and exposure to heat strain for firefighters identifying potential adverse events before they occur. Using these results, more accurate physiological monitoring devices may be developed to inform users more rapidly of hazards and safety risks. These results can also lead to the advancement of heat stress knowledge in multiple occupational disciplines and identify potential adverse events before they occur.

Method: Eighteen firefighters participated in live firefighting training (mean age 38.1 years ± 5.7, body weight 214 lbs ± 37, BMI 29 ± 4) while performing following tasks: search and rescue, hose advancement and backup, each performed for three different scenarios. Prior to heat exposure (PRE) and following each scenario (POST), firefighters' postural balance was assessed with a lightweight (weight 16 grams) wearable inertial sensor system quantifying time dependent changes in acceleration and angular velocity (AV) about three orthogonal axes [Anterior-Posterior (AP), Medial-Lateral (ML), and vertical (V)] during one foot balance test for 30 seconds. The data obtained were processed by creating phase plane plots between AV and angular displacement (AD) about three axes. The postural balance characteristics were quantified by the size (max excursions about three axes) of the phase plane plots, and set of stability metrics based on the root mean square (RMS) and variance of AD and AV about three axes.

Results: The stability parameter about the ML axis significantly increased from PRE to POST ($p < 0.10$). The max excursions, for the AV about ML axis also increased significantly from PRE to POST ($p < 0.10$). The RMS AV response from PRE to POST also increased significantly ($p < 0.10$) about the ML axis.

Conclusion: Significant increases in stability parameter, excursion, and RMS response about the ML axis, associated with tasks performed in hot environments, suggest an increase in postural instability, larger postural sway and increased efforts to maintain

balance, respectively. These increased postural instability outcomes, around ML axis, in the front-back direction, may increase their risk of falling.

Acknowledgement: *This research study was supported by the National Institute for Occupational Safety and Health Targeted Research Training Program of the University of Cincinnati Education and Research Center Grant #T42-OH008432*

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University of Cincinnati
14th Annual
Pilot Research Project Symposium
October 10-11, 2013

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Hosted by: The University of Cincinnati Education and Research Center
Supported by: The National Institute for Occupational Safety and Health. (NIOSH) Grant #: T42/OH008432-08

Produced by Kurt Roberts Department of Environmental Health