Assessing gait changes in firefighters due to fatigue and protective clothing

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\textbf{A R T I C L E  I N F O}

\textbf{Article history:}
Received 29 November 2010
Received in revised form 18 January 2011
Accepted 25 January 2011
Available online 17 February 2011

\textbf{Keywords:}
Firefighting
Personal protective equipment
Gait performance
Obstacle crossing

\textbf{A B S T R A C T}

Each year, roughly 11,000 firefighters are injured as a result of slips, trips and falls, which account for over 25% of all fireground injuries. Wearing personal protective equipment (PPE) can increase risk of fall-related injuries due to its weight, restrictiveness, and increased heat stress. Modification of PPE may serve to mitigate firefighter injuries related to loss of balance and falls. We examined the effects of choosing ‘enhanced’ protective clothing (lightweight, breathable, and less restrictive compared to typical firefighting PPE) and simulated firefighting tasks (18-min bout over four activities) on subsequent gait performance. To assess the effect of wearing protective clothing and firefighting activity, seven gait parameters and three movement errors were assessed during level and obstacle-crossing walking tasks. Forty-four firefighters wore one of two types of PPE (‘Standard’, ‘Enhanced’) during three testing conditions (baseline in station uniform, pre-firefighting activity in PPE, and post-firefighting activity in PPE). The effect of donning any PPE was found to significantly impair gait performance. Fatigue may impact effective mobility since more movement errors were observed during post-activity than pre-activity assessments. Although the Enhanced PPE did not lead to any significant differences in gait parameters compared to Standard PPE, participants in Enhanced PPE made twice as many movement errors, potentially attributed to lack of familiarity with the gear. These results suggest that wearing firefighting PPE and heat-stress induced fatigue are associated with reduced gait performance and increased risk for tripping over obstacles.

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1. Introduction

Firefighting is an extremely hazardous occupation, resulting in approximately 80,000 occupational injuries per year, roughly half of which occur on the fireground (Karter, 2003; Karter and Molis, 2009). Each year, one of the leading categories of firefighter injury is slips, trips and falls (STF). These events resulted in over 11,000 injuries per year on the fireground, or more than 25% of all fireground injuries (Karter, 2003; Karter and Molis, 2008). These injuries are more common than burns, smoke inhalation, contact injuries, and overexertion/strain injuries. Furthermore, while many responses do not involve fires and associated risks for burns and smoke inhalation, STF-related events remain a frequent cause of injury in all emergency operations. Accidents due to falls have also been found to result in the longest work absences for firefighters (Cloutier and Champoux, 2000). In a 2003 study, the average total worker’s compensation claim per STF injury was $8662, which is well above the mean of all claims – $5168 (Walton et al., 2003).

These data indicate that sufficient mobility and balance abilities are important for safety and efficient work performance in the firefighting occupation.

Firefighters wear personal protective equipment (PPE) that typically consists of coat, pants, boots, hood, gloves and helmet on nearly all fire or rescue-related emergency responses and during training. When on the fireground or in an environment that is immediately dangerous to life and health, firefighters also wear a self-contained breathing apparatus (SCBA) that provides an external air supply. PPE including SCBA serves to protect firefighters from burn and inhalation injuries in hot and hostile environments.

The use of this PPE, however, may contribute to fall-related problems due to increased fatigue rate, reduction in flexibility and mobility, and changes in firefighters’ center of gravity (Park et al., 2010; Punakallio et al., 2003). PPE also adds to the metabolic work that must be performed, and interferes with heat dissipation because of encapsulation. Thus, PPE may compound issues related to heat stress (Smith and Petrizzello, 1998; Smith et al., 1995). A number of previous studies have shown that wearing PPE with SCBA leads to decreased functional performance as measured by