

# FIND BALANCE

## IFSI study examines how PPE affects walking & balance

**T**he National Fire Protection Association (NFPA) estimated that in 2006 there were approximately 27 fireground injuries per 1,000 fires. Nearly 24 percent of these injuries were attributed to slips, trips or falls (Karter & Molis, 2007).

Since 1990, injuries due to slips, trips or falls have consistently ranked as either the first- or second-most common cause of fireground injury, averaging more than 11,200 injuries per year. The most common injuries resulting from falls were sprains, strains, fractures and dislocations, which account for 79 percent of injuries (Houser, et al., 2004). What's more: These events are likely underrepresented by the reported injury statistics because people tend to report more significant injuries, as opposed to more minor fall-related injuries, such as cuts and scrapes.

Total fireground injuries declined from 1990 to a low in 2004, and then rose again between 2004 and 2006—a trend that tracks with changes in total fire incidence over the same time period. However, injuries due to slips, trips or falls have remained relatively constant over this same period.

Slips, trips and falls can result in significant injury, leading to high costs to departments and municipalities in addition to loss of productivity. Studies on Canadian firefighters indicate that accidents due to falls resulted in the longest injury-related work absences. Plus, although 16 percent of all firefighter injuries were due to slips, trips or falls, these accidents accounted for 25 percent of the total time lost due to injury (Cloutier & Champoux, 2000; Ault, 2002). This information highlights the devastating impact of these injuries on firefighter health and productivity.

Despite the large amount of data indicating that slips, trips and falls result in high injury rates and large amounts of lost work time, efforts to understand the underlying mechanisms and develop possible

interventions to reduce these events have been minimal. The fireground is an inherently dangerous location with certain risks that cannot be avoided; we believe, however, that through research to quantify the problem, properly designed personal protective equipment (PPE), and educational interventions, injuries related to slips, trips and falls can be significantly reduced.

### A CLOSER LOOK AT FALLS

In an effort to understand the mechanisms related to fireground slips, trips and falls, the University of Illinois Fire Service Institute (IFSI) was awarded a FEMA Assistance to Firefighters Grant under the Fire Safety and Prevention Program. A major component of this study focused on understanding of how fireground activities and the design of firefighting personal protective equipment (PPE) affect firefighter balance and walking ability.

The 122 firefighters who participated in this study were split into two equal groups: those wearing a *standard* PPE configuration and those wearing an *enhanced* set of gear. The standard PPE was relatively heavy, provided a high degree of thermal insulation and featured relatively low breathability. It was selected to reflect what's worn in a "typical" fire department without a large budget.

The enhanced PPE was relatively light and provided less thermal insulation than the standard PPE. It was designed to reflect some of the lightest PPE available that meets current NFPA standards. The enhanced PPE also included a design element that circulated exhaled air from the firefighter SCBA mask to the coat's inner lining to provide evaporative cooling.

Half of each group completed a study to examine walking patterns with the PPE, while the other half completed a study focused on balance. The participants repeated the assessments three times: in station



**FAR LEFT:** One test of balance required firefighters to step down to walk along a narrow plank within a confined space.

**LEFT:** For the some trials during the walking protocol, a 12" obstacle was placed across the walkway. Changes in walking parameters (step length, step width, etc.) as well as boot-to-obstacle clearances were monitored.

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blues, after donning PPE and after 18 minutes of simulated firefighting. The simulated firefighting activities included 2-minute work-rest cycles that consisted of climbing stairs, chopping on a sled, performing a secondary search and advancing a line.

For the walking protocol, participants walked at two speeds—"normal, comfortable pace" or "as fast as you can without running"—on a 29' pressure-sensitive gait mat. For some trials, a 12" obstacle was placed across the walkway. Changes in walking parameters (step length, step width, etc.) as well as boot-to-obstacle clearances were monitored.

For the balance protocol, participants performed a dynamic balance task. This task required firefighters to step down to walk along a narrow plank, step up and turn around within a confined space, return along the plank and, finally, stop at the original raised starting point. Firefighters were instructed to perform the task as quickly and safely as possible. For some trials, the task was made more challenging by placing an overhead obstacle across the center of the pathway at 75 percent of the participant's height. Time to complete the task and errors per pass were recorded.

#### WHAT WE FOUND

The results from both protocols suggested that **wearing PPE of any type has a significant affect on balance and walking performance.** Nearly all measurements showed significant differences between the baseline condition (station blues) and donning the PPE. Little changes were noted as a consequence of performing the short-term simulated firefighting activities. These results suggest that use of PPE affected walking and balance performance much more significantly than firefighting activity, even though the activities were strenuous enough to significantly raise the firefighters' core temperature in only 18 minutes and induced a high enough fatigue level in some participants that they were unable to complete the post-activity assessment. Interestingly, the walking ability protocol indicated that **the use of the enhanced PPE may reduce firefighter fatigue,** as parameters such as step length and step width did not change as drastically from baseline as compared to when wearing standard PPE.

## Finding meaning in the Research

*By Editor-in-Chief Tim Sendelbach*

Over the last 25 years, manufacturers have made monumental advancements in the design and development of the protective ensemble—but there is still work to do. This research provides quantifiable evidence directly related to injury prevention, specifically in the areas of strains/sprains (historically the most common fireground injury) and heat stress (a noted factor in many cardiac-related fireground fatalities).

By publishing the findings of this research, we hope to encourage firefighters, company officers, spec committees, etc., to strongly consider the preventative measures that exist in relation to the design and development of protective

clothing. Although not all injuries can be prevented, quantifiable evidence supports the need for well-designed, lightweight, ergonomically conforming protective clothing.

*The bottom line:* The personal protective ensemble is essentially your lifeline. So do your homework about what's available to you and encourage PPE manufacturers to continue innovative pursuits in the name of safety. Review the research that has been done on our behalf, and make a point to find the right PPE. Paying the price up front might actually prevent us from paying the ultimate price in the end.

These results suggest that firefighter balance and walking ability will be significantly modified just by donning PPE. Thus, firefighters may be at an increased risk for falls on any response that requires wearing firefighting PPE—not just after firefighting activities (e.g. auto accidents, investigations). Although design of PPE has the potential to reduce some of the negative impacts on firefighter balance and mobility, an increased awareness of the forced changes in biomechanics due to PPE can go a long way toward reducing fireground injuries if firefighters are more cognizant of their limitations while wearing this gear.

The full report from this study, *Firefighter Fatalities and Injuries - The Role of Heat Stress and PPE* can be downloaded from IFSI's Web site: [www.fsi.uiuc.edu/documents/research/FFLSRC\\_FinalReport.pdf](http://www.fsi.uiuc.edu/documents/research/FFLSRC_FinalReport.pdf).

### Study Conclusions at a Glance

- ✓ Wearing PPE of any type has a significant affect on balance and walking performance.
- ✓ The use of the enhanced PPE may reduce firefighter fatigue.
- ✓ It's important to understand how PPE affects your balance and gait to prevent slips, trips and falls.

Dr. Gavin Horn and Professor Denise Smith are research scientists at the Illinois Fire Service Institute, where they conduct firefighter health and safety studies. In addition, Dr. Horn serves as a volunteer firefighter with Savoy (Ill.) Fire Department, and Professor Smith holds an appointment as a professor of exercise science at Skidmore College in New York. Professors Liz Hsiao-Wecksler and Karl Rosengren, and graduate students Pilwon Hur and Kiwon Park from the University of Illinois and Northwestern University, also study how changes in walking and balance can affect slip, trip and fall risk for people across the lifespan.

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