Heat-related illness among wildland firefighters

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The 2019 bushfire catastrophe in Australia is only the most recent example of the increasing duration and intensity of wildfire events. In the past decade, the USA experienced 67 000 wildfires annually with an average 7 million acres burned. Over 34 000 US wildland firefighters (WLFFs) are engaged in arduous, high-risk duty, yet several features of this occupation limit our ability to understand the associated short-term and long-term health risks. For example, wildfire suppression activities are spread over multiple state and federal agencies, and most WLFFs are seasonally employed and assigned to multiple locations within a season. The mobile nature of firefighting, oftentimes in difficult terrain, further complicates the potential for observational occupational health studies in this population. In this edition of *OEM*, West *et al*[1] overcame these challenges with one of the largest to date field studies of WLFF physiological measures with directly observed work activity assessment.

Among the many potential health risks for this population is heat-related illness (HRI). WLFFs may be at risk for HRI because they are engaged in long periods of arduous activity in hot environments with heavy fire-protective clothing. Occurrence of HRI has not been directly assessed in WLFFs, but several studies have assessed WLFF core body temperature (Tc) in both real-world and laboratory settings with mixed results. Some studies have shown minor increases in Tc over shift duration or in simulated WLFF activity under high-temperature conditions (eg, Raines *et al*,[2] Larsen *et al*[3]). Other studies have not shown Tc increases by duration of fire (eg, Rodríguez-Marroyo *et al*[4]). The latter findings may suggest that WLFFs have self-modulated to control Tc by adjusting work intensity to fitness level or through behavioural adaptations such as hydration practice or use of base layer clothing with wicking properties. Nevertheless, panel studies have demonstrated that WLFFs experience mild to moderate hyperthermic conditions (Tc >38°C) during a small percentage of work shift time (≈18%).[5]

West *et al*[1] add a new dimension to these prior studies as they assessed 1 min interval Tc with respect to changing job tasks during the wildfire work shift. WLFF activities change frequently during work shifts. For example, the investigators identified 55 job tasks, and the 298 person-days of observation translated to 3996 person-job tasks. Most prior studies evaluating physiological measures in WLFFs have used cruder, surrogate indications of activity such as crew type, direct versus indirect fire attack, or work shift duration, measures which are heterogeneous with respect to activity intensity. Indeed, 52.6% of person-task observations in the West *et al*[1] study were characterised as sedentary or light physical activity. Better understanding physiological change and, ultimately, health risk by specific job task will be essential for informing related worker protection measures.

With these directly observed minute-by-minute specifications of job task, the investigators were able to show modest, monotonic increases in Tc for ascending categories of job-task activity. For example, Tc was 0.38°C higher during high activity job tasks compared with sedentary activity job tasks. Importantly, these analyses adjusted for several factors, including time-varying factors such as meteorological conditions and time spent in each job task category during the prior 60 min. From a health risk perspective, we then ask how this modest Tc increase translates to HRI risk for WLFFs. It is possible that HRI risk among WLFFs is limited to specific, time-limited job tasks that correspond to high physical activity.

Among this worker population, more than one quarter of all activity time is spent in these high physical activity job tasks. However, we must consider the HRI risk in the context of how workers switch across job tasks throughout the work shift. The authors argue that multiple tasks in the high intensity category would shift a WLFF towards moderate hyperthermia. Based on the predicted Tc changes by job task category and duration illustrated in West *et al*[1] (figure 1), a shift to moderate hyperthermia of +1.5°C from baseline 37°C would require that a WLFF was engaged in high-intensity activity for approximately 360 min. Such a scenario appears to be inconsistent with the observed person-task frequencies. It is possible, and in some cases likely, that WLFFs engage in several low-frequency, high physical activity job tasks, but it is also likely that these job tasks are interspersed with sedentary or light physical activity job tasks that allow a WLFF to return to normal Tc. As the authors note, the high physical activity of ingress or egress hiking may be the one exception as this task can occur over long, uninterrupted periods and accounts for about 19% of all job-task time in this population. Indeed, Tc excursions to moderate hyperthermia conditions have been observed during periods of extensive hiking during firefighting.[6] A better understanding of HRI risks specific to job tasks suggests the potential for designing administrative monitoring and controls on time spent in these high physical activity tasks.

The primary consideration for WLFF health is, and should remain, focused on minimising the risk of acute injury and fatality inherent in this dangerous occupation. As we learn more about the specific and time-varying activities of these workers, we will be better able to evaluate other intermediate and long-term health risks. For example, orienting work shift by job task will inform more precise WLFF job exposure matrices for particulate matter and other inhalation hazards. Wildfires will continue to have an increasing impact on our societies, prompting the need for continued research on the health risks and protective strategies for WLFFs.

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