

FIRE NOTE

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HYDRATION OF AUSTRALIAN RURAL BUSHFIRE FIGHTERS

SUMMARY

There is some evidence to support the belief that hydration may influence a firefighter's health and safety on the fireground. Given the existence of a gap in information related to hydration strategies for firefighters, the Bushfire CRC Firefighter Health and Safety research group conducted two studies; the first examining the impact of a pre-shift drinking strategy, the second exploring the impact of prescribed fluid consumption over the course of a whole firefighting shift.

In both studies, firefighters were observed to arrive at their shift in a dehydrated state and leave in a hydrated state, regardless of experimental interventions. These findings imply that, although firefighters may not pre-hydrate themselves before a shift, they are able to consume adequate fluids and food over the course of a shift in order to meet their hydration needs, at least in the mild conditions faced in the current studies.

No differences were observed between groups for heart rate response or work output for either of the hydration strategies. However, the firefighters who consumed 500-600 ml of fluids during the 'in-shift' drinking study experienced lower core temperature values than those in the control group (who drank 200-300 ml), suggesting that hydration strategies may have potential advantages over self-paced drinking.

As the research was conducted in relatively mild weather conditions, it is not clear how the results translate to more severe conditions. Therefore, more work is required.

ABOUT THIS FIRE NOTE

This *Fire Note* is part of the Bushfire CRC *Firefighter health and safety* project and focusses on two studies investigating the role of prescribing fluids before firefighters deploy to the fireground and the prescription of fluids during their fireground shift. The effect of these hydration strategies on firefighters' physiology and productivity when working to curtail the spread of bushfires is outlined and discussed.

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▲ Jenni Raines conducting her research on firefighters at a controlled burn in the Ngarkat Conservation Park, South Australia, in 2008.

CONTEXT

The health and safety of rural firefighters is a priority of fire agencies across Australia and New Zealand. Adequate firefighter hydration is thought to be an easily modifiable practice that may improve firefighter productivity, health and wellbeing.

BACKGROUND

Bushfires regularly threaten structures, mining resources, wilderness zones, logging areas, highways and power lines (REFERENCE 1). Such a threat can result in extensive property damage, loss of produce and livestock, as well as personal injury and sometimes death to residents living in fire-affected areas and the firefighters themselves (1). Over 15 years, Victoria's Country Fire Authority and New South Wales' Rural Fire Service have suffered approximately 1.5 firefighter deaths per year (2). As the health and safety of our firefighter population is central to the successful suppression of wildfire, quantifying the major risk factors which threaten the wellbeing of our firefighters is crucial.

RESEARCH OVERVIEW

With these two studies, the 'firefighting shift' ran from when firefighters left the research station to the end of the day's work. It included intense but intermittent manual labour performed routinely on the fire ground (such as manual lifting, carrying, stepping on and off vehicles, using handtools and chainsaws to clear low lying vegetation, and using hoses to apply water, retardant or foam suppressants). Additionally, the research incorporated vehicle transit time, attendance at briefings, ad lib fluid and food consumption, the loading of vehicles and performing equipment checks; all of which also contribute to a firefighting workday. The peak temperatures reached over the seven day research period ranged from 18°C to 34°C and were considered mild to warm. The participants were volunteer firefighters, as well as US wildfire crews and Australian land management agency staff.

Dehydration risks for firefighters

Heat stress, which includes dehydration, has been found to be one of the top three major health and safety risks facing volunteer firefighters today (4). Bushfire fighters are particularly susceptible to dehydration due to the following unmodifiable factors:

- **Physical work** generates heat which needs to be dissipated to the environment primarily through the evaporation of sweat, which leads to body water loss. Working for 10-15 hours per shift could place firefighters at a serious risk of dehydration if mitigation measures are not in place (5).
- **Personal protective clothing** is worn to reduce the radiant, convective and conductive heat loading encountered in the bushfire fighting environment. However, wearing these can trap the firefighters' metabolically produced heat, reducing heat dissipation. This may result in increased sweat production by the body in an effort to cool itself, further increasing the risk of dehydration (6).
- **Hot, low-humidity environments**, such as in the bushfire-fighting environment, are known to increase levels of dehydration beyond that experienced during mild weather conditions. In this environment, firefighters bodies gain heat from radiation and convection instead of dissipating it via these mechanisms, again encouraging increased sweat production by the body, further increasing the risk of dehydration (7).

Pre-shift hydration

Previous researchers have found that firefighters often arrive on shift in a dehydrated state, and maintain or accentuate that level of dehydration upon conclusion of their work shift (8). Given this finding, fire agencies require practical strategies to counter dehydration in their personnel. A logical and convenient option is to provide firefighters with a prescribed amount of fluid before their shift. The American College of Sports Medicine recommends that dehydrated individuals consume 5-7 ml/kg of fluid four hours prior to exercise, and potentially a further 3-5 ml/kg two hours before exercise (9).

Results from laboratory studies show that consuming fluid (ranging 100-3500 ml) before activity can have the following effects:

- Extended exercise time until exhaustion (10).
- Decreased heart rate (10-13).
- Decreased core body temperatures (10, 12, 13).

However, it was not clear whether these



relationships between prescribed pre-shift fluid consumption, physiology, and exercise (physical work) performance would transfer from the laboratory to a field environment, hence the need for these Bushfire CRC studies.

The first such study conducted by the current research team utilised 32 firefighters, who were placed into one of two groups:

1. Ad lib (AD; 17 firefighters self-selected the volume, beverage type (water or sports drink) and timing of intake).
2. Pre-shift (PS; 15 firefighters consumed 500 ml water prior to leaving the research station then continued drinking at their own pace for the remainder of the shift).

Before deploying on shift, firefighters provided blood and urine samples and they were fitted with equipment that recorded heart rate, core and skin temperature and physical activity throughout the shift. Those in the PS group consumed the prescribed pre-shift fluid. Firefighters were asked to adhere to normal work practices and reminded to eat and drink as much or as little as they desired, and to record all food and drink intakes and urine produced in a pocket book provided. Both water and sports drink were available to firefighters throughout their shift. At the completion of the work shift the blood and urine tests were repeated.

The major findings of the research were that:

- There were no differences in hydration status between experimental groups pre to post-shift.
- Firefighters from both groups arrived on shift in a dehydrated state.
- According to urine colour (a common fire industry measure of hydration)

firefighters were still considered dehydrated post shift. However plasma osmolality levels (a more precise measurement of dehydration) revealed that firefighters finished their shift in a hydrated state.

- There were no differences observed between groups for either volume of fluids consumed or the type of fluid (water or sports drink) consumed during the shift.
- There were no differences in urine output between experimental groups.
- There were no differences observed for heart rate or work output between the two groups.
- There were no differences in core temperature between experimental groups.

This study illustrates that firefighters experienced no real benefit from drinking the prescribed 500 ml fluids prior to their shift. It is possible that the amount of fluids ingested was not sufficient for advantages to occur. Alternatively, as the research was conducted in relatively mild weather conditions (16 ° - 31°C), it is not known what impact the prescribed pre-shift fluid may play in hot and/or hot-humid environments.

'In shift' fluid consumption

Previous occupational research in fields similar to bushfire fighting (such as forestry work, foundry work, structural firefighting) has shown that workers neither eat nor drink enough during work time to maintain body weight and remain hydrated (14-17). In the Project Aquarius studies, Australian land management firefighters were found to drink enough to replace only

43 per cent of their sweat losses; although the highest drinking rate measured offered 96 per cent fluid replacement, demonstrating that adequate replacement was attainable (18). In an emergency bushfire, the delivery of drinking fluid to an active firefighting crew can cause a substantial diversion of effort and manpower from the task of fire suppression (18), and workers don't always want to stop work to consume fluids (19).

Fluid prescriptions

There are disagreements in the scientific literature regarding fluid prescriptions generally (20-25). Two fluid prescription philosophies are currently suggested in the literature; "drink as much as tolerable or to replace lost fluid" (forced drinking) versus "drink according to the dictates of thirst" (self-paced), with varying results (26). This disagreement in the hydration literature and lack of studies performed directly on bushfire fighter fluid needs may have partially contributed to the considerable variation of fluid volume prescriptions from fire agencies across Australia and New Zealand (ranging from six to 36 litres recommended across a 12-hour shift) (27). The wide range of recommended fluid volumes may affect logistics planning for multi-agency operations, as considerations need to be made for each agency's firefighters and their respective fluid consumption plans.

The second study conducted by the current research team utilised 33 volunteer firefighters, who were placed into one of two groups:

1. Forced (prescribed) drinking (17 firefighters were instructed to consume 1200 ml/hr ; 600 ml water and 600 ml sports drink).
2. Ad lib drinking (16 firefighters selected the volume, type and timing of their fluid consumption).

As with the first study, firefighters provided blood and urine and were fitted with heart rate, temperature and activity monitors that recorded data throughout the shift. All food and drink intake and urine output were recorded in a pocket book.

The major findings of the research were:

- The prescribed drinking group consumed more fluids (~300 ml per hour) than the ad lib group, despite not meeting the 1200 ml/hr requirements.
- Across both groups, firefighters chose to consume greater volumes of water than sports drink, despite the prescribed group being instructed to consume equal quantities of both beverages.
- Participants in the prescribed fluid

END USER STATEMENT

"The research outlined in this Fire Note throws valuable light upon the much discussed topic of hydration strategies which can be used by bushfire fighters, and on the place of sports drinks in these strategies.

"The work done by the Deakin University team and their volunteer subjects is a step forward in improving firefighter workplace safety. The research will help both employers and firefighters to resolve the apparently contradictory advice on the topic, until now mainly derived from studies conducted on people undertaking activities of little relevance to firefighting tasks."

– Tony Blanks, Manager, Fire Management Branch, Forestry Tasmania

group had higher volumes of urine output.

- Participants in the two groups exhibited no differences in hydration status across the work day; they arrived on shift dehydrated and left in a hydrated state. However, as with the previous study, there were discrepancies between the dehydration measures, questioning the validity of the practised hydration tools currently used by the fire industry.
- Prescribed fluid consumption resulted in significantly lower core temperatures from the ad lib group.
- There were no differences noted for heart rate response or work output.
- Stomach discomfort was noted by several participants in the prescribed drinking group.

These findings illustrate that, when both food and fluid availability and choice are not limited, self-paced drinking will permit firefighters to reach the end of their shift adequately hydrated. These findings demonstrate that bushfire fighters, regardless of age or work location, can self-regulate their fluid consumption behaviour and work rate in a way that enables them to leave the fireground hydrated, at least in mild-warm weather conditions. Although the lowered core temperature values noted for the prescribed drinking group did not affect productivity in the current study they could, however, have an impact in extremely hot weather conditions. Further research comparing the two fluid replacement strategies during extremely hot or hot-humid environmental conditions is needed before such inferences can be made.

Industry implications

These findings raise a number of questions for industries where fluid prescription and hydration monitoring are considered important. Bushfire fighters are returning from their shift hydrated after consuming fluid at their own pace – which undermines the need for formal fluid prescriptions. Secondly, the practical tools currently

available for use in the field are inaccurate in discerning hydration status. Thirdly, arriving on shift dehydrated appears to have no effect on firefighters' productivity and physiology early in their shift – so of what benefit is there in knowing a firefighter's initial hydration status?

Consuming additional volumes of fluid does not provide conclusive benefits to firefighters' physical activity, distance covered (on foot), or their cardiovascular strain, but it may buffer the rise in core temperature during prolonged work in mild to warm weather. Given the current findings and that of other literature (21, 28), it is recommended that fire agencies, during bushfire fighting work in mild to warm weather:

1. Provide free access to both sports drinks and water for drinking.
2. Advise firefighters to consume fluid according to the dictates of thirst.
3. Do not rely on urinary markers to determine a firefighter's hydration status.
4. Continue awareness campaigns promoting drinking fluid for health and performance.

It is contended that fire agencies (by adhering to the above) will potentially fulfil their Occupational Health and Safety obligations to "eliminate risks to health and safety so far as is reasonably practical" and if unable to eliminate risks, to "reduce those risks so far as is reasonably practicable" (29). This Bushfire CRC research identified that dehydration exerted a minimal consequence in mild to warm emergency bushfire fighting conditions; however it is important to note that these findings are limited to the specific environmental and work conditions outlined in the studies.

For operations in hotter conditions or those in which work profiles involve longer periods of intense work or multi-day deployments, the effect of self-paced fluid intake on physiological response is yet to be quantified.

This Fire Note is a companion to Fire Note 80.

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