

Commentary

Hydration, Hydration, Hydration

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Throughout the world, large numbers of manual workers perform physically demanding labour in conditions of high environmental heat stress. Although the importance of adequate hydration in combating heat stress is universally recognized, studies in a range of worker groups have demonstrated a disturbingly poor hydration level in a high proportion of at-risk workers. Management of work in hot environments traditionally focuses on environmental monitoring, while strategies to promote and ensure good hydration behaviour are often haphazard at best. An example is given of simple guidelines for adequate and appropriate fluid intake and practical recommendations to foster compliance.

Keywords: dehydration; environmental monitoring; heat illness; heat stress; hydration

INTRODUCTION

Ensuring that workers are adequately hydrated is one of the most effective interventions to safeguard their health and productivity when working in hot environments. Management of occupational heat stress has tended to focus on the monitoring of environmental parameters to identify when an environment becomes hazardous to health, and a number of heat stress indices have been developed to do this; however, all make the implicit assumption that the workers are physiologically able to lose heat at the maximum rate permitted by the environment. Where workers are not adequately hydrated this simply is not the case.

Studies by the authors over a number of years in Australia, New Zealand and most recently in the Middle East (Bates *et al.*, 2010) have shown a consistent pattern of poor hydration in workers from diverse ethnic, cultural, and economic backgrounds employed in a range of industries where environmental heat stress is a common factor.

One Australian study of outdoor workers in the Pilbara region of Northwest of Australia (Miller and Bates, 2007) found that >70% of the 710 urine samples collected indicated that the workers were poorly hydrated, 51% of the samples showed levels of dehydration that put the worker at increased risk of heat-related illness, and impaired performance with 16% corresponding to a state of clinical dehydration. Results from other Australian studies have been variable, but in almost all groups, the mean hydration status as assessed by urine specific gravity was at best marginally adequate with a significant proportion of workers being compromised in their ability to work safely in the heat. In the most recent study (Bates *et al.*, 2010), a similar situation was found among expatriate (predominantly south Asian) workers in the United Arab Emirates with ~30% of urine samples in the increased risk categories.

HYDRATION AND HEALTH IN THE HEAT

In cold climates, metabolic heat production in the body is necessary to maintain a stable 'operating temperature'. In warmer environments, excess metabolic heat is dissipated to the environment by a combination of conduction, convection, radiation, and

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evaporation of sweat. As environmental temperatures increase, the relative efficiencies and importance of these processes alters. As the environmental temperature approaches and exceeds that of the skin, dry heat loss (by conduction, convection, and radiation) diminishes and is replaced by heat 'gain', under these circumstances evaporation of sweat is the only available heat loss mechanism and sweat rate increases markedly. Evaporation of sweat is facilitated by air movement and low humidity, keeping conditions comfortable even at high ambient temperatures; however, when humidity is high, sweat runs uselessly from the skin and soaks clothing, causing discomfort, potential skin disorders, and depleting fluid reserves.

Physical work increases heat production in the body. An adequate level of hydration is essential to dissipate this heat, with the blood plasma acting both to transport heat to the body surface and as the source of the fluid lost in sweating. Failure to replace fluid losses reduces plasma volume and compromises the ability of the circulatory system to simultaneously maintain sufficient blood flow to both the skin and the working muscles, leading to muscle fatigue and increases in body temperature and the possibility of collapse as blood supply to the brain falters. Subclinical levels of dehydration and core temperature elevation have been shown to affect physical performance and coordination and to impair cognitive function, both potentially contributing to an increase in workplace injuries.

An important observation in all of our studies has been that, both on a group and an individual level, hydration status tended not to change much over the course of a shift. In other words, in most workers, the fluid intake over the course of the day was adequate to maintain, but not to improve, the hydration status. This is not surprising given that in some of these environments, sweat rates may be up to or even exceed 1 l h^{-1} (Brake and Bates, 2003; Miller and Bates, 2007). This is approaching the maximum rate of fluid absorption from the gut (Costill, 1990), so improving hydration status against a background of heavy sweat loss is extremely difficult. The key is to start work in a well-hydrated state and to maintain this, if necessary with scheduled drinking, using electrolyte replacement beverages to enhance water uptake and retention where sweating is exceptionally heavy, or where dietary salt intake may be inadequate.

The electrolyte replacement product chosen should be one that is formulated for industrial use, i.e. prolonged consumption. Products designed for sporting use are frequently high in carbohydrate con-

tent as maintenance of blood glucose during heavy exercise is a priority. However, in the industrial setting, the main focus is to encourage high volume consumption over a shift of up to 12 h, which can lead to an excessive calorie intake if a high carbohydrate product is used. In addition, lower carbohydrate drinks are more palatable in the long term encouraging greater consumption.

CREATING A 'HYDRATION CULTURE'

Traditionally, inhabitants of hot climates have avoided work during the hotter part of the day; however, the modern world places increasing numbers of people in situations where the combination of manual work and environmental conditions puts them at increased risk of heat-related illness or accident, a situation which is likely to be exacerbated by predicted changes in climate. The more severe the thermal environment, the greater the importance of, and potential benefits from, improvements in the hydration status of workers. That it is possible to remain well hydrated while working in the heat has been clearly demonstrated. In the Pilbara study (Miller and Bates, 2007), in contrast to the majority of worker groups, one team exhibited a high awareness of the importance of remaining well hydrated and despite having the highest sweat rates of all groups in the study ($>1 \text{ l h}^{-1}$), they were the best hydrated, consuming an average of almost 9 l of fluid and having a minimal weight loss over the shift. An interventional study in construction workers in the Middle East (Bates and Schneider, 2008) demonstrated that simple strategies to promote adequate intake of fluid enabled the workers to remain adequately hydrated in ambient temperatures reaching 50°C or more with working heart rates showing no evidence of physiological strain despite the severe thermal conditions. A combination of adequate hydration with a policy of self-pacing (permitting workers to adjust their work rate to the thermal conditions) takes advantage of humans' highly efficient physiological adaptation to hot environments, allowing work to continue safely in all but the most extreme thermal conditions (Brake and Bates, 2002; Bates and Schneider, 2008).

Establishing and maintaining a culture of 'hydration awareness' may require changing of habitual behaviours in relation to the timing, type, and quantity of fluid ingestion, the aim being to start the work shift in a well-hydrated state and to maintain this by replacing fluid to keep pace with sweat losses. Where sweat losses are high, this cannot be left to

voluntary drinking, at least until behaviour patterns are established, minimum fluid intakes must be prescribed, and strategies put in place to ensure compliance. As an example, the following practical recommendations were made to the Safety Manager at one of the construction sites reported on in the paper appearing in this issue (Bates *et al.*, 2010). These can be adapted to suit any situation in which workers are exposed to significant heat stress.

- Supply each worker with a personal insulated 2-l drink container to accompany the worker on site and be kept as close as practicable at all times.
- Encourage workers to arrive on site well hydrated by requiring each person to carry their drink bottle and to drink while on the bus from the work camp in the morning.
- As a guideline, workers should be drinking between 600 ml and 1 l of water per hour in summer. At the start of the shift, the drink container should be full and workers should be instructed that it should be consumed and refilled every 2–3 h.
- During hot weather, when sweating is heavy, an appropriate electrolyte replacement beverage should be available. Each worker should consume ‘at least’ one 2-l container full of this beverage per day, ideally during the morning work period, to maintain electrolyte and energy levels. Other studies in the United Arab Emirates have suggested that the salt content of the typical workers’ diet may not supply adequate sodium

to prevent hyponatraemia in summer. Supplementing throughout the day with an electrolyte replacement beverage will help to address this.

- During the ride home, encourage further drinking of water or electrolyte drink to replace afternoon losses.
- Educate workers to monitor their hydration levels from urine colour and volume. Reinforce this with posters in the latrines and rest areas.

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