HYDRATION REQUIREMENTS OF THE WMC FERTILIZERS WORKFORCE AT PHOSPHATE HILL

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Abstract

Introduction: A study of the hydration requirements of the WMC Fertilizers workforce at Phosphate Hill was undertaken as part of the James Cook University (JCU) study on the workplace environment and health. The main aims of the study were to estimate the rate of fluid loss and to establish fluid intake targets for sub-groups of employees.

Methods: The study involved a.m. and p.m. measurements of weight, a measurement of fluid intake and a structured questionnaire detailing hydration behaviour and toilet activity.

Results: A total of 127 employees participated in the study. Employees working predominantly in direct sunlight have a higher median fluid loss (September, 3.7; February, 4.8 $L.kg^{-1}.h^{-1}x10^{-3}$) compared to those working in shade (September, 2.7; February 4.0 $L.kg^{-1}.h^{-1}x10^{-3}$) and air conditioning (September, 2.3; February, 3.3 $L.kg^{-1}.h^{-1}x10^{-3}$). Subjects working predominantly in direct sunlight are less likely to maintain their fluid balance than those in air conditioning and shade. The recommended body weight and task specific fluid intake targets for the workforce are:

Body weight	Air conditioning Fluid intake target (L/shift)	Shade Fluid intake target (L/shift)	Direct sunlight Fluid intake target (L/shift)
70 kg	4 to 5	5 to 6	6 to 7
85 kg	5 to 6	6 to 7	7 to 8
100 kg	6 to 7	7 to 8	8 to 9

Conclusions: This research study provides detailed information on the fluid loss and hydration requirements of the WMC Fertilizers workforce and demonstrates that;

- Hydration facilities and strategies for workers in air conditioning or shade appear to be adequate;
- Employees working predominantly in direct sunlight require improved access to fluids;
- Urine colour is an accurate indicator of hydration in the workplace;
- Water is the preferred beverage for hydration in the workplace.

Introduction

A study of the hydration requirements of the WMC Fertilizers workforce at Phosphate Hill was undertaken as part of the James Cook University (JCU) study on the workplace environment and health. The study was conducted in warm conditions from Tuesday 17 to Friday 20 September 2002 and repeated in hot conditions from Tuesday 18 to Friday 21 February 2003.

The WMC Fertilizers Phosphate Hill plant is located in Australia's dry tropics where employees are exposed to relatively hot temperatures for much of the year. JCU conducted a baseline survey of the workforce health in December 2001. Elevated levels of serum albumin, aspartate transaminase, and potassium, known biochemical markers for dehydration[1,2], were observed in the workforce. This data was corroborated by an electrolyte analysis and the observed urine colours. The self-reported symptoms commonly experienced by employees at work including tired or strained eyes, dry or itchy skin, unusual fatigue and drowsiness, and headache are consistent with the known symptoms of hypohydration[3]. Therefore, the prevalence of the signs and symptoms of hypohydration among employees at the Phosphate Hill site were concerning and worthy of further investigation.

Much of the hydration research in the scientific literature has examined the short-term physical effects of hypohydration in athletic settings[4]. A balanced fluid loss and intake sustains physiological function and exercise performance[5]. Fluid loss exceeding 2% of body mass has demonstrated effects on psychological and physiological functions. Arithmetic ability, short-term memory and visuomotor tracking deteriorate significantly at –2% body mass[6]. Aerobic endurance, heat loss, sweat rate and cardiovascular function are impaired at –2% to –3% of body mass[7,8,9]. Lactate threshold occurs significantly earlier and at lower exercise intensities in subjects that are hypohydrated to –4% of body mass compared to adequately hydrated subjects[10]. These physiological effects of hypohydration are enhanced in hot compared to temperate environments[11,12].

Studies in workplace settings have identified hypohydration as a significant risk factor for heat illness due to impaired dissipation of body heat[2,13]. In hot conditions, work must be performed at slower rates to maintain a body temperature of less than 38°C[14]. High body temperature decreases time to fatigue during prolonged exercise in uncompensable hot environments[15]. While no published data are available in the scientific literature of the relationship between hydration and injury, the significant physiological and neurological effects implicate hypohydration as a potential risk factor for occupational injury.

Employees at the Phosphate Hill site are at increased risk of hypohydration and heat stress. The site is located in inland tropical Australia and employees are exposed to hot temperatures for much of the year. Mean daily maximum temperatures range from approximately 23°C in July to 38°C in December. The standard protective clothing requirements (long-sleeved shirts, long pants and helmets) for the Phosphate Hill site increase sweat rates and decrease evaporative sweat efficiency[16]. As workers in occupational settings usually perform physical activities at lower intensities, more frequently and for longer periods compared to athletes, the rates and causes of fluid loss and the hydration requirements of workers will differ accordingly.

Several long-term health effects of occupational hypohydration have been identified. These include increases in the prevalence of urinary stones[17] and dental erosion[18]. Large population based studies have demonstrated an inverse relationship between total daily fluid intake and the risk of bladder cancer[19]. Optimal hydration levels are not only vital for employees to perform physical activity and maintain optimal productivity, but more importantly, to ensure workplace safety and long-term health.

In response to the findings of the baseline health survey and the known risks, causes and effects of hypohydration in occupational settings and hot environments, an assessment of the hydration requirements of employees at the WMC Fertilizers Phosphate Hill site was conducted. The main aims of the study were to estimate the rate of fluid loss for sub-groups of employees and to establish weight- and task-specific fluid intake targets for the workforce.

Methods

The study was conducted onsite in warm conditions from 17 to 20 September 2002 and repeated in hot conditions from 18 to 21 February 2003. Participation was voluntary and all employees of WMC Fertilizers, as well as contractors of Golding, United KG, Darling Downs Tarpaulins (DDT) and Epoca at the Phosphate Hill site were invited to participate. The study involved a.m. and p.m. measurements of weight, a measurement of fluid intake and a structured questionnaire detailing hydration behaviour and toilet activity.

The Human Ethics Sub-committee of James Cook University granted approval for all parts of this study (Approval Number H1450).

Weight

Subjects were weighed fully clothed including boots but without personal protective equipment and tools. Initial weighing (a.m.) was conducted as close as practically possible to the commencement of the day shift. Repeated weighing (p.m.) was conducted prior to consumption of the main lunchtime meal. Subjects were weighed prior to obtaining urine samples.

Fluid intake

Participants were issued with a 2 Litre insulated water container at the initial weighing and were given instructions on how to fill and empty the container and to record the number of refills. The remaining water in the container was also measured at the time of the second weighing when determining the measured fluid intake for the period of observation. Participants were advised to adhere as closely as possible to their usual hydration behaviours.

Questionnaire

Details relating to other fluid intake, food consumption and toilet activity were obtained via a structured questionnaire. Participants were asked to record the intake volume of fluids other than from the provided water container. The number of cups was recorded and the cup volume was estimated as 0.25 Litres where the cup volume was not known.

Hydration calculations

- Total fluid intake during the period of observation was calculated as:
  measured fluid intake + other fluid intake
- Total fluid loss during the period of observation was calculated as:
  a.m. weight – p.m. weight + measured fluid intake + estimated other fluid intake
- Rate of fluid intake was calculated as:

$$\frac{\text{(measured fluid intake + estimated other fluid intake)}}{\text{a.m. weight x hours of observation}}$$

- Rate of fluid loss was calculated as:

$$\frac{\text{(a.m. weight – p.m. weight + measured fluid intake + estimated other fluid intake)}}{\text{a.m. weight x hours of observation}}$$

- Difference in rate of fluid intake and loss was calculated as:
  rate of fluid intake - rate of fluid loss

Fluid intake targets

Fluid intake targets for the period of a 12 hour shift were calculated as;

Median fluid loss per kilogram per hour x 12 hours x 1.5 (loss to urine factor)[20].

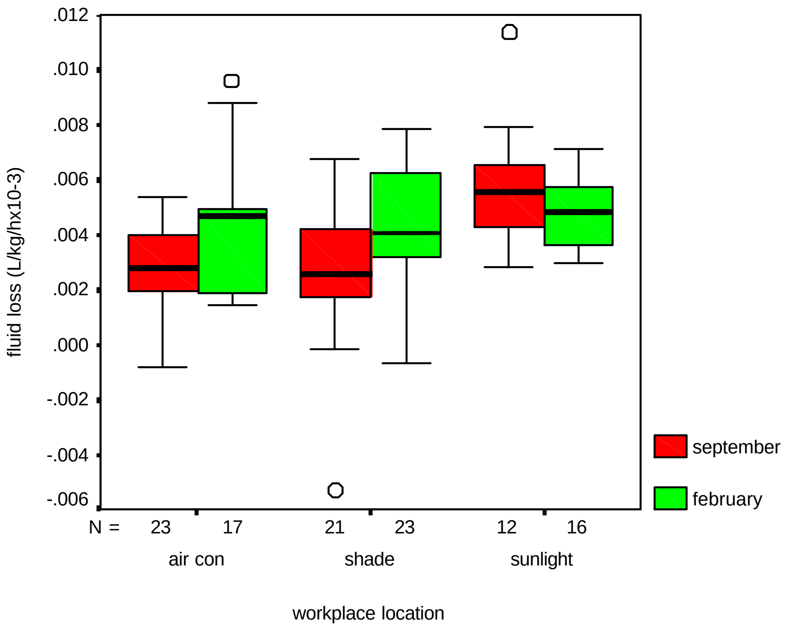
Subjects who had eaten their main lunchtime meal prior to the p.m. measurements and those who performed predominantly non-routine tasks were excluded from the fluid intake target calculations. No adjustment was made for toilet activity during the period of observation in any of the hydration calculations.

Results

In September 2002, 63 subjects provided a.m. and p.m. weights and fluid intake measurements and completed questionnaires. In February 2003, 64 subjects provided a.m. and p.m. weights; completed questionnaires were obtained from 61 subjects.

Employees working predominantly in direct sunlight have a higher median fluid loss (3.7 $L.kg^{-1}.h^{-1}x10^{-3}$) compared to those working in shade (2.7 $L.kg^{-1}.h^{-1}x10^{-3}$) and air conditioning (2.3 $L.kg^{-1}.h^{-1}x10^{-3}$) in September (Figure 1). Similarly, in February the median fluid loss for employees working in sunlight (4.8 $L.kg^{-1}.h^{-1}x10^{-3}$) is higher than for employees working in shade (4.0 $L.kg^{-1}.h^{-1}x10^{-3}$) or air conditioning (3.3 $L.kg^{-1}.h^{-1}x10^{-3}$).

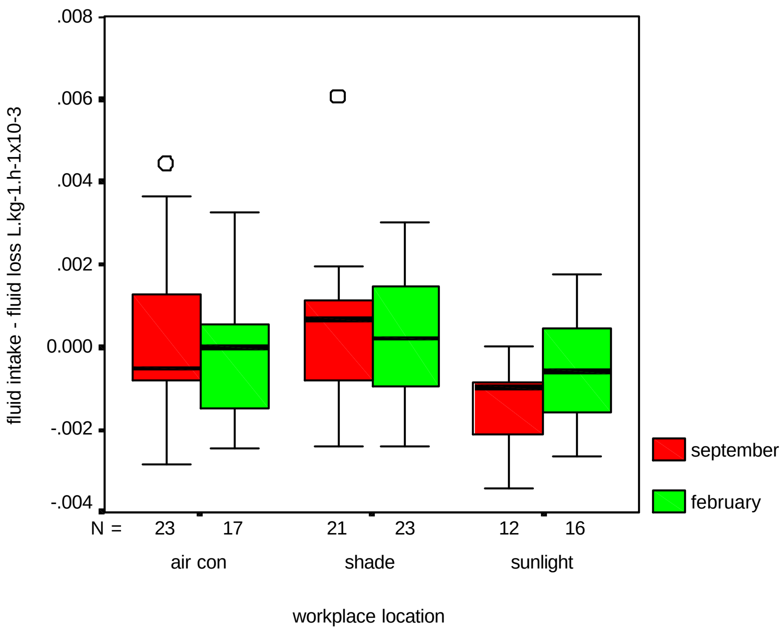
Figure 1. Fluid loss by workplace location and month.



The difference between fluid intake and loss by workplace location is displayed in Figure 2. Subjects working predominantly in direct sunlight (-1.0 $L.kg^{-1}.h^{-1}x10^{-3}$) are less likely to maintain their fluid balance than those working in air conditioning (-0.5 $L.kg^{-1}.h^{-1}x10^{-3}$) and shade (+0.7 $L.kg^{-1}.h^{-1}x10^{-3}$) in September. A similar trend is observed in February. Employees working predominantly in direct sunlight have a negative median fluid balance (-0.6 $L.kg^{-1}.h^{-1}x10^{-3}$), while those in air conditioning maintain (0.0 $L.kg^{-1}.h^{-1}x10^{-3}$) and those in shade improve (+0.2

L.kg^{-1}.h^{-1}x10^{-3}) their fluid balance. Fluid intake equalled or exceeded fluid loss for approximately half of the participants in both September (51%, n=32) and February (52%, n=31).

Figure 2. Difference between fluid intake and fluid loss by workplace location and month.



Fluid intake targets.

The recommended body-weight and workplace specific fluid intake targets for the workforce are detailed in Table 1. These targets are based on the median fluid losses in Figure 1 and have been calculated as described in the Methods section.

Table 1. Recommended fluid intake targets by body weight and workplace location.

	Air conditioning	Shade	Direct sunlight
Body weight	Fluid intake target (L/shift)	Fluid intake target (L/shift)	Fluid intake target (L/shift)
70 kg	4 to 5	5 to 6	6 to 7
85 kg	5 to 6	6 to 7	7 to 8
100 kg	6 to 7	7 to 8	8 to 9

Discussion

Fluid intake equalled or exceeded fluid loss for approximately half of the participants in both September (51%, n=32) and February (52%, n=31). These results indicate that the facilities currently provided at the Phosphate Hill site in combination with the behaviour of employees working predominantly in air conditioning or shade appear to be adequate for maintaining or improving hydration in the workplace.

However, the results indicate that improved rehydration strategies for employees working predominantly in direct sunlight are required. Employees working predominantly in direct sunlight have consistently higher fluid loss compared to employees working in shade and air conditioning. Accordingly, the hydration requirements of this group are different from the rest of the workforce as their fluid balance deteriorates during their shift.

A plausible explanation for the insufficient fluid intake in subjects working predominantly in direct sunlight is access to water. Employees working in air conditioning and shade are either inside or close to site buildings and have access to taps or water coolers. Employees in direct sunlight are more likely to be further away from buildings in situations where water is not easily accessible while performing work duties. Additionally, the relatively low humidity at the Phosphate Hill site enables an efficient evaporation of sweat. Employees may be unaware of their fluid loss through sweat and the amount of fluid required to sufficiently maintain hydration. The working conditions and hydration behaviours of this sub-group of employees require further investigation to develop strategies to increase fluid intake in the workplace.

The recommended fluid intake targets for the workforce as detailed in Table 1 are based on estimates of the median fluid losses obtained in this study and are consistent with guidelines published in the scientific literature[21]. These targets cannot provide employees with an exact fluid intake per shift due to the daily variations in environmental conditions (temperature, humidity and wind speed) and individual physiological factors (aerobic fitness, endurance training, heat acclimation, gender and body composition)[22] that affect fluid loss. Rather, these figures are intended to serve as a guide only to inform employees as to their fluid intake requirements and increase fluid intake for those who may be hypohydrated. It is strongly recommended that employees use urine colour rather than the amount of fluid ingested or thirst as the most valid indicator of their hydration status, as urine colour is strongly correlated with urine specific gravity and urine osmolality[23].

A review of the scientific literature indicates that water is the preferred beverage for hydration for fluid loss rates of the magnitude observed in this study due to its availability and low sodium levels[24]. Commercially prepared electrolyte replacement drinks have a limited role and may exceed the salt requirements and may, in the long-term, even cause renal damage due to the hydrogen ion load[25], dental erosion due to low pH and diarrhoea due to high sugar levels[26]. The main advantage of carbohydrate-electrolyte beverages is their increased palatability compared to water[27]. While absorption of beverages increases with sodium content[28], rehydration can be achieved by the intake of larger volumes of fluid containing little or no sodium[29]. The electrolytes contained in regular balanced meals are sufficient to replenish any loss through sweat. Supplementary sodium chloride is usually not required for workers that are accustomed to the work duties and environmental conditions[30].

Conclusions

This research study provides detailed information on the fluid loss and hydration requirements of the WMC Fertilizers workforce at Phosphate Hill. Based on the results of this study, the following statements and recommendations with respect to the hydration requirements of the workforce can be formulated:

- The current workplace hydration facilities and strategies for people working in air conditioning or shade appear to be adequate;
- People working in direct sunlight require improved access to fluids;
- Urine colour is an accurate indicator of hydration in the workplace;
- Water is the preferred beverage for hydration in the workplace.

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