



OVERVIEW

## An Overview of Hydration Status and Its Relation to Occupational Heat Stress among Workers

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### Abstract

Working in high temperature environment is unavoidable condition for an outdoor worker, especially the outdoor workers in to tropical countries such as Indonesia. Heat stress leads to various heat-related illnesses, such as heat stroke, hyperthermia, heat exhaustion, heat cramps or heat rashes. A mild and moderate heat stress usually less serious and did not harm general health condition, however it could cause individual fatigue and unfocused, which will interfere the working performance and productivity. Numbers of studies showed that there were strong correlation between occupational related heat stress and workers' hydration status. Unfortunately, there were still very limited recommendation and guideline specifically regulated the importance of hydration toward outdoor worker as well as those who were working in high temperature working environment.

**Keywords** heat stress, heat-related illness, workers, hydration

### Introduction

Working in high temperature environment is unavoidable condition for an outdoor worker, especially for outdoor worker in tropical countries such as Indonesia as well as worker in industry dealing with hot temperature environment. The similar environment also applies to worker in industry or factories with extremely high temperature and heated environment. A study in Indonesia reported that during 2012 – 2013 there were numerous of heat and high temperature occupational exposure cases in Indonesia, which

was including 13 death cases and 7 among them were showing heat stress with moderate workload. According to this report, one of the potential medical condition suffered by outdoor workers are heat stress.<sup>1</sup>

Numbers of studies showed that there were strong correlation between occupational related heat stress and workers' hydration status. Unfortunately, there were still very limited recommendation and guideline specifically regulated the importance of hydration toward outdoor worker as well as those who were working in high temperature working environment.

### Occupational Heat Stress: Definition and How It Affects Physiology of Worker

Occupational heat stress defined as a net load to which a worker exposed from the various or combined factors or exposures of metabolic heat,

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environmental factors and clothing worn which results in an incremental heat storage in the body.<sup>2</sup> Heat stress leads to various heat-related illnesses such as heat stroke, hyperthermia, heat exhaustion, heat cramps or heat rashes.<sup>3</sup> A mild and moderate heat stress usually less serious and did not harm general health condition, however it could cause individual fatigue and unfocused, which will interfere the working performance and productivity. Heat stress will had caused physiologic response of the body, as it needs to reduce the increased temperature inside the body, this is known as heat strain condition.<sup>4</sup>

Skin evaporation through sweating were the most dominant mechanism of the body in order to reduce the elevated body temperature. Apart of ambience temperature, the impermeable clothing would also prevent the normal body evaporation mechanism. ACGIH has defined threshold value for working in hot place to maintain the body's core temperature in +1°C from normal temperature (37°C). The limit of body's core temperature can be excessive under certain conditions with selected populations, environment and physiological monitoring and other controls. Assessment in evaluating whether a worker in extreme hot environment experiences heat stress and heat strains is very important for health professionals to prevent the occurrence of disease caused by heat (Table 1).

#### *Central nervous system*

The central nervous system is responsible for the function of thermoregulation. The hypothalamus as part of the central nervous system structure acts as a location to control body temperature. The anterior hypothalamus acts as a thermostat and posterior hypothalamus as a determinant of the set point of core body temperature and initiates a normal physiological response to temperature changes. The ratio of sodium and calcium plays an important role in regulating this thermoregulation system. The posterior hypothalamus is responsible in physiological mechanism to maintain body temperature. When the ambient temperature

exceeds the set point, through the sympathetic nervous system, the blood vessels will expand and the sweating process begins, intended to restore body temperature to normal.<sup>6</sup>

#### *Working capacity and muscle work activity*

The proportion of aerobic capacity needed to do certain jobs. First, the cardiovascular system will respond to increase oxygen demand when working in a hot environment by increasing pump volume (stroke volume) and heart rate. When stroke volume achieved, an increase need for cardiac output done by increasing the heart rate. Problems will arise if the work intensity is high enough in the hot place and carried out for a long time. Second, muscle work activity is associated with an increase in muscle temperature and will have an impact on the body's core temperature, which in turn will affect the thermoregulation control. Third, the high workload in a hot environment can result in insufficient oxygen tissue demand.<sup>7</sup>

#### *Circulation system*

The circulation system is responsible in oxygen distribution and nutrients to all body's tissue. In certain conditions, the heart is unable to fulfill oxygen and body heat expenditure needs. The autonomic nervous system and endocrine system will help blood flow to overcome this need.<sup>8</sup>

#### *Sweating mechanism*

Sweat glands founded in almost all skin tissue. This gland stimulated by sympathetic nerve and produce hypotonic fluid out of the skin surface. Sweat production up to 1 L/hour in industrial worker recorded and illustrated a large body cooling process. Each liter of sweat produced represented 580 kcal of heat to the environment. Too much sweat loss will threaten the function of thermoregulation due to a decrease for body fluids progressively and if the body fluids is not replaced immediately, the body temperature will rise rapidly. The main composition of sweat is salt or sodium chloride.<sup>9</sup>

Table 1. Health effect to hot environment exposure

<b>Disorder</b>	<b>Cause</b>	<b>Symptoms</b>	<b>Treatment</b>
<i>Heat Cramp</i>	Excessive sweating with loss of body's salt	<ul style="list-style-type: none"> <li>- Ache, spasm in the arm, feet and stomach</li> <li>- Sudden</li> <li>- Hot and moist skin</li> </ul>	<ul style="list-style-type: none"> <li>- Drink water</li> <li>- Massage in cramp area</li> <li>- Take a rest</li> </ul>
<i>Heat Exhaustion</i>	Dehydration non acclimatization	<ul style="list-style-type: none"> <li>- Excessive sweating</li> <li>- Thirsty</li> <li>- Pale, moist and cold skin</li> <li>- tachycardia</li> <li>- Fatigue</li> <li>- Fainted</li> </ul>	<ul style="list-style-type: none"> <li>- Move to the shady area or air conditioned room</li> <li>- Take a rest with higher feet</li> <li>- Loosen the clothes</li> <li>- Drink water</li> </ul>
<i>Heat stroke</i>	Excessive heat exposure and lead to body regulator to malfunction	<ul style="list-style-type: none"> <li>- Body temperature increase</li> <li>- Sweat decrease</li> <li>- Redden, hot, and dry skin</li> <li>- Breath difficulties</li> </ul>	<ul style="list-style-type: none"> <li>- Emergency action</li> <li>- Emergency call</li> <li>- soak the patient in water</li> <li>- Cold compression</li> </ul>

Source: ACGIH TLVs & BEI Book 2011

Salt requirement in normal people is 2.3–3 grams per day, but loss of fluid while working in moderate activities in hot environment reaches an average of 0.8 liters per hour, so the sweat that is produced every 8 hours can reach more than 6 liters per day, while sodium loss that comes out with sweat can reach 4.8–6 grams which is equivalent to 10–15 grams of salt.<sup>10</sup>

Potassium loss in sweat can also lead to blood potassium deficiency, which will lead to heat stroke. Fluids replacement for loss of fluid due to sweating is very necessary. If fluid is not immediately given, there will be a shrinkage of the extracellular and interstitial spaces and plasma volume. Evidence show that sweat production is highly dependent on hydration status, so hypo hydration progression can be caused by excessive sweating and will increase body temperature which will lead to danger of heat stroke.<sup>9,10</sup>

#### *Heat acclimatization*

Workers exposed to heat will show distress signs and discomfort characterized by body temperature

and pulse increase, headache, nausea and even fainting. The level of acclimatization determined by workers' physical fitness and the work period in the hot place.<sup>11</sup>

#### **Heat Related Illness among Outdoor Workers**

When the body tries to tolerate hot temperatures, the body will experience heat stress, which manifests in body temperature and pulse increase. The body will compensate for the hot environment by sweating to reduce body temperature. If the humidity is high enough, the sweat will be difficult to get out, which prevents the body from releasing heat quickly. If this condition occurs continuously, workers can experience heat related illness such as heat cramps, heat exhaustion and even heat stroke that can lead to death.<sup>12</sup>

In a study conducted in several mining plant in Australia, reported that 40% of mining workers working in hypo hydration status (mild to severe),<sup>13</sup> while in a study conducted in India of 58 firefighters, 20% of firefighters had a health impact

caused by heat exposure in the form of heat exhaustion 18.3%, heat cramps 6.2% and heat syncope at 4.1%.<sup>14</sup> Factors influence heat stress are age, sex, acclimatization, health status, body mass index, type of clothing used, direct exposure to sunlight, fluid intake, and workload.<sup>10</sup>

Of these factors, fluid intake is the easiest factor to control in preventing the effects of heat stress on workers. The type of fluid consumed to replace electrolyte loss due to sweating is a factor that needs to be investigated in an effort to prevent the effect of heat stress. The variation in the body's response to heat exposure varies from mild to severe. This disorder triggered by an increase in body core temperature with lack of fluid complication. The prognosis depends on rapid treatment to reduce body temperature and fluid and electrolyte intake (Table 1).<sup>9, 10, 13</sup>

### **Hydration Status and Heat Stress in Outdoor Workers**

Most of the studies in heat acclimatization<sup>15-19</sup> focused on physiological responses to heat. In terms of physiological adaptation, long-term heat-acclimatized individuals are reportedly to have smaller rises in core temperature during heat exposure<sup>20,21</sup> and an advantage in body fluid regulation<sup>19</sup>, in which they indicate the ability to deal with stress from any given heat exposure.<sup>22,23</sup>

Numbers of literature to date examining the effects of hydration status on cognition, exercise in the heat used as the dehydration protocol. Such studies typically result in hypo hydration of ~ 2% body mass loss and have demonstrated decrements in various cognitive functions, including working memory, vigilance and perception.<sup>24-28</sup> However, some studies have reported no effect of exercise induced hypo hydration on short-term memory, concentration and choice reaction time.<sup>29-31</sup>

In resting conditions, the body requires fluid intake of 2 liters per day, and in moderate physical activity, fluid requirements can increase to 3.5 liters per day. Fluid loss while working in moderate activities in hot environments reach an average of 0.8 liters per hour, so the sweat that is produced every 8 hours can reach more than 6 liters per day, while sodium loss that comes out with

sweat can reach 4.8–6 grams which is equivalent to 10–15 grams of salt.<sup>10</sup>

### **Drinking and Rehydration to Treat Heat Stress**

Working in hot temperature environment, the body will be easily dehydrated due to sweat production as body mechanism to release heat generated from physical activity. Too much sweat production will release electrolyte. Salt is the most excreted electrolyte with an average loss of 4.8 – 6 grams of sodium for 8 hours of working or equivalent to 10 – 15 g of salt. Significant loss of electrolyte in the worker in extreme hot environment, need electrolyte replacement from fluid intake. Appropriate ion drink will provide a quick replacement for the body's electrolyte loss.<sup>32</sup>

Although the American College of Sports Medicine Guidelines on Nutrition and Athletic Performance recommend the amount of fluid intake.<sup>33</sup> In a recent study shows that deep-ocean water taken from the coast of Hualien, Taiwan at a depth of 662 m improves recovery following a dehydrating exercise, evidenced by accelerated recovery of aerobic capacity, increased lower-body muscle power performance and significantly reduced levels of exercise-induced muscle damage markers compared to participants drinking purified tap-water.<sup>34</sup>

Another study reported that a deep-ocean mineral water was shown to increase the exercise performance of gerbils, compared to distilled water, measured by retention rates during a 90-min treadmill exercise.<sup>35</sup> Considering the established connection between hydration status and exercise performance, these data suggest that mineral water may provide optimal rehydration for performance recovery following high-intensity exercise. A study suggested that mineral water had the potential to improve lower-body muscle strength as well as acute rehydration rate after dehydrating exercise.<sup>36</sup>

### **Conclusion**

Potential risk of heat stress and heat related illnesses are higher among outdoor and high temperature work place-based workers. The mechanism and pathophysiology of heat stress and heat related illnesses are well studied, however an

intervention study focus on rehydration are still needed to demonstrate the benefits of it in reduce the heat stress and heat related illnesses in high risk population of workers.

### Conflict of Interest

AM currently is The Leader of Occupational Health and Medicine Chief SKK MIGAS, RWB is Head of Medical Nutrition Services Department in Nestle Nutrition Institute Indonesia. Other author declares no conflict of interest.

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