Employee Safety

White Paper: Dehydration and Heat Stress

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Overview

Dehydration and heat stress are legitimate concerns of the working world that can cause decreases in performance and efficiency, as well as an increase in the likelihood of injury. Employers, safety managers, and employees all want to work
safely while maximizing productivity. Each person wants to prevent accidents or injury at all costs, and to do so it is critical to know the symptoms of dehydration. This white paper examines dehydration, dehydration-caused illness and injury, and the risks associated with operating while dehydrated.

Dehydration and Heat Stress Defined

Dehydration is defined as a 1% or greater loss of body mass as a result of fluid loss[1]. The human body weight is made up of around 60% to 70% fluid. Dehydration occurs when the body is losing more fluids than being consumed, which causes the
body to not perform maximally. It is important to note that the sensation of thirst is not a reliable indicator of dehydration because most people do not sense thirst until they are already dehydrated. In addition, it is considered to work best during rest[2].

Fluid loss from the body through normal daily activity, breathing, perspiration, urination, and defecation, is around 2.5L that needs to be replaced daily[1]. Even in mild dehydration, losses of 2% body mass or more can cause a decrease in performance of up to 50%[3].

The impairment of performance and productivity worsens exponentially with prolonged fluid restriction, and an increase in the level of dehydration. The signs of early dehydration are thirst, darkened and less regular urination, headache, dizziness, and slower reaction times[4]. The signs of dehydration can mimic other serious medical issues, so it is critical to talk with a healthcare provider for an appropriate diagnosis. As the time of fluid restriction lengthens, the body's core temperature and pulse begin to elevate, causing an increased likelihood of a heat stress event.

As the intensity of the work or activity increases, so does the risk for dehydration or a heat stress event. For each 2.2 pounds of weight a person loses in an activity, the fluid loss is around 1L[2]. Extreme activity in hot environments can cause the body to lose 2.5L per hour, which is greater than the body's ability to absorb consumed fluids[3]. If the fluid loss is 5% to 6%, cognitive function declines significantly, and tingling is often felt in the limbs[3]. A loss of 10% to 15% can cause muscle cramps, skin crinkling, less frequent and painful urination, and even delirium[3]. If fluid loss becomes greater than 15%, death becomes almost imminent[3].

The National Safety Council defines three levels of heat stress as **heat cramps**, **heat exhaustion**, and the more extreme as **heat stroke**. Heat cramps typically first appear in the abdomen or upper and lower

extremities, and present as spastic muscles in these areas[5]. Heat exhaustion occurs when too much fluid is lost from the body. A person experiencing heat exhaustion can have symptoms of pale and clammy skin, elevated heart rate, fatigue, and nausea[5]. The early signs of heat stroke occur when the body stops sweating and the core temperature begins to increase, which typically causes hot skin, slowed mental capacity, and in extreme circumstances seizures or coma[5]. Heat stroke is very serious, and can often lead to lasting organ damage and even death. Dehydration and heat stress are harmful to the body as well as to the workplace.

Factors That Increase the Risk of Dehydration

There are many factors that can increase the risk of dehydration and heat stress. The body is constantly losing fluids through natural body functions to maintain homeostasis and a core body temperature. The preparation of the body, as well as the condition, both play key parts in the risk level. Other factors include age, gender, and environmental exposure. Fluids, nutrients, and body salts that are lost must be replaced to prevent dehydration[2]. Part of this replacement is through fluids and foods that contain water, sodium, potassium, calcium, and magnesium.

Stressors on the body such as diarrhea, vomiting, fever, excessive sweating, or frequent urination can deplete these nutrients and fluids and lead to an increased risk for a heat stress incident[3]. Drinks that are caffeinated or carbonated can also lead to dehydration, because these lead to higher urine outputs[6]. Medications for high blood pressure often contain diuretics, which increase the volumes of urine loss from the body.

Chronic illnesses such as diabetes, kidney disease, and even common colds put workers at a predisposition to dehydration[4]. Even with minor colds or illnesses people tend to eat and drink less, which increases the chance of dehydration[4]. Older adults
are also at a higher risk of dehydration. Older adults have smaller volumes of fluid reserves, and have diminished thirst sensations, which cause a delay in the awareness of dehydration[4].

On top of medical preconditions and physical health, there are also external factors that contribute to fluid loss. The amount of exertion, poor air flow and circulation, radiant heat from equipment, heavy personal protective clothing, extreme temperatures, and humidity all have a negative effect on the loss of fluid from the body. It is important to note that humid temperatures can cause an increase in the vulnerability for dehydration. When the temperatures are extreme and humid, the body is unable to cool the core temperature by evaporating sweat as fast as usual[4]. This, in turn, leads to a higher core temperature and further fluid loss.

Cold temperatures also put people at an increased risk for dehydration. Cold weather can cause the chemistry of the body to confuse the mind, and can lead to a decreased awareness of sweating in thick clothing, decreased sensation for thirst, and an impaired capacity to know when to replace lost fluids[6]. Also, cold temperatures cause body fluids in the outer limbs to move inward to maintain a core temperature, but in doing so causes an amplified urine flow and increased risk for heat stress or dehydration[6].

More specifically, the human body has a temperature range called the thermal neutral zone. The thermal neutral zone is the ambient temperature range a normal adult can conserve the core body temperature of around 98.6 degrees Fahrenheit without using more energy than required for the standard basal metabolic rate . Researchers have found that the thermal neutral zone for a clothed person doing light office work is between 14.8°C-24.5°C (58.6°F-76.1°F)[14]. Ambient temperatures outside

of the thermal neutral zone will cause a change in the internal core temperature that activates the central nervous system and hypothalamus to regulate the heat loss or production[15].

The thermoregulatory response to cool the body's core is by vasodilation of extremity blood vessels and sweating, but to heat the body's core temperature, extremity blood vessels are constricted and muscle shivering occurs[15]. More people die each year from being exposed to dangerous hot and cold temperatures outside of this range than all other weather-related deaths collectively[15]. Knowing how the body can be affected by these risk factors helps people to be more prepared against the threats of dehydration.

Liability of Operating Industrial Equipment Dehydrated

Operating industrial equipment while dehydrated can be just as hazardous as operating while intoxicated. During a study at Loughborough University, researchers discovered that slightly dehydrated drivers had similar errors as those whose blood alcohol concentration was above .08%[7]. According to the Department of Motor Vehicles, a blood alcohol concentration of .08% is the highest legal limit before being considered as driving under the influence or driving while impaired[8].

Similarly to alcohol, minor dehydration has been shown to decrease concentration, cognitive function, alertness, and alter mood[9]. The study was conducted by accessing the performance of the participants on a driving simulator while properly hydrated and while mildly dehydrated. For the hydrated trial, participants were given 85 ounces of fluid the day before the trial and 16 ounces the day of[9]. The mildly dehydrated participants were only give one-fourth of this amount before the driving test[9].

The primary author, Dr. Phillip Watson, wanted to ensure the dehydration level of the participants was minor as to create real-life conditions[7]. The conditions were intended to mimic having a hectic day, and forgetting to take breaks to rehydrate. The level the participants were dehydrated was minimal, but the research found this was still significant enough to cause double the amount of errors as the hydrated participants[9]. These errors correlated to the same mistakes made by previous participants while inebriated[9]. The errors also increased with time as well as with prolonged limitation of fluids[9]. The interpretation of the study is as such, mild dehydration can lead to an impaired ability to safely and maximally operate[9].

The impaired ability to operate while dehydrated is not only a physical liability, but is also a financial liability. Illness, injury, and even death from dehydration and heat stress is almost always preventable. Each year businesses lose $170 billion because of injury, illness, or death of members of the workforce[10]. The loss of productivity alone costs companies around $60 billion annually[10]. These losses impact employers, employees, and the communities not only financially, but also physically and emotionally.

Most of the stress and suffering caused from occupational injury or illness can be prevented. Each year in the United States alone, over 4,500 workers die and over 4.1 million are seriously injured because of a job-related incident[11]. OSHA estimates that each life lost because of an occupational incident costs around $8.7 million[11].

According to the National Safety Council, the likelihood to die from subjection to too much heat is 1 in 16,584 persons[12]. In one year alone, 244 individuals lost their lives because of dehydration and heat

stress, and over 500,000 were hospitalized[5,13]. On top of the direct costs recorded to companies, indirect costs are estimated to be an additional two to four times more[11]. These indirect costs include having to retrain new employees, more missed days, and a decrease in the product or service quality[11].

By being aware of the liabilities associated with operating industrial equipment dehydrated, the chances of conflict because of occupational injury are reduced significantly. This helps not only to save lives, but also leads to a more fulfilling and prosperous business model.

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To learn more about how Sqwincher can help protect workers against dehydration and heat stress, see their landing page on MSCDirect.com.