

# Dehydration Index and Fatigue Level of Workers Laboring in Heat-Exposed Environments

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## ABSTRACT

**Background:** Workers who are exposed to extreme heat may be at high risk of *heat stress* which can affect the workers' health and reduce their work productivity. This study aimed to analyze dehydration index and fatigue level of employees working in heat-exposed environments. **Methods:** The participants of this cross-sectional descriptive study were 52 employees working on shoveling sand. The urine and peripheral blood of the research subjects were taken for laboratory analysis. The dehydration index was determined from the color, specific gravity, and acidity of urine and from the hematocrit level of blood. The *heat stress* was assessed using the indicators of wet-bulb globe temperature (WBGT) and the amount of UV exposure. Fatigue level was measured using occupational fatigue questionnaires referring to *Subjective Self Rating Test (SSRT)*. **Results:** The results of *heat stress* measurement showed that the average of WBGT was above the threshold limit value, and it meant that the workload of workers was high. All workers (100%) were exposed to UV radiation that higher than recommended threshold limit value. It was found that 11% of the workers were dehydrated based on hematocrit levels and 25% of those were dehydrated based on urine pH level test. Dehydration index based on urine color observation revealed that 52% of workers were severely dehydrated, whereas based on the urine specific gravity 72.3% of the workers were moderately dehydrated. The measurement of fatigue level showed that 89% of the workers developed mild fatigue. **Conclusion:** Heat-exposed environments could make some changes in dehydration index and cause mild fatigue in workers. It is necessary for people working in heat-exposed environments to have regular medical check-ups and maintain the balance of body fluids.

**Keywords:** *dehydration, fatigue, heat exposure*

## I. INTRODUCTION

In tropical countries, heat exposures become one of the trending issues to discuss since the dry season that occurs almost throughout the year. Working in places exposed to extreme heat, especially in urban areas, can cause our body to produce excessive heat. This is a normal body mechanism to cope with the extreme heat received from the environments [1].

Extreme heat exposure in occupational environments is potential to yield *heat stress* in workers. *Heat stress* can create well-known risks of heat-related illnesses and limit workers' productivity [2,3]. *Heat stress* occurs through a combination of several factors (environment, occupation, and clothing) and tends to increase core body temperature, heart beat/pulse rate, and sweat production [4]. Workers laboring in heat-exposed environments are particularly vulnerable to health problems and injuries [5] especially those who work in outdoor settings with heavy workloads and are exposed to direct sunlight [6]. A study of

Frimpong *et al.* suggested that outdoor workers such as farmers and those managing their farms manually are at high risk of exposure to *heat stress* that can affect their health and productivity [7].

A study of Rainham & Smoyer showed that continuous exposure to *heat stress* and air pollution had significant effect in the increase of mortality rate [8]. Jay & Kenny estimated that the 20 deaths of heat-related illness found in 2001 would be 300 deaths by 2020 [9]. A similar study conducted by Kamijo and Nose in 2001-2003 found that 483 workers did not go to work for more than 4 days due to heat-related illness and 63 of them were reported dead [10].

According to Permenakertrans RI No. Per.13/Men/X/2011, the threshold limit value (TLV) of physical factors in workplace for work climate is 28°C for workload in the medium category with 75% working hours and 25% breaks [11]. If workers work in workplace with work climate higher than recommended threshold limit value, *heat stress* may occur. *Heat stress* is a

condition that occurs when the body is unable to regulate its internal temperature [12]. The signs of *heat stress* include subjective complaints such as heat exhaustion, heavy sweating and thirst, feeling of discomfort, and loose of appetite as a result of dehydration through sweating [13]. This study aimed to analyze dehydration index and work fatigue level in workers who work in heat-exposed environments.

II. METHODS

This was a cross-sectional study on 52 people working on shoveling sand in Depot Pasir Mutiara, Boom Baru Palembang. The study was conducted in July-August 2017. The urine and peripheral blood samples of research subjects were examined in Laboratory of Bio Science Research Palembang. This study was approved by the Research Ethics Committees of Faculty of Medicine Number 381/kepkrsmhfkunsri/2017.

*Heat stress* index was determined by analysing wet-bulb globe temperature(WBGT) and the amount of UV exposure. The dehydration index was measured by analysing color, specific gravity, acidity of urine samples and hematocrit level of blood samples. Fatigue level were measured using a work fatigue questionnaire based on the *Subjective Self Rating Test* (SSRT). The data obtained were then processed for computer assisted data analysis.

III. RESULTS

a. Characteristics of Research Subject

Characteristics of research subjects which were analyzed in this study included age, weight, height, and pulse rate. The results indicated that 87% of the workers aged > 35 years old, 68% with height ≥ 160 cm, 90% with weight ≥ 50 kg, and 77% with pulse rate > 80bpm (see Table 1).

Table 1. Characteristics of Research Subject

No.	Characteristic	n	f(%)
1.	Age		
	a. 18- 35 years old	8	13
	b. > 35 years old	57	87
2.	Height		
	a. < 160 cm	21	32
	b. ≥ 160 cm	44	68
3.	Weight		
	a. < 50 kg	6	10
	b. ≥ 50 kg	59	90
4.	Pulse Rate		
	a. ≥ 60-80 bpm	15	23
	b. > 80 bpm	50	77

b. Analysis of Wet-Bulb Globe Temperature(WBGT)

In this study,the WBGT analysis was used to determine the temperature of work climate in Depot PasirMutiara, Boom Baru Palembang. Instantaneous data of work climate was collected from three time testing. Based on the results, it was found that WBGT in the workplace was higher than recommended threshold limit value. Therefore, the workload of the workers was categorized heavy (see Table 2).

Table 2. Average Result of Wet-Bulb Globe Temperature (WBGT)

Location	Result (°C)	TLV (°C)	Workload
Depot Pasir Mutiara	30.83	27.5	Heavy

c. Ultraviolet Radiation in Heat-Exposed Workers

To find out the amount of ultraviolet radiation in the workers of Depot Pasir Mutiara, Boom Baru Palembang, each of research participants was measured for the exposure of ultraviolet radiation.The results of instantaneous measurements of occupational exposure to ultraviolet radiation showed that all workers (100%) were exposed to ultraviolet radiation above the threshold limit value (TLV) (see Table 3).

Table 3. Average Result of Ultraviolet Radiation

Location	N	Average of UV Radiation (mW/cm <sup>2</sup> )	TLV (mW/cm <sup>2</sup> )	Source of Radiation
Depot Pasir Mutiara	52	.00022	.0001	Direct Sunlight

d. Dehydration Incidences in Heat-Exposed Workers

The incidences of dehydration in workers exposed to extreme heat were assessed from various dehydration indicators in urine (specific gravity, acidity, and color), and blood (hematocrit level).This study found that 11% of the workers was dehydrated based on hematocrit levels, and 25% was dehydrated based on urine pH tests. The dehydration level was then analysed by observing urine color and urine specific gravity. From urine color, it was found that 52% of the workers was severely dehydrated, and from specific

gravity, it was found 72.3% of the workers was moderately dehydrated (Figure 1).

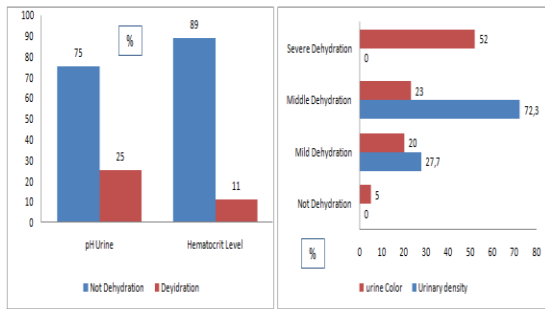


Figure 1. The Percentage of Dehydration of Heat Exposed Workers

e. Work Fatigue in Heat-Exposed Workers

Work fatigue in workers was analyzed using a work fatigue questionnaire based on the *Subjective Self Rating Test* (SSRT). Based on the data obtained from the study, it was found that most workers (89%) developed mild fatigue (Figure 2).

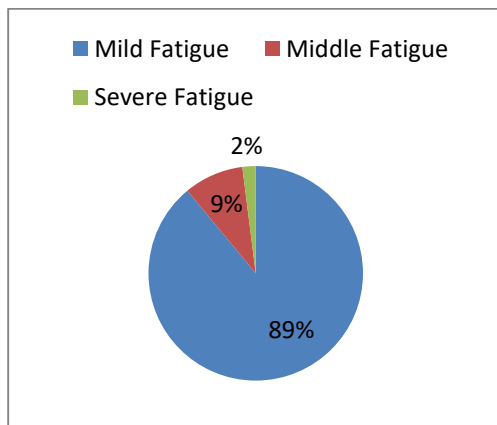


Figure 2. The Percentage of Work Fatigue of Heat Exposed Workers

IV. DISCUSSIONS

The results of ultraviolet radiation examination on the workers showed that all workers were exposed to UV radiation that was higher than recommended threshold limit value (TLV). These results were similar to those of work climate using wet-bulb globe temperature that work climate was above TLV and the workload was heavy.

The threshold limit value (TLV) of work climate is believed to be a level to which a worker can be exposed day after day for working hours of 8 (eight) hours a day or 40 (fourty) hours a week without having illness or health disorders [11]. The results of this study were in line with those of Heidari *et al.* that conducted a study on

workers who work in the summer and spring. In the summer the *heat stress* index was 60% and > 75%, while in the spring the *heat stress* index was 20-25%. The workload measurements in workers who work in the summer and spring indicated moderate to severe [12].

Heavy workloads can trigger the occurrence of *heat stress*. When a person is in a workplace, his/her body will interact with ambient temperature, humidity, and air flow. The body metabolic processes that interact with heat in workplace environments will cause the workers experience *heat press* [1].

*Heat press* in workers is influenced by the heat produced by the workers themselves and that from work climate, which is occurring as a combination of ambient temperature, air humidity, speed of air movement and radiant heat and workload as well [13]. According to Hughes and Ferret, human body is very sensitive to external temperature changes. Normal body temperature is around 37°C and the body will maintain body normal temperature at that level if there are temperature changes from outside [14]. The heat stress can cause workers dehydrated due to a lack of fluids due from excessive sweating during work. Long exposure to heat will disturb body's balance system so the body produces more sweats as a compensatory mechanism [15].

At high temperatures, the body will have difficulty to maintain the core body temperature resulting in excessive sweating. Therefore, body needs more fluids and electrolytes excreted by sweating [14]. If fluids are not replaced by drinking, excessive perspiration will remove fluids from tissues and body cells, affecting the incidence of dehydration. According to Richard *et al.*, fluid loss through sweats up to 1.4% of body weight can still be tolerated without serious problems. However, if fluid loss reaches 3-6% of body weight, body productivity will be affected [16].

The level of dehydration was analysed from urine color and specific gravity. Based on urine color observation, most of the workers were severely dehydrated. However, based on the urine specific gravity tests, some workers were moderately dehydrated. According to Binkley *et al.*, clarity, color, and specific gravity of urine can be used as clinical indicators to determine dehydration status. When the body is dehydrated, the urine specific gravity will be higher than 1.010, and the color of urine will look darker and more concentrated [17].

According to Guyton & Hall, concentrated urine is formed by kidneys to maintain homeostasis of body fluids. As kidneys increase the reabsorption of water, the volume of urine is decreased. Water reabsorption occurs due to elevated levels of Hormone Anti Diuretic (ADH). The elevated ADH levels cause collective tubules

highly permeable to water, causing large amounts of water is reabsorbed [18]. The urine concentration is also influenced by decreased glomerular filtration rate (GFR). The decrease in LFG causes a decrease in the volume of fluid that plays a role in the countercurrent mechanism, so that the velocity of fluid through loop of Henle is inhibited and urine becomes more concentrated [19].

Severe dehydration will disrupt physical and mental performances and induce potential risks to health, especially during or after doing activities in a extreme heat climate. Dehydration effects will occur when working at high ambient temperatures [20]. Workers who work in heat-exposed environments and have not adapted to the work environment will be more susceptible to dehydration than those who have adapted to.<sup>17</sup> In addition to dehydration, *heat stress* can also accelerate the occurrence of fatigue in workers. According Tarwaka, one of the causes of work fatigue is work activity. Work activity creates workload as a result of doing the activity [21].

The results of work fatigue level measurements in this study showed that most workers working in heat-exposed environments developed mild fatigue. This was probably because the workers had been adapting to these environments. The people who work in heat-exposed environments tend to feel tired, and the symptoms of fatigue will increase in line with the elevated exposure of heat [22]. Fatigue is a body protective mechanism to prevent body from further damages. The recovery process will take place after taking a rest for quite sometimes. Fatigue causes less efficiency and decreased work capacity and endurance [21]. According to Kjellstrom *et al.*, the main factor that causes various health problems in people working in heat-exposed environments is dehydration. Excessive dehydration will increase fatigue and causes various diseases especially renal failure. In addition, *heat stress* can also trigger psychological and physical disorders such as depression, nervousness, emotional inadequacies, electrolyte disorders, cardiovascular diseases, and some changes in blood flow. The combination of these psychological and physical disorders will result in lower work capacity and work skills, fatigueness, and lack of concentration that can contribute high impacts on the increase of work errors [15].

## V. CONCLUSION

Heat exposure to workplace can cause some changes in dehydration index and result in mild fatigue. Doing regular medical check-ups and maintaining body fluids balance should be performed by those working in heat-exposed environments.

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