ORIGINAL ARTICLE

The Relationship Between Nutritional Status and Drinking Water Consumption With Dehydration Among Workers in the Production Unit of an Animal Feed Company in East Java, Indonesia

Zulfatul Kharimah[1], Noeroel Widajati[1,2], Indriati Paskarini[1,2], Alvin Ubaid Khoiri[2]

[1] Master of Occupational Health and Safety, Faculty of Public Health, Universitas Airlangga, Surabaya, East Java, 60115 Indonesia
[2] Department of Occupational Health and Safety, Faculty of Public Health, Universitas Airlangga, Surabaya, East Java, 60115 Indonesia

ABSTRACT

Introduction: Dehydration is a common occupational health risk among industrial workers, particularly those exposed to hot working environments. If not adequately managed, dehydration may impair physical and cognitive performance and increase the risk of work-related accidents and occupational diseases. Adequate drinking water intake is therefore essential for preventing dehydration among workers. This study aims to analyze the association and strength of the relationship between Body Mass Index (BMI) and water consumption with the incidence of dehydration in the production unit of an animal feed company in East Java, Indonesia. **Methods:** This analytical observational study employed a cross-sectional design and involved all 66 workers in the production unit. BMI was calculated based on measured body weight and height. Drinking water consumption was assessed using the Beverage Intake Questionnaire (BEVQ-15), while dehydration status was determined using the urine color scale developed by Armstrong. Data were analyzed using Spearman's rank correlation and contingency coefficient tests to assess the strength of associations between variables. **Results:** Most workers had a normal BMI (48.5%), insufficient drinking water consumption (62.1%), and experienced severe dehydration (40.9%). BMI showed a very weak and non-significant association with dehydration status. In contrast, drinking water consumption demonstrated a statistically significant moderate association with dehydration. **Conclusion:** Drinking water consumption plays a more influential role than BMI in determining dehydration status among workers exposed to hot working environments. These findings emphasize the importance of promoting adequate hydration behavior and ensuring sufficient access to drinking water as key strategies for preventing dehydration in industrial settings.
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Corresponding Author:
Dr. Noeroel Widajati, S.KM., M.Sc.
Email: noeroel.widajati@fkm.unair.ac.id
Tel: +6281554170023
Fax: +6281554170023

INTRODUCTION

Every workplace has potential hazards and risks that may affect workers' safety and health. Occupational hazards are commonly classified into physical, biological, chemical, ergonomic, and psychosocial hazards. hysical hazards, including extreme environmental conditions such as hot work climate, pose a significant threat to workers' health and safety [1]. If these hazards are not properly managed, they may lead to occupational accidents or work-related diseases. According to data from the Employment Social Security Agency of Indonesia (Badan Penyelenggara Jaminan Sosial Ketenagakerjaan, BPJS Ketenagakerjaan) in 2022, there were 234,370 reported cases of occupational accidents and work-related diseases in Indonesia, including heat stress, fatigue-related injuries, and dehydration-related kidney disorders. [2].

One of the most common physical hazards in industrial environments is a hot working climate. High workplace temperatures are often generated by production processes that require heat-intensive machinery [3]. This condition is further aggravated by global climate change. East Java has experienced one of the highest temperature increases in Indonesia, reaching approximately 35 °C. Exposure to a hot working climate significantly increases the risk of dehydration among workers [4, 5]. Hot working climates exceeding threshold values may impair physical and cognitive performance and induce excessive sweating, leading to fluid loss and an increased risk of dehydration, fatigue, and occupational safety problems [6, 7].

Dehydration occurs when fluid loss exceeds fluid intake. Even mild dehydration, defined as a 1-2% loss of body fluids, can impair concentration, cognitive function, and physical performance [8]. In addition, if dehydration is not promptly addressed, it may lead to more severe health consequences, including kidney disorders and an increased risk of occupational accidents [9]. Furthermore, research by Lestari and Widajati demonstrated a strong association between dehydration and work fatigue [10]. These findings indicate that even mild dehydration can reduce performance, increase fatigue, and impair cognitive functions such as concentration and alertness in physically active workers.

Adequate drinking water intake is therefore essential as a protective factor against dehydration, especially for workers in hot environments. Water constitutes approximately 60% of adult body mass and plays a crucial role in maintaining thermoregulation and physiological balance [11]. Workers exposed to heat are recommended to consume at least 2.8 liters of drinking water per day, equivalent to approximately 11 glasses of 250 ml [12]. Insufficient drinking water consumption significantly increases the risk of dehydration. Previous research by Lestari et al. found a significant relationship between drinking water consumption and dehydration in workers. In this study, workers with low drinking water consumption were at high risk of experiencing moderate to severe dehydration among tofu factory workers in Jambi City [13]. However, adequate hydration is not solely determined by water availability, as workers' knowledge and awareness of occupational hazards have been shown to influence health-related behaviors, underscoring the importance of education in preventing heat-related problems such as dehydration[14].

In addition to environmental heat exposure, individual factors such as Body Mass Index (BMI) may influence dehydration risk. Individuals with higher BMI tend to have a lower proportion of total body water relative to body mass, which may affect a person's fluid intake and increase susceptibility to dehydration. A person with an obese BMI will have an increased risk of dehydration due to lower fluid levels compared to a person with a normal BMI [13].

A feed manufacturing company in East Java, Indonesia operates within the agrifood sector and utilizes various heat-generating production processes, including grinding, mixing, and pelleting. These processes create hot working environments in several production areas. Based on previous measurements conducted at the same workplace by Ramadhania, several work areas in the production unit of animal feed manufacturing company in East Java, Indonesia were found to have a hot working climate exceeding the threshold value (Nilai Ambang Batas, NAB). These areas included the premix area, hand add section, and first floor dosing area. In areas with predominantly moderate workloads, the measured Wet Bulb Globe Temperature (WBGT) values exceeded the NAB of 28°C, which is the permissible limit for the moderate workload category [15]. Such conditions place production unit workers at increased risk of dehydration due to excessive heat load and fluid loss.

A preliminary study among production unit workers revealed that 68% of respondents experienced moderate dehydration symptoms, including persistent thirst during work, frequent sensations of heat, throat dryness, and increased sleepiness while working. These findings suggest that dehydration remains a prevalent occupational health issue among production workers exposed to hot working environments.

However, limited studies in Indonesia have simultaneously examined the relationship between BMI and drinking water consumption with the incidence of dehydration among industrial workers, particularly in high-temperature production settings. Therefore, this study aims to analyze the association and strength of the relationship between BMI and drinking water consumption with the incidence of dehydration among production unit workers in an animal feed company in East Java, Indonesia.

MATERIALS AND METHODS

This study employed a quantitative analytical observational design with a cross-sectional approach, in which all variables were measured at a single point in time. The study population comprised all workers in the production unit of an animal feed manufacturing plant. A total population sampling technique was applied, resulting in the inclusion of all 66 production workers as study participants. Data collection was conducted between October 2023 and April 2024.

Independent variables included age, working hours, BMI, and drinking water consumption. Age was categorized according to the classification issued by the Ministry of National Development Planning of Indonesia (Badan Perencanaan Pembangunan Nasional/Bappenas) into young age (15–24 years), early working age (25–34 years), middle age (35–44 years), and pre-retirement age (45–54 years) [16]. Working hours were classified based on the Regulation of the Minister of Manpower of Indonesia No. 5 of 2018 into ≤8 hours and >8 hours per day [17].

BMI was calculated as body weight in kilograms divided by height in meters squared (kg/m^2). BMI categories followed the Regulation of the Minister of Health of the Republic of Indonesia No. 41 of 2014 [18] and were defined as severely underweight (BMI <17.0 kg/m^2), underweight (BMI 17.0–<18.5 kg/m²), normal (BMI 18.5–24.9 kg/m²), overweight (BMI 25.0–27.0 kg/m²), and obese (BMI >27.0 kg/m²).

Drinking water consumption was assessed using the Beverage Intake Questionnaire (BEVQ-15) and categorized as sufficient (≥2.8 liters/day) or insufficient (<2.8 liters/day). A fixed cut-off value of 2.8 liters/day was applied to standardize intake classification and to facilitate comparison across participants, rather than calculating individualized fluid requirements based on body weight.

Dehydration status, as the dependent variable, was assessed by collecting urine samples from participants after completion of their work shift. Each participant was provided with a urine collection container, and urine color was evaluated by the researcher using the eight-point urine color scale developed by Armstrong [19]. Interpretation of the urine color scale is presented in **Figure 1**. Scores of 1–2 indicated euhydration, scores of 3–4 mild dehydration, scores of 5–6 moderate dehydration, and scores of 7–8 severe dehydration.

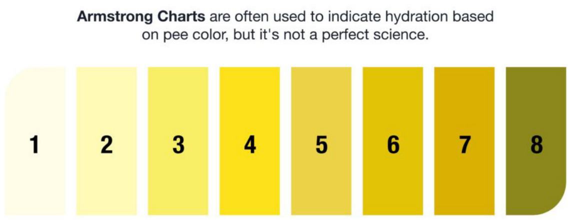

Fig. 1: Urine color scale for assessing hydration status according to Armstrong (1994). Source: TrainingPeaks (Andi Blow).

Data were analyzed using univariate and bivariate statistical methods. Univariate analysis was performed to describe the distribution of each study variable. Bivariate analysis was conducted to assess the associations between independent variables and dehydration status. For ordinal-scale variables, the strength and direction of association were evaluated using Spearman's rank correlation coefficient (r). For nominal-scale variables, associations were assessed using the contingency coefficient (C). Multivariable analysis was not performed due to the exploratory nature of the study and the relatively small sample size, which may increase the risk of model overfitting.

Ethical approval for this study was obtained from the Research Ethics Committee of the Faculty of Dental Medicine, Universitas Airlangga (No. 1391/HRECC. FODM/XII/2023)

RESULTS

Table I presents the distribution of respondents' characteristics based on age, working hours, BMI, drinking water consumption, and hydration status. Most workers were in the 35–44-year age group (45.5%) and worked ≤8 hours per day (72.7%).

Table I: Univariate Analysis Results

Variable	Frequency (n=66)	Percentage (%)
Individual Characteristic		
Age		
15-24 years	6	9.1
25-34 years	19	28.8
35-44 years	30	45.5
45-54 years	11	16.7
Working Hours		
≤ 8 hours/ day	48	72.7
> 8 hours/ day	18	27.3
Body Mass Index		
Severly Underweight	1	1.5
Underweight	5	7.6
Normal	32	48.5
Overweight	11	16.7
Obese	17	25.8
Drinking Water Consumption		
Sufficient	25	37.9
Insufficient	41	62.1
Dehydration		
Euhydration/ Normal	7	10.6
Mild	10	15.2
Moderate	22	33.3
Severe	27	40.9

The majority of workers had a normal BMI (48.5%), followed by obesity (25.8%) and overweight (16.7%), while the proportions of severly underweight and underweight workers were relatively small. In addition, most workers had drinking water intake that did not meet daily requirements (<2.8 liters), accounting for 62.1%. Regarding hydration status, most workers experienced severe dehydration (40.9%), followed by moderate dehydration (33.3%).

Table II shows the results of the analysis examining the relationships between individual characteristics, BMI, drinking water consumption, and dehydration status. Correlation analysis indicated that age had a very weak and statistically non-significant association with dehydration status ($r = -0.085$; $p = 0.497$). Similarly, working hours showed a weak and non-significant association with dehydration status (contingency coefficient = 0.223; $p = 0.327$). These findings indicate that variations in age and working hours were not meaningfully associated with dehydration status in the study population.

Furthermore, Spearman correlation analysis demonstrated a very weak and non-significant association between BMI and dehydration status ($r = 0.104$; $p = 0.407$). Nevertheless, analysis of category distributions indicated that the proportion of moderate to severe dehydration tended to be higher among workers with overweight and obese BMI compared with those with normal or underweight BMI. However,

Table II: Bivariate Analysis Results

Variable	Dehydration				Coefficient	p-value
	Normal	Mild	Moderate	Severe		
Age						
15-24 years	1 (1.5%)	2 (3%)	2 (3%)	1 (1.5%)	r = 0.085	0.497
25-34 years	1 (1.5%)	1 (1.5%)	9 (13.6%)	8 (12.1%)		
35-44 years	2 (3%)	4 (6.1%)	8 (12.1%)	16 (24.2%)		
45-54 years	3 (4.5%)	3 (4.5%)	3 (4.5%)	2 (3%)		
Working Hours						
≤ 8 hours/ day	1 (1.5%)	5 (7.6%)	5 (7.6%)	7 (10.6%)	C = 0.223	0.327
> 8 hours/ day	6 (9.1%)	5 (7.6%)	17 (25.8%)	20 (30.3%)		
Body Mass Index						
Severly Underweight	0 (0.0%)	0 (0.0%)	1 (1.5%)	0 (0.0%)	r = 0.104	0.407
Underweight	1 (1.5%)	0 (0.0%)	1 (1.5%)	3 (4.5%)		
Normal	5 (7.6%)	7 (10.6%)	8 (12.1%)	12 (18.2%)		
Overweight	0 (0.0%)	1 (1.5%)	6 (9.1%)	4 (6.1%)		
Obese	1 (1.5%)	2 (3.0%)	6 (9.1%)	8 (12.1%)		
Drinking Water Consumption						
Sufficient	5 (7.6%)	7 (10.6%)	10 (15.2%)	3 (4.5%)	C = 0.447	0.001
Insufficient	2 (3.0%)	3 (4.5%)	12 (18.2%)	24 (36.4%)		

Notes: Spearman's rank correlation test was used for ordinal variables (age and body mass index), while contingency coefficient was applied for nominal variables (working hours and drinking water consumption).

this tendency did not reflect a statistically meaningful association.

In contrast to the other variables, drinking water consumption showed a statistically significant association with dehydration status, with a moderate strength of association (contingency coefficient = 0.447; p = 0.001). Workers with insufficient drinking water intake had a higher proportion of moderate to severe dehydration compared with those whose intake met daily requirements.

DISCUSSION

Nutritional status is a condition that can indicate whether a person has normal or abnormal nutrition based on the measurement of Body Mass Index (BMI). BMI is calculated by finding body weight in kilograms, which is then divided by height in square meters (m2) [20, 21]. This study shows that most production unit workers at Animal Feed Company in East Java, Indonesia have normal BMI. However, there are still workers with BMI outside normal. The workers with the most normal BMI are bagging off workers.

Nutritional status is a factor that can affect the body's ability to respond physiologically [22]. The study found a very weak positive association between BMI and dehydration, indicating that workers with higher BMI, particularly those classified as overweight or obese, have a slightly higher risk of dehydration compared to those with normal or underweight BMI. This may be due to lower total body water relative to body mass and reduced efficiency in dissipating heat in individuals with higher BMI [4].

This study shows that BMI is not a factor that is directly related to dehydration among workers in the production unit of a Feed Company in East Java, Indonesia. Dehydration was observed not only in overweight and obese workers, but also in those with normal BMI, particularly among bagging off workers whose tasks predominantly involve heavy physical activities such as lifting and stacking sacks weighing up to 50 kilograms. Although the most of these workers have normal BMI, exposure to more dominant risk factors, such as high physical workload, can increase metabolic heat production and sweat loss, thereby elevating the risk of dehydration. Such heavy physical demands place substantial physiological stress on the body, requiring greater thermoregulatory and metabolic adaptation. Under these physically demanding conditions, BMI also may act as an indirect modifier of physiological and biomechanical strain, as higher body mass has been associated with increased mechanical loading and a weak positive correlation with musculoskeletal complaints, including low back pain, which are common in manual handling tasks [21, 23].

In line with this study, a study conducted by Nurfrida and Lestari showed a very weak relationship between nutritional status and dehydration, with a correlation coefficient value of 0.080 in workers in the bottled drinking water production department at PT. X Semarang [24]. However, this study is not in line with the study conducted by Chang et al., which showed that BMI was significantly related to dehydration [25]. The study explained that someone with an obese BMI would be at a 1.59 times higher risk of experiencing dehydration. It was further explained that someone with a higher BMI tends to have behaviors that cause them to be less hydrated. Someone with a higher BMI has a higher level of fluid intake requirements.

The study results showed that most (62.1%) of workers in the production unit of a Feed Company in East Java, Indonesia consumed less than 2.8 liters of drinking water per day. Based on the analysis, there was a moderately strong relationship between drinking water consumption and the incidence of dehydration in workers in the production unit of a Feed Company in East Java, Indonesia.

This study shows that most workers have insufficient water consumption. Most workers with insufficient drinking water consumption are at the bagging off, premix, and silodryer locations. Low drinking water consumption by workers can be caused by several factors, such as low awareness of workers regarding the importance of drinking water consumption and a lack of awareness among workers to bring drinking water bottles. The interviews with several workers in the production unit showed that they prefer to drink cold soft drinks that they can buy outside the company during breaks, because they are considered better at quenching thirst than mineral water.

The company has provided drinking water in gallon packages that have been placed in several locations such as panel operators, bagging off-1, boiler operators, and silo operators. However, there are still work locations with drinking water locations beyond the reach of workers, such as in the bagging off-2 area where drinking water is still unavailable. In this case, the distance of workers' drinking water will increase workers' dehydration risk [20]. Research conducted by Irwan and Paskarini stated that there is a significant relationship between the location of drinking water and dehydration [26]. Workers with a distance of drinking water more than 3 meters are at increased risk of dehydration. In this case, it is necessary to re-evaluate the placement of drinking water in locations such as bagging off-2 so that it is more affordable for workers. In this case, the use of drinking bottles can be one solution to overcome the lack of drinking water consumption among workers. However, the use of drinking bottles while working, in this case, must still be paid attention to in terms of the safety of workers. For high-risk workers, such as silodryer workers who have to climb to extreme heights, it is still necessary to assess safety when carrying drinking water bottles, such as a small bag/pouch equipped with a strap. In line with this study, a study conducted by Nurfrida and Lestari explained a significant relationship between drinking water consumption and dehydration in the packaging production section at PT X [24]. The study explained that the majority of respondents had insufficient fluid intake and were not comparable when compared to the fluid output, so there is the potential for dehydration. Also, many workers still ignore drinking water habits, so there is the potential for dehydration.

Insufficient drinking water consumption in this case will result in dehydration, which, if not addressed immediately, can lead to Work-Related to Accidents or Diseases. Therefore, workers' daily drinking water consumption must be considered. Workers' awareness of fluid consumption needs to be increased so that they consume fluids in small amounts but with a more frequent drinking frequency, namely one glass every 15 to 20 minutes.

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional study design limits the ability to establish causal relationships between BMI, drinking water consumption, and dehydration status among workers. Second, the statistical analysis was limited to bivariate correlation tests, which did not allow for simultaneous assessment of multiple variables or estimation of risk magnitude in the form of odds ratios, as reported in several previous studies. In addition, potential confounding variables, such as age and daily working hours, were not controlled in the analysis, which may have influenced the statistical significance of the results. Furthermore, drinking water intake adequacy was classified based on commonly used general daily fluid intake recommendations rather than individualized requirements based on body weight, which may have led to misclassification of hydration adequacy in some workers. Finally, the relatively small sample size (n = 66) may have reduced the statistical power to detect more complex associations, particularly for multivariate analyses.

Despite these limitations, this study also has notable strengths. The use of a total population approach involving all workers in the production unit enabled the findings to reflect actual working conditions without selection bias. Dehydration status was assessed objectively using a standardized urine color scale, providing an accurate representation of workers' hydration status after work and minimizing subjective bias. Moreover, the study was conducted in a work environment characterized by high heat exposure and substantial physical workload, thereby enhancing the practical relevance of the findings within the context of occupational health and safety.

Overall, the findings of this study indicate that drinking water consumption plays a more prominent role in determining dehydration status compared to individual characteristics such as BMI, age, and working hours. Therefore, dehydration prevention efforts in the workplace should prioritize improving access to and availability of drinking water, as well as strengthening education on appropriate hydration practices, particularly in work areas with high physical demands and heat exposure. These findings may serve as preliminary evidence to support the development of promotive and preventive occupational health programs, including the integration of workplace hydration issues into occupational safety and health initiatives, with the ultimate goal of supporting worker health and productivity.

CONCLUSION

Based on this study, it can be concluded that most workers had a normal BMI, insufficient drinking water intake, and experienced severe dehydration. BMI showed a very weak association with dehydration, whereas drinking water intake demonstrated a statistically significant moderate association with hydration status. These findings highlight that hydration-related behaviors play a more dominant role than individual characteristics in determining workers' dehydration status in hot working environments. Therefore, improving access to drinking water and strengthening behavior-based promotive interventions and occupational safety and health education are essential strategies for preventing dehydration among production unit workers.

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