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THE RELATIONSHIP BETWEEN FLUID INTAKE AND HEAT SRESS WITH THE HYDRATION STATUS OF WORKERS: A SCOOPING REVIEW

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ABSTRACT
The importance of adequate water consumption as a key factor in preventing dehydration in workers is a crucial aspect in the work environment. The body, which loses fluids through sweat, urine, and respiration, needs adequate fluid replacement to prevent dehydration. Heat stress can accelerate the dehydration process, where the body responds by producing sweat to regulate body temperature. Objective: The aim of this study is to investigate the relationship between fluid intake, heat stress, and the hydration status of workers. Method: The method used in this article review is PRISMA-ScR. The publication language is English. The search was conducted through several scientific journal databases, including Scopus, Science Direct, PubMed, SpringerLink, EBSCO Host, and ProQuest, covering the period from 2013 to 2023. The process of selecting evidence sources in the initial identification yielded 21,403 articles, then through a selection process based on eligibility, topic relevance, and final assessment, eight evidence sources were selected through five stages of selection. Eligible and selected data sources are presented in a charting table. Results: The findings of this scoping review reveal that there is a connection between fluid intake, heat stress, and the hydration status of workers. The article highlights a strong correlation between fluid intake, heat stress, and hydration status in workers, emphasizing the importance of maintaining hydration balance. Conclusions: The findings suggest that while fluid intake is crucial, heat exposure can elevate the risk of dehydration, especially in hot indoor or outdoor environments.

Keywords: fluid intake; heat stress; hydration; workers

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INTRODUCTION

In the modern industrial era, workers face challenges in the work environment that require optimal physical performance. One crucial health factor to consider is the hydration level of workers, as some may start working in inadequate hydration conditions, leading to an increased risk of dehydration during work (Bethel et al., 2017; Kavouras, 2019). Hydration is a state in which the human body achieves a balance crucial for cell metabolism (Kenefick & Sawka, 2007). Conversely, dehydration refers to a situation where the body loses a significant amount of water, surpassing the intake, disrupting this balance (Kavouras, 2019).

Dehydration is a serious problem often overlooked or underestimated, but awareness of its potentially fatal consequences should be taken seriously. Dehydration, characterized by a weight loss of around 2% or a urine specific gravity (USG) level of 1.020 or higher, often

occurs in workplaces filled with manual tasks, intense physical activities, and high environmental temperatures (Brearley et al., 2015; García-Trabanino et al., 2015; Piil et al., 2018). Such work can result in significant fluid loss through sweating, increasing the risk of dehydration (García-Trabanino et al., 2015).

The National Institutes of Occupational Safety and Health (NIOSH) recommend that companies support their employees in staying hydrated by encouraging them to drink at least one glass of water every 15 to 20 minutes while working in hot environments (Jacklitsch et al., 2016). Adequate water consumption is a key factor in preventing dehydration in workers. When the body loses fluids through sweat, urine, and respiration, and these fluids are not adequately replaced, dehydration can occur. Heat stress can also accelerate dehydration in workers. When the body is exposed to high environmental temperatures, it produces sweat to help lower body temperature. Previous research indicates that adequate fluid intake can help maintain body hydration balance and prevent dehydration (Pryor et al., 2023).

Most outdoor deaths, around 50% to 70%, occur in the first few days of working in warm or hot environments as the body needs to gradually build heat tolerance over time (Heat - Overview: Working in Outdoor and Indoor Heat Environments | Occupational Safety and Health Administration, n.d.). This process is called heat acclimatization, and the lack of acclimatization is a major risk factor for fatal outcomes. The American Conference of Governmental Industrial Hygienists (ACGIH) has set Threshold Limit Values (TLV) for core body temperature at 38 °C to prevent heat stress in the working population, with the goal of keeping core body temperature within +1 °C of 37 °C(American Conference of Governmental Hygienists (ACGIH), 2017). Heat exposure can have various adverse health effects, including damage to major organs and even death if core body temperature exceeds 42 °C(Gao et al., 2018; Kjellstrom et al., 2016).

Research findings state that 58% of miners experience dehydration(Polkinghorne et al., 2013). Similar findings are also found in studies involving sugarcane, construction, and agricultural workers in Nicaragua, where morning urine specific gravity is equal to or greater than 1.030, with percentages around 15.3%, 28.6%, and 20.4%, respectively (Wesseling et al., 2016). Sometimes, workers' perceptions of hydration adequacy may not always align with the actual situation. For example, in Nicaraguan sugar plantations, highly motivated agricultural workers may lose three to four liters of body water before feeling extreme thirst (Cortez, 2009). Studies in mining environments also show that workers may not get enough fluids at night after work or in the morning before work, increasing the risk of dehydration during working hours(Wesseling et al., 2016).

Dehydration, influenced by inadequate fluid intake and exposure to heat stress, can have serious impacts on the well-being and productivity of workers. Therefore, this article aims to conduct a comprehensive review or scoping review to explore possible relationships between fluid consumption, heat stress, and the level of dehydration in workers. By detailing relevant literature, we can better understand how these factors interrelate, providing a solid foundation of understanding and identifying knowledge gaps that need to be addressed in further research. It is hoped that this research can make a positive contribution to the context of preventing dehydration in the workplace, offering valuable guidance to companies and relevant institutions in improving the health and well-being of workers.

METHOD

The method used in this review article is PRISMA-ScR (Tricco et al., 2018). This study conducted a literature search strategically with eligibility criteria not limited to any geographical region and encompassing international and national journals. The language of publication is English. The search was performed through several scientific journal databases, including Scopus, Science Direct, PubMed, SpringerLink, EBSCO Host, and ProQuest. The types of publications included in this study are original articles from 2013 to 2023. The keywords used for literature search in this review include water intake, body water, water consumption, drinking water, dehydration, hydration, heat stress, heat, heat stress exposure, workers, and workplace. The total initial database search results were 21,403. In the first stage, articles with subjects other than humans and duplicate articles were excluded, resulting in 7,365 articles remaining. In the second stage, after screening the titles, 222 articles remained. In this stage, the author filtered the articles based on titles and excluded those that did not present data on fluid intake, heat stress, and hydration status in workers. In the third stage, articles were further excluded based on the mismatch of information in the abstract and the focus of the research, leaving 169 articles. In the fourth stage, articles that were not free access or did not have full text were excluded, resulting in 48 articles. The fifth stage involved the exclusion of articles that did not meet the criteria upon full-text assessment, resulting in a final selection of 8 articles.

To avoid bias, each relevant article is read by all authors to ensure its relevance to the research, and data charting is conducted independently by team members. After confirmation, data from the completed articles are extracted using the charting table, and the charting table template can be seen in Table 1 below. This table contains the methods used in the articles and the research subjects relevant to the topic. Additionally, the table explains the relationship between fluid intake and dehydration levels and the relationship between heat stress and dehydration levels. After all data in the charting table is reviewed by all team members, any differences are collectively corrected, and in the final stage, all team members agree on the final version of the charting table before proceeding with the analysis.

RESULTS

The results of literature studies on the relationship between fluid intake, heat stress, and hydration status in workers are presented in Table 1. The data in Table 1 describe the correlation between fluid intake, heat stress, and hydration status in workers across various professions, with the majority of them engaged in outdoor activities. Good hydration status is a crucial factor supporting optimal body function and active participation. On the other hand, poor hydration or dehydration can lead to various changes in physiological functions, such as decreased concentration, cognitive ability, and an increased risk of urinary tract infections, kidney stones, ischemia, and kidney failure. Dehydration is a factor that can affect the health, productivity, and safety of workers in their tasks. Various factors contribute to dehydration, including individual factors such as knowledge, pregnancy, underlying illnesses, and medication consumption. Occupational factors include clothing usage, personal protective equipment, availability of drinking water, and toilet facilities. Environmental factors, such as high workplace temperatures, also play a role.

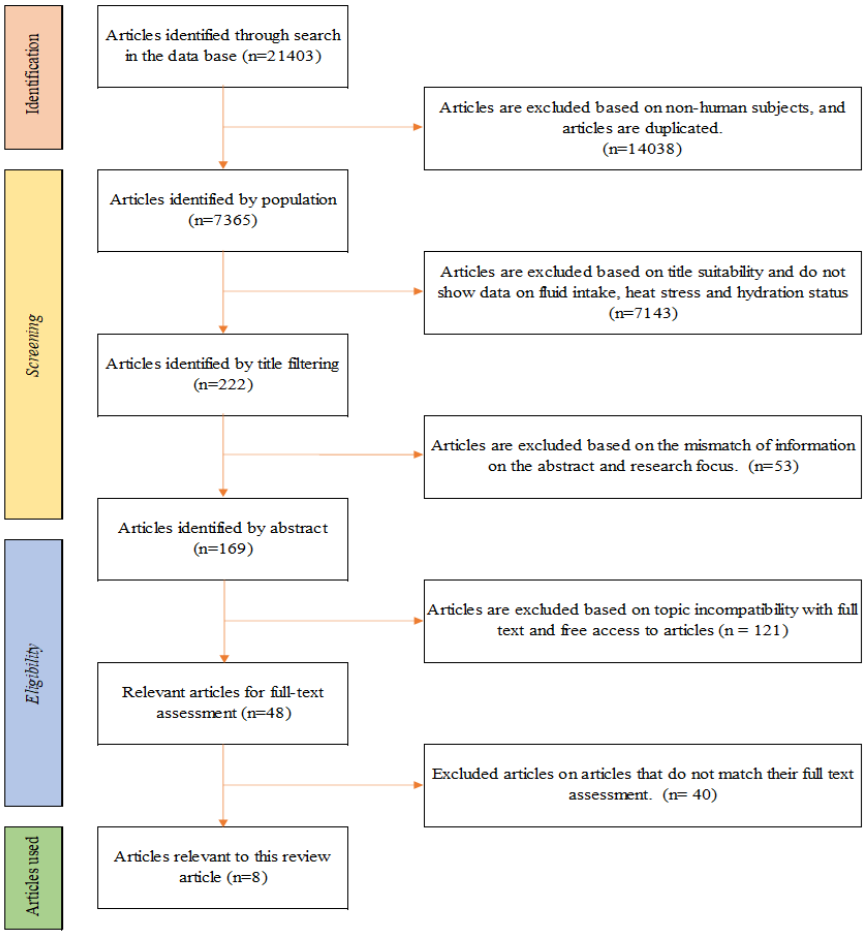

Figure 1. Flow Diagram for Selecting Articles

Relationship between Fluid Intake and Hydration Status

Five articles indicate a relationship between fluid intake and hydration status in workers. From the findings of these reviewed articles, it can be concluded that there is a close connection between fluid intake and dehydration status in workers. Farmers working outdoors, exposed to a hot working environment, have the opportunity to drink water but still experience dehydration due to limited accessibility and quality of water in their workplace. Despite high average fluid intake, dehydration incidents still occur frequently, emphasizing the need to consider other factors such as adequate water availability and quality. Other findings highlight that fluid intake significantly influences hydration status, as reflected in the decrease in urine specific gravity and osmolality with increased fluid intake. This confirms that increasing fluid intake can play a role in maintaining optimal hydration in workers. Among sugarcane cutters, low fluid intake is identified as a primary cause of recurring dehydration. There is also a correlation between low fluid intake and the tendency for concentrated urine, indicating that monitoring and increasing fluid intake can be an effective strategy to prevent dehydration in this worker group.

Relationship between Heat Stress and Hydration Status

Four articles show a relationship between heat stress and hydration status in workers. Hot and humid environmental factors contribute to repeated dehydration in workers. The results of one of these four articles indicate that in a working environment with a temperature reaching 42.3°C, out of 30 respondents, 28 experienced dehydration. Another study states that construction workers, especially those working outdoors, tend to experience significant dehydration levels during work in hot environments. High concentrations of urine specific gravity indicate that workers generally start and finish their shifts in a dehydrated state (USG ≥1.020).

Table 1.
Charting Table

Refe**rence**	Location	Population	Objective	Methodology	Result
Al-Bouwarthan, M., Quinn, M. M., Kriebel, D., & Wegman, D. H. (2020). A field evaluation of construction workers' activity, hydration status, and heat strain in the extreme summer heat of Saudi Arabia. Annals of Work Exposures and Health, 64(5), 522-535(Al-Bouwarthan et al., 2020).	Saudi Arabia	65 construction workers	This study aims to provide a comprehensive understanding of how summer heat exposure impacts residential construction workers in Al-Ahsa, Saudi Arabia.	Cohort	Construction workers, especially outdoors, tend to experience significant levels of dehydration while working in hot environments. High concentrations of ultrasound indicate that workers generally start and end their shifts dehydrated (ultrasound ≥1,020).
Mizelle, E., Larson, K. L., Bolin, L. P., & Kearney, G. D. (2022). Fluid Intake and Hydration Status Among North Carolina Farmworkers: A Mixed Methods Study. Workplace Health & Safety, 70(12), 532-541(Mizelle et al., 2022).	North Carolina	28 Farm laborers	The aim of this research is to explore how socio-cultural and occupational factors, as well as the environment Heat stress affects fluid intake and hydration status among agricultural workers	A community-informed, mixed methods	Before work, 46.7% of agricultural workers were dehydrated, which increased to 100% after work due to heat exposure
Orysiak, J., Młynarczyk, M., & Tomaszewski, P. (2023). Fluid intake at work in foresters working in different thermal conditions. Scientific Reports, 13(1), 15870(Orysiak et al., 2023).	Poland	59 male forest supervisors	Assess the impact of fluid intake on hydration status indices	Cross sectional	Fluid intake influences the urinary hydration index, with urine specific gravity and osmolality decreasing as fluid intake increases
García-Trabanino, R., Jarquín, E., Wesseling, C., Johnson, R. J., González-Quiroz, M., Weiss, I., ... & Barregard, L. (2015). Heat stress, dehydration, and kidney function in	El Salvador	Sugar cane cutters (N=189, aged 18–49 years, 168 of them male)	To assess heat stress, dehydration, kidney function biomarkers and their possible relationships	Cross sectional	Hot and humid environmental factors as well as low fluid intake in sugar cane cutting workers cause workers to experience repeated dehydration

sugarcane cutters in El Salvador–a cross-shift study of workers at risk of Mesoamerican nephropathy. Environmental research, 142, 746-755(García-Trabanino et al., 2015).					
Wesseling, Catharina, et al. (2016). Heat stress, hydration and uric acid: a cross-sectional study in workers of three occupations in a hotspot of Mesoamerican nephropathy in Nicaragua. BMJ open, 6(12).(Wesseling et al., 2016)	Nicaragua	194 male workers aged 17–39 years: 86 sugar cane cutters, 56 construction workers, 52 small-scale farmers	To study Mesoamerican nephropathy (MeN) and its risk factors in three pekerjaan panas.	Cross sectional	Low fluid intake is associated with concentrated urine in sugar cane cutting workers (USG ≥1.030: OR 3.5, p=0.06)
Jayasekara, K. B., et al. (2019). Relevance of heat stress and dehydration to chronic kidney disease (CKDu) in Sri Lanka. Preventive medicine reports, 15, 100928 (Jayasekara et al., 2019).	Sri Lanka	261 farmers in 4 villages	The aim of this study was to determine whether heat stress and dehydration are risk factors for Chronic Kidney Disease	Cross sectional	There is a link between heat stress and dehydration. There is also a link between lower daily water consumption and dehydration.
Siddiq, N., & Cahya, M. (2020). The Relationship between Heat Stress and Dehydration in the Continous Casting Machine Section of Pt X. Indian Journal of Forensic Medicine & Toxicology, 14(2)(Nur Siddiq & Mulyono, 2020).	Indonesia	30 workers working in CCM (Continuous Casting Machine)	The aim of this research is to find correlation between heat stress and dehydration in the CCM (Continuous Casting Machine) PT	Cross sectional	Significant relationship between work climate and dehydration ($p = 0.045 < \alpha$).

DISCUSSION

This scoping review aims to explore recent literature regarding the relationship between fluid intake, heat stress, and dehydration status in workers, especially those exposed to heat either indoors or outdoors. Based on the review of eight articles, it is indicated that there is a relationship between fluid intake, heat stress, and dehydration status. Fluid intake is a direct

factor in determining hydration status(Suma'mur, 2009). Consuming water before, during, and after work is crucial. The recommended daily water intake for adults is 2 liters or equivalent to 8 glasses per day(Permenkes, 2014). In hot working environments, it is recommended to consume ≥ 2.8 liters/day, while for non-hot environments, at least 1.9 liters/day is advised(Direktorat Kesehatan Kerja RI, 2014). Drinking water is recommended at least 1 glass or 8 ounces (240 ml) every 20 minutes with the optimum water temperature being 10°C-21°C for workers in a hot working environment(National Institute for Occupational Safety and Health, 2016).

The habit of drinking only when thirsty is detrimental because the thirst mechanism may not compel workers to drink enough to replace the water lost through sweating, leading to dehydration. Workers in hot environments will lose fluids through excessive sweating, and if this fluid loss is not balanced by sufficient intake, dehydration may occur. It's essential for workers to maintain adequate fluid intake, even when not feeling thirsty, to prevent dehydration and maintain optimal performance and health, especially in environments with high heat exposure.Various methods can be used to evaluate the adequacy of water in the human body, including changes in body mass, total body water changes, thirst sensation, plasma/serum osmolality, urine osmolality, urine color, and urine specific gravity (USG)(Lacey et al., 2019; Liska et al., 2019; McCubbin et al., 2020; Sutarto et al., 2022). The method of measuring urine specific gravity, using a refractometer on urine samples, proves to be suitable for evaluating hydration status due to its sensitivity to both acute and chronic hydration changes. Urine specific gravity categories include euhydrated if USG <1.015, mild dehydration if USG 1.016-1.02, moderate dehydration if USG 1.021-1.030, and severe dehydration if USG >1.030(Brake & Bates, 2003; Crowe et al., 2022; Pryor et al., 2023).

Heat stress is a combination of environmental heat, metabolic heat, and clothing(Jacklitsch et al., 2016; Wagoner et al., 2020). The body's exposure to heat increases body temperature, prompting the hypothalamus to release heat by vasodilating skin blood vessels, resulting in excessive sweating to dissipate heat. Excessive fluid loss without adequate fluid intake can lead to dehydration(Santoso et al., 2011),(Pranata, 2013). This aligns with a study in Thailand on salt farmers, showing that 50% of farmers experienced dehydration due to heat exposure, with the Wet-Bulb Globe Temperature (WBGT) averaging 33.83°C(Luangwilai et al., 2021). Hot temperatures in the workplace can have negative effects on workers' performance and health. Exposure to high temperatures can impair agility, slow reaction times, reduce the accuracy of cognitive tasks, disrupt sensorimotor coordination, and even trigger emotional reactions. This can result in decreased productivity, increased risk of workplace accidents, and even serious health problems. Extreme working conditions, especially in hot environments, can jeopardize workers' safety and health. Therefore, it is important for companies or business owners to take preventive measures to minimize potential hazards in the workplace. One solution to consider is adjusting work hours, especially during hot weather. Additionally, it is important to implement protective measures such as providing adequate drinking water, cool rest areas, and sufficient ventilation)(Nur Siddiq & Mulyono, 2020).

CONCLUSION

The results and discussion in this article clearly outline the significant correlation between fluid intake, heat stress, and hydration status in workers, particularly in environments exposed to heat, whether indoors or outdoors. The findings indicate that fluid intake is a key factor in maintaining hydration balance, but heat exposure can increase the risk of dehydration.

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