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Relationship between Physical Workload and Thermal Work Environment with Dehydration in Laundry Operators

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ABSTRACT

The production process at PT. K, a garment company in Malang, relies on manual equipment and human labor, exposing workers to physical strain and heat. Prolonged exposure to high temperatures can impair performance, accelerate fatigue, and increase the risk of dehydration. However, research on hydration status among laundry workers in the garment industry remains limited. This study aimed to examine the relationship between physical workload and the thermal work environment with hydration status among laundry workers at PT. K. This analytical cross-sectional study applied a total sampling method with 31 respondents. Data were analyzed using Spearman's rank correlation test. Results showed no significant correlation between physical workload and hydration status ($r = 0.302$, $p = 0.099$), while a significant positive correlation was found between the thermal work environment and hydration status ($r = 0.562$, $p = 0.001$). In conclusion, thermal conditions were strongly associated with dehydration, whereas physical workload showed no significant relationship.

INTRODUCTION

Laundry operators are a high-risk group exposed to heavy physical workloads and unideal working conditions, such as high temperatures, high humidity, and inadequate ventilation systems. These conditions can increase the likelihood of health issues, including dehydration, which can lead to reduced productivity, excessive fatigue, and impaired organ function (Zulkarnain et al., 2020). Persistent dehydration can cause health problems and even lead to occupational diseases. Dehydration in workers can be triggered by a combination of strenuous physical activity, exposure to high temperatures in the work environment, and inadequate fluid intake during working hours. Additionally, global climate change, which has led to rising environmental temperatures, exacerbates the risk of dehydration, particularly among informal sector workers such as laundry operators (Ioannou et al., 2022).

Previous analyses have shown that high physical workload and exposure to hot working environments can significantly increase the risk of fatigue, decreased work capacity, and the emergence of health problems, including kidney disease caused by chronic dehydration

(Venugopal et al., 2020). Meta-analyses and systematic reviews have found that exposure to workplace heat increases core body temperature, heart rate, and urine specific gravity, which serve as indicators of dehydration (Ioannou et al., 2022). Analyses in various industrial sectors, including laundry, reveal a high prevalence of dehydration among workers, which has an impact on decreased cognitive and motor performance, as well as an increased risk of work-related injuries (Zulkarnain et al., 2020). In addition, physical environmental factors such as temperature, humidity, and ventilation, as well as fluid intake behaviour, play a significant role in determining workers' hydration status (Hakim & Sulistyorini, 2021). However, most studies still focus on the agricultural, construction, and manufacturing sectors, while specific studies on laundry operators are still limited.

PT. K is a garment company with various production stages in jeans manufacturing, including the washing process. The washing work area consists of three main sections: washing, packaging, and quality control (QC). In the washing area, industrial washing machines use hot water generated by a steam heating unit (boiler) in the washing process. The next stage is the oven or curing (smoking) process, which serves as a drying process. These activities expose workers to heat from the oven and curing machines, with an average temperature of around 70°C, increasing the risk of dehydration among laundry operators due to the high ambient temperature. Based on qualitative data obtained from five laundry operators, it was found that some of them experienced symptoms indicative of dehydration, including dry lips, headaches, difficulty concentrating, increased fluid intake needs, and fatigue. Additionally, the workers' urine appeared yellowish, which is one indicator of dehydration. This study aims to examine the relationship between physical workload and thermal work environment with hydration status among laundry operators.

METHODS

This study employed a cross-sectional design, which allowed for the simultaneous collection of independent and dependent variables at a single observation point. Dehydration status was set as the dependent variable, while the independent variables included physical workload and work climate conditions. The target population comprised all 59 laundry operators at PT. K, all of whom were male. The sampling technique used was total sampling, based on predefined inclusion and exclusion criteria. A total of 31 individuals met the requirements to be included as respondents. Data collection was conducted at the laundry unit of PT. K from January 15 to 20, 2020.

Physical workload was assessed by measuring workers' heart rate during work using a Fingertip Pulse Oximeter (General Care LV-80 SPO2). The workload was categorized according to Iriastadi & Yassierli (2021) and further evaluated using Heart Rate Range (HRR) relative to individual maximal heart rate (Tarwaka, 2019). Work climate conditions were measured using a thermo-hygrometer (C.A. 846) to record air temperature and humidity, and evaluated based on Wet Bulb Globe Temperature (WBGT) in accordance with Permenkes RI No. 70/2016. Dehydration status was assessed via mid-stream urine color using an 8-scale urine color chart (1 = clear to 8 = dark brown), following Armstrong et al. (2005) and WHO (2010), where darker urine indicates higher levels of dehydration. All collected data were then processed using

statistical software for further analysis. Data analysis was conducted in two stages: univariate analysis to describe the distribution of each variable, and bivariate analysis to examine the relationship between independent and dependent variables. The Spearman Rank correlation test was used in bivariate analysis.

RESULTS

Referring to the results of the univariate analysis presented in Table 1, it is evident that the majority of participants in the study fell into the adolescent (38.7%) and late adolescent (35.5%) age categories. In comparison, the remaining individuals were distributed across the early adult (16.1%) and late adult (9.7%) groups. There were no respondents in the early elderly category. The majority of study participants (87.1%) had ≤5 years of work experience, while the rest (12.9%) had 6–10 years of work experience. No participants in this study had more than a decade of work experience.

Table 1. Univariate Analysis

Variable	n	%
Age (WHO)		
10–19 (Adolescents)	12	38,7
20–24 (Young adults)	11	35,5
25–59 (Adult)	8	25,8
≥60 (Elderly)	0	0,0
Working Period		
≤5 years	27	87,1
6-10 years	4	12,9
>10 years	0	0,0
Physical Workload		
≤30% (Light)	18	58,1
31-60% (Moderate)	13	41,9
61-80% (Heavy)	0	0,0
81-100% (Very Heavy)	0	0,0
>100% (Very severe)	0	0,0
Thermal Work Environment		
Temperature <18^{0}C and humidity >95% (Cold)	0	0,0
Temperature 18^{0}C-30^{0}C and humidity 65%-95% (Moderate)	5	16,1
Temperature >30^{0}C and humidity <65% (Hot)	26	83,9
Dehydration status		
Not dehydration	11	35,5
Dehydrated	18	58,0
Severe Dehydration	2	6,5

Source: Primary Data, 2020

Based on physical workload, the majority of participants had a light workload (58.1%), while the rest had a moderate workload (41.9%). There were no participants with heavy, very heavy, or hefty workloads. In terms of physical working conditions, the majority of participants (83.9%) worked in hot environments, while the remaining 16.1% worked in moderate temperature environments. None of the participants worked in cold environments. The dehydration status of the participants showed that most of them were dehydrated (58.0%), while 35.5% were not dehydrated, and the remaining 6.5% were severely dehydrated (Table 1).

Table 2. Relationship between Physical Workload and Dehydration Status of Laundry Operators

Independent Variable	Dependent Variable	Correlation Coefficient (r)	Significant Value (p)
Physical Workload	Dehydration Status	0.302	0.099

Source: Primary Data (Processed), 2020

The results of the statistical analysis, using Spearman's rank correlation test, showed *r = 0.302* and a statistically insignificant *p-Value (0.099)*. Referring to a significance value greater than 0.05, the correlation between physical workload and dehydration status in laundry operators was found to be statistically insignificant.

Table 3. Relationship between Thermal Work Environment and Dehydration Status of Laundry Operators

Independent Variable	Dependent Variable	Correlation Coefficient (r)	Significant Value (p)
Thermal Work Environment	Dehydration Status	0.562	0.001

Source: Primary Data (Processed), 2020

The results of data analysis using Spearman's rank correlation test showed *r = 0.562* and *p-Value = 0.001*. With a significance value below the threshold of 0.05, it can be concluded that there is a statistically significant correlation between the work climate and the dehydration status of laundry operators.

DISCUSSION

This study examined the relationship between physical workload, working conditions, and hydration status among laundry operators at PT. K. The findings showed that most operators experienced moderate dehydration. Dehydration is a condition that can cause significant physiological changes, including hemodynamic alterations in blood circulation and electrolyte imbalances, which may ultimately affect health (Dhareshwar, 2023).

In this context, length of service refers to the duration of a worker's employment at PT. K, calculated from the start of employment to the time of the study. The majority of laundry operators had been employed for ≤5 years, with the largest proportion in the less than one-year category. The length of service is closely related to an individual's ability to adapt to the type of work and its corresponding working conditions. Hua et al. (2023) emphasized that the

Wet Bulb Globe Temperature (WBGT) index, which accounts for air temperature, humidity, wind speed, and radiant heat, objectively reflects the thermal load on the body in hot environments. In this regard, work tenure may increase exposure to heat stress and gradually enhance physiological adaptation, but extended service can also lead to fatigue and reduced awareness of workload demands, which may affect hydration behaviors.

Most laundry operators at PT. K exhibited a hydration status categorized as moderate dehydration. Internal factors, such as insufficient rest time, low fluid intake, and inadequate consumption of fruits and vegetables, contributed to this condition. In addition to internal factors, external factors included exposure to environmental temperatures exceeding the comfort threshold, which further increased the risk of dehydration. Hua et al. (2023) explained that WBGT reflects the combined effect of multiple meteorological factors on human heat load, and elevated WBGT values may intensify body fluid loss through sweating in high-temperature environments. This process of evaporation reduces body fluids and increases the likelihood of dehydration.

Based on physical workload measurements, most subjects in the laundry unit were classified as having light to moderate workloads. The results of the Spearman correlation test revealed no significant relationship between physical workload and hydration status. The relatively low metabolic heat generated from light to moderate workloads is considered the main explanation for this finding. The higher the intensity of workload, the higher the body's metabolic rate, which increases both fatigue and fluid requirements. If fluid needs are not adequately met, this condition may lead to dehydration. Heat stress occurs when the body's thermoregulatory system fails, causing elevated body temperature and heart rate (Srinivasan et al., 2021).

These findings exhibit a similar pattern to those of Tarwiyanti et al. (2020), who reported no significant correlation between workload intensity and hydration status ($p = 0.333$). This indicates that the intensity of physical work at the study site was within the mild to moderate range, which was insufficient to produce excessive metabolic heat. As a result, the relatively low intensity of physical activity may have reduced the risk of dehydration among workers, as the body's response to heat stress and fluid loss was less evident in this context.

According to Hess et al. (2025), who examined metabolic workload in relation to work intensity and core body temperature, workloads that exceed permissible intensity levels result in greater metabolic heat production and significant increases in core temperature. Based on this principle, heavy workloads should be associated with higher levels of dehydration. However, two participants in this study, despite having light workloads, were identified as being severely dehydrated, which is not entirely consistent with theoretical expectations. This suggests that light to moderate workloads do not substantially increase dehydration risk, as no statistically significant relationship was detected in this study.

The working climate at PT. K's laundry unit was characterized by high temperatures and low humidity. The average ambient temperature was recorded at 31.5°C, exceeding the maximum limit established by Ministry of Health Regulation No. 70 of 2016, which sets an acceptable range of 18–30°C with relative humidity between 65% and 95%. High-temperature environments pose a major risk of dehydration for workers. The combination of body heat from metabolism and elevated room temperature can result in heat stress, leading to excessive

sweating and fluid loss. When fluid loss is not balanced by adequate intake, workers become vulnerable to dehydration.

Another external factor influencing this condition was ventilation. Although blowers were installed on the roof of the building, they were not used regularly, resulting in poor air circulation in the work area. Limited airflow contributed to heat accumulation, which was further exacerbated by production machinery and steam released during laundry processes. Regular operation of the blowers could reduce room temperature by improving airflow efficiency, thereby lowering the risk of dehydration.

This analysis is also supported by Sutarto et al. (2022), who reported significant correlations between workplace climate and hydration status ($p = 0.002$) and between adequate fluid intake and hydration status ($p = 0.013$). In their study, environmental temperature was found to exert the strongest influence on hydration status, with workers in areas ≥28°C WBGT—particularly dough preparation, steaming, and shaping—accounting for 33 cases (37.5%). Similar results were obtained by Suryadi et al. (2020), who reported an average temperature of 34.75°C at the Tirtonadi Bus Terminal, which exceeded the threshold and showed a significant correlation with hydration status. Furthermore, Salsabila et al. (2023) found that 71.4% of dehydrated workers were in areas above the permissible temperature threshold, compared with only 16.7% in cooler environments. These consistent findings reinforce the conclusion of Hua et al. (2023) that WBGT monitoring is critical for assessing heat-related risks and preventing dehydration in workplace settings.

The limitation of this study lies in its use of a cross-sectional method, whereby conclusions are based on a single point in time. This means that some variables that fluctuate could not be monitored continuously. Additionally, several respondents declined participation, resulting in a reduction in sample size. Nevertheless, univariate and bivariate analyses were conducted in this study to minimize the influence of confounding variables, allowing the results to adequately describe the relationship between physical workload, working conditions, and hydration status among laundry operators.

CONCLUSION

This study concluded that there was no statistically significant relationship between physical workload and the dehydration status of laundry operators at PT. K. This indicates that the predominantly light to moderate level of physical activity was not sufficient to cause a significant fluid imbalance in the body. Conversely, a significant relationship was found between working conditions, particularly high temperatures and low humidity, and the dehydration status of workers. These findings confirm that exposure to heat in the work environment is a significant risk factor that affects body fluid balance and can increase the incidence of dehydration, even in workers with light physical workloads.

The findings of this analysis recommend the importance of controlling work environment factors, such as optimizing ventilation systems and scheduling breaks accompanied by fluid intake, to prevent the long-term health effects of dehydration. Further research can be directed at evaluating the effectiveness of workplace interventions (such as the use of air conditioning, increased hydration education, or workload modification) in reducing

the prevalence of dehydration, as well as considering other biomarker aspects such as serum osmolality or urine volume for more objective validation of hydration status.

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