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Factors related to MDA levels in female tiles industry workers in Grobogan, Indonesia: a cross-sectional study

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Abstract. Malondialdehyde (MDA) is a marker of work fatigue that occurs. Work fatigue often occurs in workers, but workers do not realise that continuous work fatigue causes health problems in the body. The damage that occurs is oxidative stress in the body that produces the end product, MDA. We conducted a cross-sectional study on as many as 96 home industry workers making tiles in Karang Asem, Grobogan, Central Java, Indonesia. We identified individual factors, individual habitual factors, occupational factors, and work environment factors during the study period and correlated these factors with workers' MDA levels. MDA is measured using an ELISA reader. Data analysis used the Rank-Spearman correlation test. We identified that the mean value of MDA is 8.66. The analysis correlation test between factors with MDA explained age *($p = 0.001$),* BMI *($p = 0.922$),* sleep quality *($p = 0.000$),* working period *($p = 0.390$),* workload *($p = 0.002$),* length of work *($p=0.776$),* awkward posture *($p = 0.013$),* and heat stress *($p = 0.040$).* There was a significant correlation between age, sleep quality, workload, awkward posture, and heat stress with workers' MDA levels. Future research should examine other factors related to MDA levels.

1 Introduction

The informal industry is a work sector carried out by individuals, groups, families or organizations with irregular work mechanisms[1]. Informal workers dominate jobs in Indonesia. Informal industry is a work sector carried out by individuals, groups, families or organizations with irregular work mechanisms in Indonesia. Data from Indonesia's Central Statistics Agency in August 2022 stated that informal workers dominated by 59.31% compared to formal workers[2]. The critical industry is one of the informal industries. Critical industries have complex potential hazards. The hot environmental conditions that are sourced from the burning of tiles, the weather and the work involve physical activity. Continuous physical activity results in work fatigue in workers[3].

Fatigue during activity is one of the common physiological reactions, which refers to a syndrome caused by physical and/or mental fatigue[4]. There is an imbalance between free

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radical levels and antioxidants in the body due to excessive physical activity[4]. Excess Reactive Oxygen Species (ROS) will be produced which affects the defence of antioxidants in the body so that oxidative stress is formed[5]. MDA is one of the end products of peroxidation lipids that can be used to evaluate the degree of fatigue[6]. The highest reaction sensitivity of MDA can be used as an indicator of the presence of free radicals in the tissue. A person's long-term fatigue will result in a risk of health problems such as anxiety, diabetes, heart disease, gastrointestinal disorders, high blood pressure, decreased fertility and depression[7].

Informal workers in the African Market Trade explained that informal workers are dominated by female workers at 59.7%[8]. The proportion of employment in female workers is 64.43% in 2022 work as informal workers[9]. Previous studies explained that the majority of informal workers in seaweed farmers are female workers as many as 60.9%[10]. Work fatigue is vulnerable to female workers. In a previous study, it was explained that as many as 84.2% of female workers experienced fatigue compared to men[11]. Previous research explained that the average MDA of female workers was 1.58 uM while male workers were 1.00 uM[12]. A long period of time with fatigue will result in the risk of health disorders such as anxiety, diabetes, heart disease, gastrointestinal disorders, high blood pressure, decreased fertility and depression. Based on data explaining 10-15% of the population of developed countries feel work fatigue.

The results of the study showed that MDA concentration (lipid peroxidation) was significantly affected by age. Senior subjects (45–53 years) showed significantly higher levels of lipid peroxidation (MDA concentration) than middle subjects (38–44 years) and young subjects (31–37 years) during the study[13]. The test results showed that MDA concentration was significantly lower in younger active and inactive elderly men compared to older active and inactive elderly men[14]. There is an effect of hormonal differences between the genders of workers[15]. Factors such as disease history, individual habits, mental health, work-related related fatigue[16–19]. The livelihood of the people of Karangasem Village, Wirosari District, Grobogan Regency, Central Java, is precarious maker. In the process of making tiles, there are manual work parts and some have been assisted using machines and work that involves intense physical activity. In addition, there is heat stress, and unergonomic work posture which puts the fatigue level of workers with MDA biomarkers at risk of increasing compared to other workers. When workers were asked if they felt tired, most of them felt not tired and were used to feeling tired because they worked continuously. Therefore, there is a need for a biomarker to objectively measure fatigue in the human body that is suspected of damage to the body with MDA. This is the basis for researchers to analyze factors related to MDA levels in tile manufacturing workers.

2 Methods

This study is a type of observational research with a cross sectional design. This research was conducted in the tile manufacturing industry in Karangasem Village, Grobogan, Central Java, Indonesia. The population in this study is all female tile-making workers in Karangasem Village, Grobogan, Central Java, Indonesia as many as 490 female workers with sampling using lemeshow formula sample technique. Workers who are included in the criteria for critical workers are female as many as 96 workers.

The research instrument used is a general questionnaire to find out the age (≥ 40 years and <40 years), working period (>8 hours and ≤8 hours), and length of service (long and short working period). The Pittsburgh Sleep Quality Index (PSQI) questionnaire is utilized to assess the quality of sleep (good and poor). The BMI(normal and abnormal) variable was measured using a weight scale and a microtoise to measure height. The worker's workload (Heavy, Medium, and Light) is measured using the worker's pulse while resting and working then using the %CVL formula. The worker's awkward posture was measured using the REBA (Rapid Entire Body Assessment) form. Heat stress (above and below threshold value) is measured using a heat stress meter. While MDA levels were measured by ELISA READER, MDA levels were taken from the blood serum of workers after work.

This research has been approved by the Ethics Committee for Health Research at the Faculty of Nursing and Health Sciences at the University of Muhammadiyah Semarang Number 209/KE/09/2023. We used IBM SPSS Statistics 21 to analyze data. The data analysis carried out was univariate analysis which presented table data of mean values ± standard deviation or as a median (minimum-maximal), bivariate analysis using the Spearman rank correlation test on the relationship test of numerical data.

3 Result and Discussion

Workers characteristics was shown in Table 1. Participants had a mean age 38.50±9.23 years. Then mean BMI was 26.92±5.46. The mean sleep quality was 6.72±2.79, length of work was 6.61±1.74, work load was 68.10±10.81, and duration of work was 8.63±0.68. The mean awkward posture 5.65±2.72. The mean heat stress was 37.59±2.48. The mean MDA was 8.66±0.33(Table 1).

Table 1. Baseline Characteristic of Participants (n=90)

Variable	f(%)	Mean±SD	Median (Min-Max)
Age, years		38.50±9.23	40.00 (20.00-57.00)
≥ 40	49(51,00)		
< 40	47(49,00)		
BMI, kg/m^2		26.92±5.46	27.09 (16.94-43.26)
Abnormal	72(75,00)		
Normal	24(25,00)		
Sleep Quality		6.72±2.79	6.00 (2.00-13.00)
Poor	57(59,40)		
Good	39(40,60)		
Length of Work, Year		6.61±1.74	7.00 (2.00-9.00)
Long	78(81,30)		
New	18(18,80)		
Work Load, %		68.10±10.81	68.80 (36.50-93.70)
Heavy	14(14,60)		
Medium	65(67,70)		
Light	17(17,70)		
Duration of work, hour		8.63±0.68	9.00 (8.00-11.00)
> 8	51(53,10)		
≤ 8	45(46,90)		
Awkward posture, Score		5.65±2.72	5.50 (2.00-10.00)
Yes	72 (75,00)		
No	24(25,00)		
Heat Stress, °C		37.59±2.48	38.90 (30.10-39.70)
Above thersold value	96 (100,00)		
MDA, nmol/L		8.66±0.33	8.61 8.01-9.23)

Test results showed that there was a relationship between age and MDA levels and a weak relationship strength. The higher the age of the worker, the higher the MDA level (Table 2). The correlation between sleep quality and MDA levels among workers is weak, indicating that the poor the quality of sleep for workers, the higher their MDA levels will be (Figure 1) The workload exhibits a weak correlation with the MDA levels; however, the opposite is true, as the heavier the workload, the lower the MDA value, because there are other stronger factors Awkward posture is weakly related to MDA levels. The worse a worker's awkward posture, the higher the MDA level. It is also weakly related to MDA levels in a negative direction, which indicates that the higher the heat stress value, the higher the MDA level.

Table 2. Strength and Relationship Direction Test Analysis

Variable	Correlation coefficient	p value[a]
Age, years	0.323 [b]	0.001*
BMI, kg/m^2	-0.010	0.922
Sleep Quality	0.349 [b]	0.000*
Length of Work, Year	-0.089	0.390
Work Load, %	-0.306 [b]	0.002*
Duration of work, hour	-0.029	0.776
Awkward posture, Score	0.252 [b]	0.013*
Heat Stress, ºC	-0.210 [b]	0.040*

*Information: a: Spearman Rank Test, b: weak relationship, *p≤0,05: Statistically significant*

Oxidative stress has been reported to be closely related to fatigue, even though the mechanism is still unclear[20]. Excessive physical exertion leads to an imbalance between the body's oxidation and antioxidation systems. As a result, the overproduction of reactive oxide species (ROS) and malondialdehyde (MDA) is attributed to fatigue symptoms[21].

In this paper, we evaluated the prevalence of MDA level among female tile roof workers in Grobogan, Indonesia. According to numerous studies in the informal sector, women have a higher percentage of fatigue than men. One study explained that MDA levels in women are higher than in men[12]. A different study on tile workers too, explained that 68.3% who experienced subjective work fatigue[22]. This is due to gender differences in humans can be of several types, including anthropometric, anatomical, physiological, biological, psychological, cognitive, and behavioural differences[23,24].

The work of making tiles is the main livelihood of the people in Grobogan, Indonesia. In Among individual risk factors, also sleep quality and relationship with MDA level were investigated. Sleep quality plays a significant role in influencing malondialdehyde (MDA) levels in workers in the tile manufacturing industry. It turns out that the impact of this sleep disorder is an increase in MDA levels in the worker's body, which is influenced by factors such as chronic stress, inflammation, and metabolic disorders related to inadequate sleep[25,26]. This was in accordance with the results of our study, which explains that there is a significant relationship between sleep habits and MDA levels. It was Other studies have shown that sleep disorders increase the production of reactive oxygen species (ROS), which contribute to oxidative damage and increased levels of MDA[27].

The working period is related to the adaptability of workers, their work and the work environment, both positive and negative adaptations. Negative adaptation will lead to work fatigue and decreased psychological and physiological function[28]. However, another study explained that the longer the working hours, the greater the benefits that workers receive due to the work environment and other reasons[28]. This is in line with our research explaining that there is no relationship between 2-9 years of service life with MDA levels. Same with duration of work. In our study, the duration of work in the tile industry for 8-11 hours a day is not related to MDA levels.

Workers with a high workload, revealing the connection between oxidative stress and low-grade emotional inflammation[29]. In our paper, work activity with a heavy workload causes health problems, exacerbated by excessive activity. It was significant with MDA level in our study. Acute exercise may also cause increased oxidative stress in the body and produce MDA that widely used as a biomarker of oxidative stress[30]. We assessed one of work related factors is ergonomics by the REBA method, which evaluates harmful posture and movements for certain areas of the body. Our study explain, there was a corelation between awkward posture with MDA level. The work posture variable affects musculoskeletal disorders[31]. Growing research indicates that fatigue failure processes in musculoskeletal tissues may be the cause of musculoskeletal disorders (MSDs) [32].

In both hot and cold temperature of workplace, there is an increased risk of accidents due to physical exhaustion and reduced mental ability[33]. In our study, it was significant with MDA Level. Thermal strain is the term used to describe the physiological, haematological, and hormonal changes that occur as a result of heat stress. One of the most significant variables that can raise the reactivity of oxygen species production (ROS) is heat stress[34]. Previous studies have provided an explanation for why bakers with WBGT values above the threshold have significantly higher MDA levels in heat-exposed industries[35].

Periodically, when people are overworked or overtired, they experience transient fatigue[36]. However, some people have chronic fatigue for extended periods of time for no apparent reason. As a result, fatigue is a serious issue that interferes with daily functioning16. Therefore, efforts for real-time fatigue monitoring of workers can enhance safety and help in preventing accidents[37]. Generally, fatigue can only be improved with enough rest and a healthy diet[36].

Nevertheless, our study has several limitations. There are still other factors associated with MDA levels. Additional limitations encompass the cross-sectional design, which precludes the drawing of causal inferences, and the possibility of inaccuracies arising from self-reporting. This study has not conducted a multivariate analysis. Future research should examine other factors related to MDA levels.

4 Conclusions

The MDA level of tile manufacturing workers has a high prevalence. A significant relationship between individual factors and work-related factors with MDA levels was found. Older age is a factor related to higher MDA levels. In addition, workers with poor sleep quality lead to higher levels of MDA. Worsening awkward posture leads to higher MDA levels. Meanwhile, workload and heat stress are also significantly related to MDA levels.

The goal of workplace preventive measures should be to enhance the ergonomic work environment and lessen job strain brought on by an insufficient workload, workers should improve the quality of sleep not only from the duration of sleep but also to achieve quality sleep but short. Improvement in terms of reducing heat exposure exposed by workers is one of the preventive efforts to overcome high heat stress.

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