RELATIONSHIP BETWEEN PHYSICAL WORKLOAD, SLEEP QUALITY, WORK CLIMATE, AND NOISE LEVEL WITH WORK FATIGUE IN ROLLING MILL WORKERS IN SIDOARJO STEEL INDUSTRY

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ABSTRACT

Introduction: Every year 250 million work accidents occur and more than 160 million experience occupational diseases (ILO, 2013). One factor that causes work accidents is unsafe behavior caused by work fatigue. The purpose of the study was to analyze the relationship between physical workload, sleep quality, work climate, and noise with work fatigue in Rolling Mill Steel Industry section workers Sidoarjo. **Methods:** This study is an observational and analytical study with a cross-sectional design. The study population was 34 workers and a sample of 31 respondents were workers in the Rolling Mill section. The sampling technique used simple random sampling. Independent variables were physical workload, sleep quality, work climate, and noise. The dependent variable was fatigue. Spearman correlation test was used to determine the relationship between physical workload and work fatigue. A Chi-square test was used to determine the relationship between sleep quality, work climate, and noise with work fatigue. **Result:** The result showed (61,3%) workers experienced moderate physical workload, (61,3%) workers had good sleep quality, (64,5%) workers worked above work climate threshold limit value, (77,4%) workers worked above noise threshold limit value, and (48,5%) workers had normal fatigue. Statistical analysis shows physical workload ($p = 0.031$), sleep quality (continuity correction = 0.047), work climate (fisher exact = 0.002), and noise (fisher exact = 0.009) have a relationship with work fatigue. **Conclusion:** This study concludes that physical workload, sleep quality, work climate, and noise have a relationship with work fatigue.

Keywords: fatigue, physical workload, sleep quality, work climate, noise

INTRODUCTION

The rapid development of the industry in Indonesia is encouraging companies to improve industry and production quality. The development of industry has increased the standard of human life, but it can also cause work accidents. Work accidents result in significant losses to the industry. Based on data from the International Labour Organization (2013), work accidents occur 250 million times. In addition to the crash, 160 million workers experience illness as a result of hazards while working. Occupational accidents and occupational diseases have an impact on economic losses in some countries, even reaching 4% of the Gross National Product.

In doing work, two of the common causes of accidents are unsafe work behavior and an unsafe work environment. Based on these two reasons, work accidents are predominantly caused by unsafe behavior, hitting 80% to 85% of such cases (Anizar, 2013). Unsafe work behavior is one of the effects of work fatigue. So based on the concept of work fatigue risk management proposed by Tarwaka (2015), fatigue does impact unsafe work behavior and with the final impact of increasing the risk of work accidents.

The problem of fatigue is one of the significant issues. Based on a survey conducted in the United States, 24% of patients who were adults who went to the clinic experienced fatigue (Setyawati, 2010). Based on data from the International Labour Organization (2013), over the years 2 million workers in various parts of the world died as a result of workplace accidents caused by fatigue. The study showed the results of 58,115 samples studied, and 32.8% of them experienced

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work fatigue. Research conducted by O'Neil (2013) showed work losses due to fatigue, which, if valued materially, can result in losses of $ 1000 / week.

According to Safe Work Australia (2013), the factors causing work fatigue are work schedules, work factors such as workload, sleep quality, and work environment conditions.

In the production process of steelmaking, there are potential hazards experienced by workers. The hazard that occurs is due to the steel casting activity which results in environmental conditions having a hot work climate and high noise intensity. These two factors provide additional workload for workers which results in acceleration of the onset of work fatigue. Harmful effects due to work fatigue result in a decreased focus on doing work, thereby increasing the risk of work accidents.

Based on this explanation, to reduce the risk of work accidents, research on the causes of work fatigue is important to do. The results obtained, can explain and provide recommendations related to comprehensive prevention related to work fatigue so that the risk of work accidents can be minimized.

METHOD

The conducted research was observational analytic research or research conducted by observing the object without giving treatment and conducted to determine the relationship between the independent variables with the dependent variable. The approach used was cross-sectional which means the research was carried out at one time. The population in this study were all workers of the Rolling Mill of the Sidoarjo Steel Industry as many as 34 workers. The sample taken was a portion of the workers using the simple random sampling formula to obtain a research sample of 31 workers. This research was conducted in the Rolling Mill section of the Sidoarjo Steel Industry. Data was collected in February 2019.

The dependent variable in this study was work fatigue. The independent variables in this study included physical workload, sleep quality, work climate, and noise. Data collection techniques were carried out by measuring physical workload by measuring pulse with the Cardiovascular Load (CVL) method, measuring work climate and measuring noise, and filling the Pittsburgh Sleep Quality Index (PSQI) questionnaire.

Spearman correlation test data analysis was used to analyze the relationship between physical workload variables and work fatigue. A Chi-square test was also carried out to examine the relationship between sleep quality, work climate, and noise with work fatigue. (No: 106 / EA / KEPK / 2019).

RESULT

Distribution of Workers' Physical Workload in the Rolling Mill Section of the Sidoarjo Steel Industry

Pulse measurements were carried out to calculate the physical workload received by workers. The measurement results of the pulse were then entered into the Cardiovascular Load (CVL) formula, and a cardio load value was obtained that represents the workload held by the worker. The results were then categorized according to the %CVL category. The physical workload was classified as mild if %CVL is less than 30% and medium if %CVL is between 30% and 60%.

Table 1. Distribution of Workers' Physical Workload in the Rolling Mill Section of the Sidoarjo Steel Industry

Physical Workload	Freq (n)	Percentage (%)
Light	12	38,7
Moderate	19	61,3
Total	31	100,0

The results of the measurement of physical workload showed that the majority or 61.3% of the total workers of the Rolling Mill section of the Sidoarjo Steel Industry received a moderate category of workload.

Distribution of Workers' Sleep Quality in the Rolling Mill Section of the Sidoarjo Steel Industry

Sleep quality can be interpreted as a description of someone's satisfaction with the sleep they experienced (Ohayon, 2017). Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) questionnaire. There were 7 variables of sleep quality assessment which include subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleeping pills, and disruption of activity during the day.

Each component of sleep quality contained questions with a Likert scale. Sleep quality is categorized as good if the PSQI score obtained from the assessment carried out has a value less than 5, and is categorized as poor if it has a value of more than 5.

Table 2. Distribution of Workers' Sleep Quality in the Rolling Mill Section of the Sidoarjo Steel Industry

Sleep Quality	Freq (n)	Percentage (%)
Good	19	61,3
Poor	12	38,7
Total	31	100,0

The estimated sleep quality of 61.3% of the total workers of the Rolling Mill section of the Sidoarjo Steel Industry showed that the quality of sleep was in a good category.

Work Climate in the Rolling Mill Section of the Sidoarjo Steel Industry

Work climate measurements were carried out at 5 points at the Rolling Mill work location. The working climate was measured using a digital instrument measuring the working climate with the brand Questemp. Each measurement point was measured for one minute and the measurement results were obtained in the form of dry temperature (SK), wet temperature (SB), ball temperature (SG), and relative humidity (RH).

Then the measurement results using the work climate formula were calculated and the working climate was obtained in the form of the Wet and Ball Temperature Index (ISBB).

Table 3. Measurement Result of Work Climate in the Rolling Mill Section of the Sidoarjo Steel Industry

Measurement Location	DT (^oC)	WT (^oC)	GT (^oC)	RH (%)	WBGT (^oC)
Conveyor A	37,1	29,4	49,1	36,7	37,0
Lower BRF A	34,2	28,8	37,0	66,4	31,2
Upper BRF A	45,5	30,8	49,1	63,7	37,0
Descaller	31,5	26,8	34,2	69,7	28,8
BRF A Control Room	27,6	24,5	27,7	78,4	25,4

Work climate measurements show Conveyor A and Billet Reheating Furnace (BRF) A were the highest working climate locations with temperatures of 37^{o}C. Control Room was the location with the lowest working climate with temperatures of 25.4^{o}C.

Determination related to the fulfillment of the work climate with a Threshold Limit Value (TLV), the results of the work climate measurement were adjusted to the workload. These results were then compared with Regulation of the Minister of Manpower and Transmigration (2018) concerning Occupational Safety and Health at Work Environment. The respondent's work climate was categorized

to be less than the same as the TLV and exceeding the TLV.

The distribution of the work climate shows that the majority or 64.5% of the total workers in the Rolling Mill section of the Sidoarjo Steel Industry worked in climatic conditions exceeding the TLV.

Table 4. Distribution of Work Climate in the Rolling Mill Section of the Sidoarjo Steel Industry

Work Climate	Freq (n)	Percentage(%)
≤TLV	11	35,5
>TLV	20	64,5
Total	31	100,0

Distribution of Noise Intensity in the Rolling Mill Section of the Sidoarjo Steel Industry

Noise in the Rolling Mill of Sidoarjo Steel Industry was measured by an instrument or measuring instrument in the form of a Sound Level Meter. The measurement results in the form of noise intensity. The results of noise intensity measurements at 5 measurement points in the Rolling Mill section of the Sidoarjo Steel Industry are as follows.

Table 5. Measurement Result of Noise Intensity in the Rolling Mill Section of the Sidoarjo Steel Industry

Measurement Location	Noise Level (dBa)
Conveyor A	94,2
Lower BRF A	88,6
Upper BRF A	89,3
Descaller	84,5
BRF A Control Room	80,2

Noise measurement results show Conveyor A point was the highest noise intensity point with a noise intensity of 94.2 dBa. Billet Reheating Furnace (BRF) A Control Room is the point with the lowest noise intensity with a noise intensity of 80.2dBa.

Determination related to the fulfillment of noise intensity with TLV was done by adjusting the results of the measurement of noise intensity with the work time of workers. The results were then compared with Regulation of the Minister of Manpower and Transmigration (2018) regarding Occupational Safety and Health at Work Environment, the noise at the work location experienced by respondents were categorized to be less than the same as the TLV and more than the TLV.

Table 6. Distribution of Noise Level in the Rolling Mill Section of the Sidoarjo Steel Industry

Noise	Freq (n)	Percentage (%)
≤TLV	7	22,6
>TLV	24	77,4
Total	31	100,0

Noise distribution shows the majority or 77.4% of the total workers of the Rolling Mill section of the Sidoarjo Steel Industry were doing work in a condition of noise exceeding the TLV.

Distribution of Workers' Fatigue in the Rolling Mill Section of the Sidoarjo Steel Industry

The measurement of work fatigue used an instrument measuring the reaction time with the light excitatory method. Light excitement was chosen because humans respond to light better so as to provide more accurate measurement results.

The measurement results were then categorized into work fatigue in the normal category if the measurement score is 150-240 milliseconds, light if the measurement score is 241-410 milliseconds, and moderate if the measurement score is 410-580 milliseconds. The following is the distribution of work fatigue for workers in the Rolling Mill of the Sidoarjo Steel Industry.

The measurement of work fatigue shows that workers in the Rolling Mill section of the Sidoarjo Steel Industry

experience work fatigue in the normal, light, and moderate categories. Based on these measurements, the majority or 48.5% of the total workers of the Rolling Mill section of the Sidoarjo Steel Industry experienced work fatigue with the category of normal work fatigue.

Table 7. Distribution of Work Fatigue in the Rolling Mill Section of the Sidoarjo Steel Industry

Work Fatigue	Freq (n)	Percentage (%)
Normal	16	48,5
Light	13	41,9
Moderate	2	6,5
Total	31	100,0

Relationship between Physical Workload and Work Fatigue in Rolling Mill Workers in Sidoarjo Steel Industry

The results showed that the majority of workers received a light physical workload or 56.3% of workers experienced fatigue in the normal category. In contrast to workers who received workloads in the light category, workers who received workloads in the medium category, the majority or 76.9% of workers experienced work fatigue in the light category.

Table 8. Relationship between Physical Workload and Work Fatigue in Rolling Mill Workers in Sidoarjo Steel Industry

Work Fatigue	Physical Workload				Total	
	Light		Moderate			
	n	%	n	%	n	%
Normal	9	56,3	7	43,7	16	100
Light	3	23,1	10	76,9	13	100
Moderate	0	0	2	100	2	100

Statistical analysis conducted using the Spearman correlation test showed $p = 0.031 < \alpha = 0.05$ which means there is a meaningful relationship between physical workload and work fatigue

Relationship between Sleep Quality and Work Fatigue in Rolling Mill Workers in Sidoarjo Steel Industry

The results showed that among workers who experienced good quality of sleep, most of them experienced normal work fatigue 81.2% of the total workers who experienced work fatigue under the category of normal work fatigue.

Whereas workers who experienced poor quality of sleep, the majority experienced mild work fatigue 53.8% of the total workers experienced work fatigue with mild work fatigue category.

Table 9. Relationship between Sleep Quality and Work Fatigue in Rolling Mill Workers in Sidoarjo Steel Industry

Work Fatigue	Sleep Quality				Total	
	Good		Poor			
	n	%	n	%	n	%
Normal	13	81,2	3	18,8	16	100
Light	6	46,2	7	53,8	13	100
Moderate	0	0	2	100	2	100

Statistical analysis conducted using the Chi-square test showed the value of Continuity Correction = $0.047 < \alpha = 0.05$ which means there is a meaningful relationship between sleep quality and work fatigue.

Relationship between Work Climate and Work Fatigue in Rolling Mill Workers in Sidoarjo Steel Industry

The results showed that workers who work in climatic conditions ≤TLV the majority experienced normal work fatigue at 62.5% of the total workers who experienced normal work fatigue.

Whereas for workers who work in climatic conditions >TLV, the majority experienced mild work fatigue 92.3% of the total workers who experienced mild work fatigue.

Table 10. Relationship of Work Climate with Work Fatigue in Workers of the Sidoarjo Steel Industry Rolling Mill Section

Work Fatigue	Work Climate				Total	
	≤TLV		>TLV			
	n	%	n	%	n	%
Normal	10	62,5	6	37,5	16	100
Light	1	7,7	12	92,3	13	100
Moderate	0	0	2	100	2	100

Statistical analysis conducted using the Chi-square test showed the value of Fisher Exact = 0.002 <α = 0.05 which means there is a significant relationship between work climate with work fatigue.

The Relationship between Noise and Work Fatigue in Rolling Mill Workers in Sidoarjo Steel Industry

The results show that workers who did work in noise conditions less than TLV, most of them experienced normal work fatigue at 43.8% of the total workers who experienced normal work fatigue.

For workers who work in noise conditions exceeding TLV. All workers who work in noise conditions exceeding TLV experienced mild work fatigue

Table 11. Relationship between Noise and Work Fatigue in Rolling Mill Workers in Sidoarjo Steel Industry

Work Fatigue	Noise Level				Total	
	≤TLV		>TLV			
	n	%	n	%	n	%
Normal	7	43,8	9	56,2	16	100
Light	0	0	13	100	13	100
Moderate	0	0	2	100	2	100

Statistical analysis conducted using the Chi-square test showed the value of Fisher Exact = 0.007 <α = 0.05 which means there is a significant relationship between noise and work fatigue.

DISCUSSION

Physical Workload on Rolling Mill Workers in Sidoarjo Steel Industry

Measurement of the physical workload of workers in the Rolling Mill section of the Sidoarjo Steel Industry found that the majority of workers received workloads in the moderate category.

In general, the workload experienced by workers is influenced by complex factors, both internal and external. Tarwaka (2015) explained that internal factors are factors that originate from within the worker such as work capacity or the ability of workers. While external factors come from the work environment, work, or organization work.

The concept of workload was also conveyed by Salvendy (2012) explaining that workload is influenced by the characteristics of workers, work design and work tools, work environment, work organization, and social and economic impacts due to the work system.

Based on this concept, the moderate workload received by most workers is because, in addition to the workers doing the main work, workers also get additional workload from the physical work environment in the form of work climate and noise.

The work was carried out in the form of benthic work, billet cutting, cleaning, and operating. Workers carry out their work with exposure to the work climate and high noise caused by the steel casting process.

According to Tarwaka (2015) workloads that are currently becoming the workers' workloads are still permitted but have the possibility of being repaired in the future. Based on this concept, supervision is needed so that the workload does not increase to become heavier. This supervision can be done in the environment so as not to increase both climate and noise.

Supervision carried out is one of the applications of the concept put forward by Tarwaka (2015), namely ergonomic balance. Ergonomics balance in the form of

a balance between work capabilities possessed by workers with workloads provided by the company. The ergonomic balance has the main objective of increasing the work productivity of workers and companies.

Sleep Quality of Rolling Mill Workers in Sidoarjo Steel Industry

The sleep quality assessment experienced by workers of the Rolling Mill section of the Sidoarjo Steel Industry found that the majority of workers experienced good quality sleep. Research conducted has results that are in line with research conducted by Putri (2018). The results of the study indicate good sleep quality which is experienced by most of the shift workers I. The concept of sleep quality put forward by Safe Work Australia (2013) stated that sleep quality is influenced by circadian rhythms and work shifts done by workers.

Based on the research and concept, good sleep quality experienced by most workers in the Rolling Mill section of the Sidoarjo Steel Industry is caused by workers doing work on the first shift, from morning to evening, and sleeping at night.

However, from the results of research conducted, there were still some workers experiencing poor sleep quality. Poor sleep quality can occur due to sleep workers, but with a short duration at night between 4-6 hours. The short duration of sleep indicates workers still have activities at night which should be used as sleep time. The activity shows that workers fight their circadian rhythm because the night is a time for sleep and rest.

Working Climate in Sidoarjo Steel Industry Rolling Mill Section

The work climate measurement results show that the majority of work locations in the Rolling Mill section of the Sidoarjo Steel Industry were work climates that exceed the TLV of the specified work climate. Observations that were made show that workers work with work time settings of 25% -50% and 50% -75% with light and moderate workloads. Based on Regulation of the Minister of Manpower and Transmigration (2018), working climate ISBB (at work time settings 25% -50% of workers work with light workloads at ISBB 32^{o}C and with medium workloads at ISBB 30^{o}C. At work time settings 50% -75% of workers work with workloads mild at ISBB 31^{o}C and with the moderate workload at ISBB 29^{o}C).

The working climate that exceeds TLV in most work locations was due to the steel casting process. Based on Suma'mur (2014), the temperature needed in the steel casting process reaches 1,850^{o}C, which is then released into the environment so that the work environment has a high work climate.

A work climate that exceeds TLV, according to NIOSH (2011) can have several impacts such as disruption of work performance in the form of work fatigue and stolen rest by workers, dehydration, prickly heat, and muscle spasms.

Work climate control is important as a preventive effort to prevent the occurrence of adverse effects due to a high work climate. According to Suma'mur (2014), one of the efforts to control the work climate is by increasing airflow. Efforts to increase air movement can be done by installing artificial ventilation at work sites.

Based on observations made at the Upper BRF A location, there had been artificial vents in the form of blowers to circulate air. However, the blowers were located far from where the workers did their jobs. Based on this, it is suggested to the company to move the position of the blower closer to the location of the worker doing the work.

Noise in the Rolling Mill Section of the Sidoarjo Steel Industry

Noise can be interpreted as a disturbing sound and the presence of it is not expected said Tarwaka (2015). Based on measurements made at the Rolling Mill section of the Sidoarjo Steel Industry, the

majority of work locations were work locations that exceed TLV. Observations made, workers worked with noise exposure for 4 and 8 working hours. Based on Regulation of the Minister of Manpower and Transmigration (2018) ISBB noise (on exposure for 8 working hours is 85 dBa and at exposure for 4 working hours is 88 dBa). Noise that exceeds the TLV is caused by the sound of production machines and work tools.

Furthermore, According to Regulation of the Minister of Manpower and Transmigration (2018) Concerning Occupational Safety and Health, the allowable noise threshold value is 85 dBa with exposure of 8 hours a day or 40 hours a week. Noise exposure that exceeds the threshold value of noise, can have an impact on work disruption which results in a decrease in work productivity.

According to Suma'mur (2014), noise can have an impact on psychological disorders that cause interference with resting and lead to fatigue. Research conducted by Dewanti (2015) suggested the impact of noise can cause hearing loss which can lead to progressive deafness.

Noise control needs to be done at the Rolling Mill of the Sidoarjo Steel Industry because most locations have noise that exceeds the TLV. One of the control efforts that can be done by companies according to Suma'mur (2014) is by controlling noise directly at the noise source. Observation of the work environment was carried out, the production machine naturally produced noise and when interviewed with workers, the engine used has been tried to be installed with a silencer to reduce the noise produced. Further observations found that there were work tools in the form of overhead cranes that should not produce noise, but instead produce noise due to lack of maintenance. So, companies need to conduct immediate maintenance to provide lubrication so that noise at the Rolling Mill of the Sidoarjo Steel Industry can be controlled.

Work Fatigue in Rolling Mill Workers of Sidoarjo Steel Industry

Fatigue measurements performed on workers at the Sidoarjo Steel Industry Rolling Mill section found the majority of workers experienced work to fatigue in a mild category. The measurement of work fatigue was carried out at 02.00 p.m. or before the worker finished doing his work, and at the end of working hours, there had been an accumulation of fatigue since the worker did the work in the morning.

Based on the concepts put forward by Safe Work Australia (2013), the work environment which includes climate and noise is a factor that affects the occurrence of work fatigue. A similar concept was put forward by Suma'mur (2014) who stated that work climate and noise are the cause of work fatigue. Based on this concept, the work environment is an important factor in work fatigue. The environmental conditions of the Rolling Mill of the Sidoarjo Steel Industry were predominantly working climate and noise that were beyond the TLV. These conditions should provide workers with more work fatigue, but based on the results of measurements made, most workers experienced normal work fatigue.

Normal work fatigue experienced by most workers can occur because workers first take a break from 11:30 .p.m. to 12.30 p.m. During breaks, workers ate lunch in the canteen and take a prayer at the company's mushalla. The company provides canteens and mushalla that are comfortable and air-conditioned.

Based on the rest that is the recovery of fatigue experienced by workers, that means when measuring work fatigue, the results obtained are mostly experiencing normal work fatigue. The concept of rest is in line with the concept of Suma'mur (2014) who explained that rest is the most appropriate effort to restore the body's condition from being tired to not tired. Another concept that supports the control of work discharge was also put forward by Dawson (2012), he explained in minimizing mistakes in doing work due to work fatigue,

thus the need for control efforts by taking adequate rest. O'Neil (2013) explained the importance of taking a break because it can minimize work fatigue and maintain optimal productivity.

The Relationship between Physical Workload and Work Fatigue in Rolling Mill Workers in Sidoarjo Steel Industry

Physical workload measurements obtained show physical workload with mild and moderate categories. Workers who received physical workloads in the mild category majority experienced normal work fatigue. In contrast to workers who received a light physical workload, workers who received a physical workload in the moderate category, the majority of it experience mild work fatigue. The difference in physical workload and its impact on work fatigue is due to differences in work activities carried out and the differences in the environmental conditions in which the work is carried out.

This study has results that are in line with research conducted by Pajow (2016) and Kusgiyanto (2017) who explained that physical workload has a significant relationship with work fatigue. Other studies on similar industries conducted by Amalia (2019) also showed the results of a meaningful relationship between physical workload and work fatigue. The results of this study are also in accordance with the concepts put forward by Safe Work Australia (2013) and Suma'mur (2014) which explained that the work fatigue factor is a work factor in the form of work monotony and environmental factors in the form of work climate and noise.

Observations made on workers who do work in the Rolling Mill section of the Sidoarjo Steel Industry are mostly repetitive work within a certain time. Work done repeatedly is a job that tends to be monotonous, this is in accordance with the concepts previously described as one of the factors that cause work fatigue.

The works carried out were benthic, billet cutting, cleaning, and operating work. In benthic work carried out at the work site, the worker conveyor repeatedly went in and out of the shelter and separated the hot wire rod stack that comes out of the forming machine. In billet cutting jobs, workers worked in half bent to cut billets before entering Billet Reheating Furnace (BRF). In the cleaning work carried out on the descaler and Billet Reheating Furnace (BRF) A Under the workers cleaned mill scale or dust from heating billets. In operating work, the operator operated the Billet Reheating Furnace (BRF) in the control room and stared at the operating monitor for a long time, occasionally exiting the control room to supervise Rolling Mill directly. The four jobs are not only monotonous but also exposed to work climate and noise.

Work fatigue, if not controlled, can cause a decrease in work productivity. Therefore, it is needed to control work fatigue. The concept presented by Tarwaka (2015) explained that the control of work fatigue can be done by setting rest periods and providing food for workers. Provision of more varied work and work reorganization to control work fatigue caused by monotonous conditions.

Relationship between Sleep Quality and Work Fatigue in Rolling Mill Workers of Sidoarjo Steel Industry

The results showed that workers who experienced good quality sleep, most of them experienced normal work fatigue. Whereas workers who experience poor quality of sleep, most experience mild work fatigue. Research conducted has results that are in line with research conducted by Trisnawati (2012) which stated that sleep quality and work fatigue have a meaningful relationship. The concept of fatigue proposed by Potter (2016), one of the causes of work fatigue is sleep disturbance. Sleep disturbance is influenced by several factors, one of which is the shift work system performed by workers. Shift work systems performed by workers can cause interference with workers' circadian

rhythms. The concept of fatigue related to circadian rhythm is strengthened by Satterfield (2013) which explained that the body has a rhythm automatically related to the time of activity and rest, when resting time is used for activity or vice versa, it will disrupt the circadian rhythm and will have the potential to cause fatigue.

Based on this concept good sleep quality should be able to cause a level of normal work fatigue in workers, however, there are some workers with good sleep quality experiencing mild work fatigue.

According to the results, Mild work fatigue can occur because of the condition where workers had good sleep quality but sleep for a short duration at night with the duration of 4-6 hours. The duration of sleep does not provide enough rest time for the body, so the body is not optimal in recovering from being tired to not tired. According to Safe Work Australia (2013), adults need 7 to 8 hours to get to sleep optimally. Therefore, in an effort to maintain and improve the quality of sleep and restore the body's condition from fatigue, workers can sleep at night for 7 hours.

The Relationship between Work Climate with Work Fatigue in Rolling Mill Workers of the Sidoarjo Steel Industry

The results of a study conducted showed that the majority of Sidoarjo Steel Industry Rolling Mill work locations are work locations with a work climate exceeding the TLV. For workers who work in climatic conditions beyond the TLV, most workers get mild and moderate work fatigue. However, the results of the study still found workers who get normal work fatigue.

Normal work fatigue obtained by workers at the Rolling Mill of the Sidoarjo Steel Industry can occur because the worker's body has received an acclimatization process to its work environment. Acclimatization causes the worker's body to become accustomed to the work environment so that the body is not much affected by the work climate that exceeds the TLV.

This research carried out results in line with the research conducted by Ramayanti (2017) and Suryaningtyas (2017) which stated that the work climate has a meaningful relationship with work fatigue. Research conducted on similar industries conducted by Dwiyanti (2019) showed the results of the relationship between work climate and work fatigue. Further concepts according to Jacklitsch (2016) the impact of a hot work climate can lead to heat fatigue or work fatigue due to heat. The working climate results in the body requiring additional efforts to maintain heat balance in the body. Additional efforts are made by the body such as the occurrence of vasodilation, an increase in body skin temperature, and core body temperature that starts with a decrease and then an increase (Soedirman, 2014). These additional efforts result in the body getting tired more quickly because the body requires more energy.

To reduce the impact caused by the work climate, it is necessary to have control of the company. Based on observations made, the company had endeavored to provide drinking water for workers. However, the drinking water provided by the company, especially in the Billet Reheating Furnace (BRF) A work area was quite far from the work location of the workers, because the drinking water supply was placed in the control room location. Efforts can be made by the company to able to provide drinking water closer to the location where the workers do their work. According to NIOSH (2011), efforts to prevent and minimize the effects caused by the hot working climate are to consume 1 glass of mineral water (150-200cc) every 15 to 20 minutes.

The Relationship between Noise Level with Work Fatigue in Rolling Mill Workers of the Sidoarjo Steel Industry

Noise intensity measurements are performed, showing that the majority of

workers carried out work in conditions beyond the noise TLV. At locations with noise intensity below the TLV, most workers experience normal work fatigue. Whereas for workers who perform in noise conditions more than TLV, the majority of them feel mild work fatigue.

Research conducted is in line with the results of research conducted by Paulina (2016) and Ningsih (2018) which stated that between noise and fatigue, there is a meaningful relationship.

This research is in line with the concept put forward by Safe Work Australia (2013) which stated that fatigue is caused by physical environmental factors, one of which is noise. The concept of fatigue is similar, explained Suma'mur (2014) which stated that noise is one of several factors that can cause work fatigue.

Noise control is to reduce the impact of noise experienced by noise receivers or workers. Suma'mur (2014) stated that control can be done using personal protective equipment (PPE). The company implemented controls by providing PPE in the form of earplugs to workers. However, based on observations made, there were found many workers who did negligent work in the use of earplugs. Based on this, there is a need for more intensive PPE supervision so that workers' compliance in the use of PPE in the form of earplugs can increase.

CONCLUSION

The research can be concluded that moderate physical workload, good sleep quality, work climate and noise that exceeds TLV and normal work fatigue are experienced by some workers in the Rolling Mill of the Sidoarjo Steel Industry.

Statistical tests conducted showed that physical workload, sleep quality, work climate, and noise are factors related to work fatigue experienced by workers at the Rolling Mill of the Sidoarjo Steel Industry.

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