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The Role of Sleep Quality as Mediator of Relationship between Workload and Work Fatigue in Mining Workers

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Abstract. The mining environment is a place to work with a high level of risk. One of the factors that cause work accidents in the mining area is work fatigue or work fatigue. The purpose of this study was to reveal the role of sleep quality as a mediator of the relationship between workload and work fatigue in mining workers in Indonesia. Research participants were mining workers who worked in the field with a 12-hour / day shift work system (n = 232). Measurements were made using 3 scales, namely Full Time Equivalent (FTE) for workload, Pittsburgh Sleep Quality Index (PSQI) for sleep quality, and Three-Dimensional Work Fatigue Inventory (3D-WFI) for work fatigue. The results of the analysis using bootstrapping 5000 showed that workload has a significant effect on the level of work fatigue which is mediated by sleep quality. High workload results in poor sleep quality and high levels of fatigue so that mining companies need to maintain the quality of sleep for field workers to minimize work accidents due to work fatigue.

***Keywords*:** mining workers; sleep quality; work fatigue; workload

Research by the National Safety Council (2018) showed that 13% of work accidents are caused by fatigue. The percentage of work accident due to fatigue is assumed to be higher in the mining industry given the combination of harsh work environment, repetitive and monotonous tasks, shift work system, long working hours, long travel times to locations due to remoteness of mine sites (Legault, 2011).

Simultaneous lack of sleep, insufficient energy recovery, strenuous mental and physical activity (Techera et al., 2016a) can make mining workers vulnerable to sleep deprivation and fatigue. The impact of fatigue at work will be dangerous and risky. A worker who experiences work fatigue tends to feel bored, lack enthusiasm, less productive, and even have an impact on increasing the risk of accidents.

Specifically, fatigue in workers in the energy and mining sectors can result in an imbalance of family life. A survey of 2,566 subjects who work in energy and mining

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sectors showed that 64% of subjects experienced fatigue after work and lost interest in other activities. Work fatigue in mining workers negatively impacted their physical and psychological health (Peetz et al., 2012). A report by the Ministry of Energy and Mineral Resources in Indonesia showed that in 2019, 24 mining workers died in the mineral and coal mining area (Anggoro, 2020).

According to Frone and Tidwell (2015), extreme work fatigue will have an impact on reducing the functional capacity of an individual during work or at the end of the workday. Essentially, work fatigue is a condition that occurs when the extortion of energy is too great which can be recovered through rest when the extortion demand has ended. Work fatigue can be classified into two conditions i.e., temporarily acute and chronic that occurs temporarily but recurs for 12 months.

Furthermore, both experts explained three work fatigue criteria. The first criterion is the occurrence of extreme fatigue or lack of energy, decreased functional capacity, and motivation to respond to stimuli or to engage in certain types of activity or behavior. The second criterion is the experience of extreme fatigue and decreased functional capacity that occur concerning all three energy sources, such as: physical, involves muscle movement; mental, involves cognitive process; and emotional, involves expression and regulation. Those criteria occur temporarily and relate to working days. It can be concluded that work fatigue is experienced at work.

In terms of process, work fatigue includes three aspects i.e., physical work fatigue, mental work fatigue, and emotional work fatigue (Frone & Tidwell, 2015). Physical work fatigue is a condition of extreme physical fatigue and reduced functional capacity to perform physical activities during work or at the end of the workday. Mental work fatigue is a condition of extreme mental fatigue and it reduces the functional capacity to engage in cognitive activities during work or at the end of the workday. Emotional work fatigue is a condition of extreme emotional fatigue and reduced functional capacity to engage in emotional activities during work. The manifestations of fatigue according to Hockey (2013) are in the form of low mood (exhaustion, weariness, lethargy) or unfocused mental conditions such as distortion, frustration, and discomfort, or unpleasant body condition, including headache, tension, also muscles and joints pain.

Mining companies are companies that implement shift work system to generate work continuity, work efficiency, and economic benefits. One of the consequences of shift work is the disruption of biological processes which are based on a twenty-four-hour cycle or the circadian rhythm of workers, which also causes a physiological disturbance. The shift work system which was applied by the company in the current study was six working days and three days off. From a biological perspective, night work can disrupt an individual's circadian rhythm or the body's rhythm in regulating interaction patterns between body functions and the environment, such as light. The circadian system stimulates individuals to sleep at night and wake up during the day. Thus, individual who works night shifts will experience change and have shorter sleep duration. This causes individuals to lose sleep hours that are accumulated during consecutive night shifts (Åkerstedt, 1995). Circadian rhythms regulate sleep and wake time, catabolism and anabolism, growth or restoration, and physical activity (Hastings & O'Neill, 2015). Physiologically, the circadian system can be observed e.g.; by the sleep-wake cycle, excretion of melatonin and cortisol hormones, and core body temperature (Rajaratnam & Arendt, 2001). Core body temperature usually drops at night and reaches the base level in the morning before it rises again (Khalsa et al., 2003). During a period of decreased core body temperature, especially around the base level, fatigue or drowsiness will increase significantly (Bjorvatn & Pallesen, 2009). Shift work system has a major impact on the occurrence of fatigue in mining workers because it results in the discrepancy of an individual's circadian rhythm. The disruption of circadian rhythm results in decreased sleep quality and quantity, affecting performance; which lead to in personal dissonance and imbalance (Theron & Van Heerden, 2011).

Sleep is a basic individual need for most organisms. It functions as a body and nervous system recovery (Duntley, 2005). An individual with good sleep quality has more energy, better cognitive function and immune system, increased memory, awareness, attention, and performance (Pete in Berhanu et al., 2018). Sleep quality refers to a collection of sleep measurements including Total Sleep Time, Sleep Onset Latency, fragmentation rate, total wake time, sleep efficiency, and sleep disorders such as apnea (Krystal & Edinger, 2008).

Several studies prove that sleep quality is related to work fatigue. A study by Patterson et al. (2011) reported that sleep quality is related to work fatigue in emergency medical personnel. According to Jauhari (2019), there is a relationship between sleep quality and work fatigue. Further, adults need between 7 and 9 hours of sleep per day to get an adequate rest time (Hirshkowitz et al., 2015). Apart from sleeping with sufficient duration, it must also be of good quality.

According to a survey by the Bureau of Labor Statistics (2019), the mining industry has the highest average of weekly working hours compared to other industries. The long working hours in the mining industry cause workers to have shorter rest periods. Overtime work or working more than 40 hours per week, and long working hours (more than eight hours a day) have the potential to cause fatigue (Bureau of Labor Statistics, 2019). The average working hours per week in the mining industry in 2018 was 45.9 hours (Bureau of Labor Statistics, 2019). Also, work schedules can interfere with sleep time. Most workers who work the night shift have difficulty getting enough sleep because their circadian rhythms keep them awake during the day (Torsvall et al., 1989). Short rest periods between shifts or less than 11 hours have been shown to significantly limit sleep duration (Vedaa, et al., 2016). Therefore, insufficient recovery is the cause of fatigue in mining workers.

Another factor that can cause work fatigue is the imbalance of body capacity with a given workload (Blafoss et al., 2019). The workload is a goal that must be achieved which includes the specified time to perform the task and performance level that must be achieved in the task, such as physical and cognitive workload (Gawron, 2008). Fatigue caused by physical workload occurs due to metabolic or nervous system degradation as a result of repeated contractions from muscles in the form of dynamic or static movements (Techera et al., 2016b). Cognitive workload can trigger fatigue when someone needs to think, decide, count, recall memory, and search excessively (Hart & Staveland, 1988). In the work context, long working hours of 50 hours or more per week and jobs that require direct cognitive response, repetition, and problem solving outside of the rote memory are strong factors that cause mental fatigue (Techera et al., 2016b).

On the other side, workload is related negatively to sleep quality and sleep quantity (Litwiller et al., 2017) whilst positively correlated with poor sleep quality in full-time workers. The mental and physical performance will decrease if individuals sleep less than 8 hours a day (Belenky et al., 2003). This finding is corroborated by the meta-analysis results of 27 studies that identified workload to be significantly correlated with a worker's sleep quality (DeArmond & Chen, 2004). Workers who work 12 hours a day have shorter rest periods than individuals who work 8 hours a day. The susceptibility to work fatigue increases when workers sleep less than 8 hours (Centers for Disease Control and Prevention, 2012).

Excessive workload and long working hours are serious problems for workers because they can cause fatigue (Choi et al., 2018). The workload in the context of long working hours or overtime work can reduce sleep time, thus resulting in fatigue (Wong et al., 2019). This is because long working hours affect the optimal recovery time and thus have an impact on sleep quality. Poor sleep quality is a cause of fatigue that often occurs in a work environment (Techera et al., 2016a). Lack of restorative sleep due to the cumulative effects of chronic and acute sleep deprivation is a contributing factor to work fatigue (Hossain et al., 2003). Based on the previous explanation, it can be concluded that workload has an indirect effect on work fatigue in mining workers. The correlation between those two variables is mediated by sleep quality. A heavy workload will lead to reduced sleep duration and other sleep disturbances which can cause a decrease in sleep quality, leading to work fatigue due to non-optimum recovery. An individual with good sleep quality is less likely to experience fatigue than the one with poor sleep quality.

The hypothesis proposed in this study is sleep quality as a mediator of the role of workload on work fatigue in mining workers. The correlation between-variables outline can be seen in Figure 1.

Participants

Participants in this study were 232 mining workers in PT TCI aged 22-50 from mining and plant departments. The composition of research subjects was 218 men and 14 women. Mining workers' working hour in this company was 12 hours per day with a work shift system. The roaster system ran by the participants was 6:3 system; which is 6 working days and 3 days off, then shift changes were made.

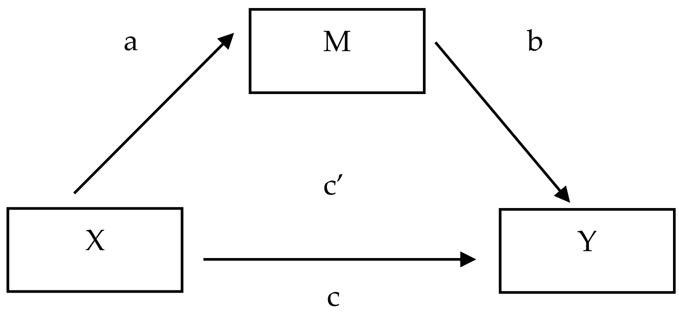

Figure 1. Outline for mediator

Method

Data collection procedure

This study used simple random sampling as a data collection technique. Data collection began with a brief explanation about research objectives and how to fill out the questionnaire. Participants who were willing to be involved in the study filled out the informed consent attached on the first page. The completion of the questionnaire took about 10 minutes and was done offline at the mining site.

Research instrument

Work fatigue scale

Work fatigue was measured using Three-Dimensional Work Fatigue Inventory (3D-WFI) composed by Frone and Tidwell (2015). The work fatigue scale consists of three sub-scale i.e.; physical work fatigue, mental work fatigue, and emotional work fatigue with a total number of 18 items. Each item has 5 alternative answers; namely very often, often, quite often, never, and very never. The higher the total score indicates the higher work fatigue experienced by workers.

Full time equivalent

The workload was measured using FTE (Full Time Equivalent) which is a method of calculating workload analysis by comparing the time used to complete work with the available effective work time. After that, the workload results are determined based on norms. According to the workload analysis guidelines issued by the State Personnel Agency in 2010, a total FTE index value >1.28 is categorized as overload, a value of 1-1.28 is categorized as normal, and a value of 0-0.99 is categorized as underload (Dewi &

Satrya, 2012). The Three Dimensional Work Fatigue Inventory (3D-WFI) has a reliability coefficient of 0.948.

Sleep quality scale

Sleep quality was measured using Pittsburgh Sleep Quality Index (PSQI) which has been adapted into Indonesian by Alim (2015). PSQI consists of seven components, namely: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunctioning. The scale has a total of 27 items with scores ranges from 1 to 21. A total score of more than 5 indicates poor sleep quality and a total score less than 5 indicates good sleep quality. PSQI scale has a reliability coefficient of 0.775.

Data analysis

Data analysis in this study was carried out using the path analysis method to determine the relationship between variables. Furthermore, bootstrapping analysis method was also utilized to determine the role of the mediator variable that attributes the independent variable and dependent variable. The bootstrapping method was used to get an empirically derived representation based on the sampling distribution of indirect effects (Hayes, 2013). Technically, data analysis was carried out by Hayes' PROCESS software installed on SPSS.

Results

Descriptive data

Participants in this study were 232 workers, composed of 218 men and 14 women. The age range of participants was 21 to 50 years old. A detailed explanation of participants can be seen in Table 1.

The participants' composition based on sex was dominated by men because they were field workers in a mining company. Most workers were married (80%) and lived away from their families. Most of them worked in the company for around 2 years.

From the descriptive analysis, researchers obtained an overview of participants' level of work fatigue, workload, and sleep quality. Seventy-six participants experienced a high to a very high level of work fatigue. Meanwhile, 156 participants were categorized as average and low. It shows that the work fatigue issue happened to more than 30% of the participants. The overview indicates that the work fatigue problem in the company is high. Ignoring this condition will risk the company's operation, especially related to work safety and organizational performance.

Descriptive data of sleep quality showed less than advantageous condition as 88% or 210 participants were categorized as having poor sleep quality. The poor sleep quality was examined with PSQI and showed a score higher than 4. Meanwhile, from a workload perspective, 197 workers (85% of the total) reported average load. A more detailed explanation can be seen in Table 2.

Table 1.
Demographics of Research Participants

N=232		
Participants Characteristics	**N**	**Percentage**
Sex		
Male	218	94%
Female	14	6%
Age		
21-30	81	35%
31-40	105	45%
41-50	44	19%
Did not complete the data	2	1%
Marital Status		
Married	185	80%
Unmarried (Single and/or divorced)	45	19%
Did not complete the data	2	1%
Working Period		
≤1 year	103	44%
>1-2 years	105	45%
>2 years	15	6%
Did not complete the data	7	3%

Table 2.
Descriptive Statistics of Research Variables

Variabel	Minimum	Maximum	Mean	SD
Workload	0.9934	1.219361	1.013664	0.025873
Sleep quality	1	15	7.57	2.547
Work fatigue	17	90	47.13	20.908

Prior to hypothesis testing, assumption tests namely multicollinearity, linearity, and normality tests were performed. The result of the multicollinearity test showed tolerance value 0.945 (0.01) and VIF 1.058 (<10), which means that there was no multicollinearity in the research data's regression model. The normality test using Kolmogorov-Smirnov showed a significance value of 0.074 (p>0.05). Linearity test between workload and work fatigue resulted in F=1143 and significance value of 0.235 (p>0.05), while between sleep quality and work fatigue resulted in F=1136 and significance value of 0.330 (p>0.05). Thus, it can be concluded that the assumptions in the study's regression model were fulfilled. Correlations between study variables can be seen in Table 3. The correlation between sleep quality and work fatigue was -0.364 (p<0.05), between workload and work fatigue, was 0.081 (p>0.05), and between workload and sleep quality was -0.234 (p<0.05).

Table 3.
Direct Effect Between Variables

Variable	Correlation Coefficient	
	Work fatigue	*Sleep quality*
Sleep quality	-0.364**	
Workload	0.081	-0.234**

Note: ** = significant (p<0.01)

To examine the relationships between variables, researcher conducted path analysis. The results can be seen in Table 4 and Figure 2.

Table 4.
Results of Path Analysis

Output	SE	t	b	LLCI	ULCI	p
Path a	6.3115	3.6475	-0.234	-35.4572	-10.5857	0.0003
Path b	0.5198	5.7494	-0.364	-4.0127	-1.9643	0.0000
Path c	53.1077	-1.2362	0.081	-170.2893	38.9904	0.2177
Path c′	51.1724	-2.6274	-0.166	-235.2778	-33.6199	0.0092

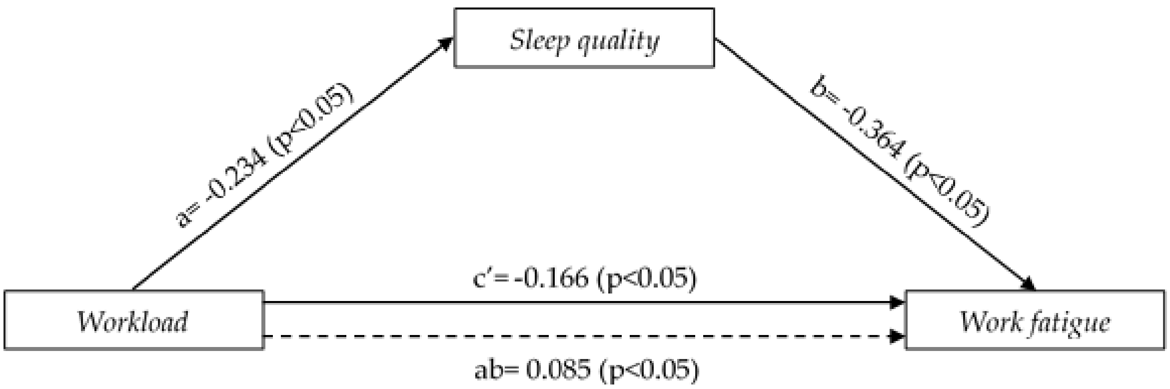

Figure 2. Relationship between variables

According to MacKinnon et al. (in MacKinnon, 2008), the requirement for the mediation test is that the coefficients for path a and path b are statistically significant. The test showed such significance. Then, from the results, it was found that path ab is smaller dan path c′ and can reduce the value of c by 0.081. Thus, it can be concluded that sleep quality can mediate the relationship between workload and work fatigue. Based on the path, it is likely that the role of sleep quality is a partial mediator. The hypothesis for this study was accepted.

In addition to the main result, sleep quality has an immediate effect on work fatigue, especially related to physical, mental, and emotional aspects. Among those three aspects, the biggest influence was found towards the physical aspect. It means that high quality of sleeping can reduce the mining workers' work fatigue. The finding is explained in detail in Table 5.

Table 5.
Regression Test for Sleep Quality and Workload towards the Aspects of Work Fatigue

	Physical Fatigue	*Mental Fatigue*	*Emotional Fatigue*
Sleep quality	-0.354**	-0.286**	-0.269**
Workload	-0.091	-0.086	-0.052

Note: ** = p<0.01

Additional analysis was done to examine the relation of research variables with participants' demographics. According to the Kruskal-Wallis test, it was found that there is no significant difference between workload and sleep quality based on age, sex, and marital status (p>0.05). However, there is a significant difference in the level of work fatigue based on the age group. The age group 21 to 30 years old was found to have a higher level of work fatigue compared to the other age groups (p<0.05). Meanwhile, if examined from sex and marital status, there is no significant difference in work fatigue level. The more comprehensive results of the Kruskal-Wallis test can be seen in Table 6.

Table 6.
Results of Kruskal-Wallis Test Based on Age, Sex, and Marital Status

	Age				**Sex**			**Marital Status**		
	21-30	**31-40**	**41-50**	**p**	**M**	**F**	**p**	**UM**	**M**	**p**
Workload	120.2	115.3	107.4	0.590	115	139.4	0.188	111.8	116.4	0.681
Sleep quality	116	116.4	112.5	0.943	115.3	134.7	0.293	101.7	118.9	0.119
Work fatigue	125.6	103.7	125.2	0.047	116.6	114.4	0.905	110.9	116.6	0.607

Keterangan:
M= Male UM= Unmarried (Single or divorced)
F= Female M= Married

Discussion

The study showed several findings. First, sleep quality was found to be a partial moderator in the relationship between workload and work fatigue among mining workers. This indicates that sleep quality can answer the unclear role of overtime and long work hours in work fatigue, which was the result of a meta-analysis conducted by Techera et al. (2016b). The 23 studies analyzed by that meta-analysis study showed inconsistent findings of those factors to the process of restoration after experiencing work fatigue. This result further reinstates that sleep quality plays an important in the relationship between workload and work fatigue, represented by overtime and long work hours. The quality of sleep could help moderate the effect of workload towards fatigue partially.

Poor sleep quality's more significant effect on physical fatigue is logically accepted because allowing the body organs to rest will help someone to not experience fatigue. Research by Park and Sprung (2015) showed such findings in a slightly different variable context. According to the study, sleep quality is a mediator in the relationship between work-school conflict and work fatigue. In this case, work-school conflict is the result of the workload experienced by students in the classroom.

The role of mining worker's sleep quality as a mediator, in this study, explained that poor sleep quality would increase work fatigue, especially when the workload is perceived as high by the mining worker. This finding supports results from a study by Querstret and Cropley (2012) that poor sleep quality is a predictive factor for chronic and acute fatigue. Of course, this is caused by the perceived workload.

Sleeping is a body inactivation period. In addition, sleeping is a recovery stage of physical and mental functions which is a part of what is termed as the sleep-wake cycle (Berhanu et al., 2018). The cycle consists of ±8 hours of nighttime sleep and ±16 hours of waking up during daytime in humans which are controlled by two internal factors: homeostasis process and circadian rhythm (Berhanu et al., 2018). The sleeping need for each individual is different. However, generally, adults require 7 to 9 hours of sleep per day. The need for sufficient sleep for the study's participants was difficult to fulfill because the working hours could be around 12 hours and the time required to reach the mining spot was 3 hours and 28 minutes per day (from home and to home). Thus, the remaining time was less than 9 hours per day. The time remained definitely could not be spent fully for resting because there were other activities to do such as preparation before working, child-rearing, et cetera so that optimum sleeping time could not be fulfilled. Sleeping works to restore energy and body tissues. Good sleeping quality will help an individual to improve energy, cognitive function, immunity system, memory, alertness, and performance (Bils, 2017). Meanwhile, an individual who does not get sufficient restoration is more prone to experience fatigue.

The lower the sleep quality a mining worker has, the higher the possibility for them to experience work fatigue. In addition to affecting work fatigue in general, sleep quality also influences each aspect of work fatigue namely physical fatigue, mental fatigue, and emotional fatigue. The influence of sleep quality on physical fatigue is higher compared to the other forms of fatigue. It is understandable as the participants were field workers, such as operators and mechanicians for heavy-duty equipment, rigger, digger, wielder, lifting, tyre man, and auto-electrician. Those positions demand a high level of physical activities and thus the physical fatigue score was higher than the mental and emotional fatigue.

A previous study done by Blafoss et al. (2019) explained that a higher level of physical activity influences after-work fatigue. Exposure to physical activities during work, such as: standing in one spot, bending or rolling the back spine, and repetitive arm motions are related to the increase of fatigue (Blafoss et al., 2019). Also, recurring tasks and the non-existence of stimulation increase the risk of fatigue and injuries (Williamson et al. 2011). The combination of previous and current findings further confirms that the poorer one's sleeping quality, the higher their mental fatigue would be.

Other relevant findings are from a study by Åkerstedt et al. (2004) which showed that mental fatigue is caused by a sleep disorder, high work immersion, high work demand, social support, gender, job position, and age. From those factors, sleep disorder becomes the most influential factor that causes mental fatigue with an estimation that individuals with a sleep disorder have a 4 times higher chance to experience fatigue if compared to individuals who do not have the disorder (Åkerstedt et al., 2004). Then, sleep quality has a negative influence on emotional fatigue. It means that the lower someone's sleep quality is, the higher their emotional fatigue. The relationship between sleep quality and emotional fatigue was also described by Li et al. (2020) who stated that sleep quality predicts the increase of emotional fatigue during the study period, but not in reverse. This finding provides evidence that sleep disorder can cause emotional fatigue.

An individual who works more than 8 hours a day is more susceptible to fatigue compared to individuals who work 8 hours a day. It is caused by a shorter and insufficient recuperation period. The average sleeping time for participants was 4.5 hours, while in 2015 National Sleep Foundation recommended that sleeping duration for adults to achieve optimum health is around 7 to 9 hours a day (Chaput et al., 2018). An experimental study by Michael et al. (2013) showed that there was a difference in cognitive performance and saliva biomarker of physical fatigue between the experimental group and the control group. In this case, the lack of sleep causes a significant change in the level of fatigue according to self-reports, cognitive performance, and saliva biomarker of physical fatigue.

In addition to the lack of sleep, the shift work system also affects the quality of sleep. In this study, the shift work applied is 6 day-shifts, 3 off-days, and then 6 night-shifts. Individuals who work in such system do not only face issues in the adjustment of Circadian rhythm. They have to do repeated adjustments every time they switch to the other shift. Although an individual has the opportunity to sleep during the day in the night-shift, it is difficult to fully adapt to the Circadian rhythm. According to Monk et al. (in Wong & Kelloway, 2016), the thing that inhibits Circadian rhythm adjustment is exposure to sunlight which naturally keeps the body awake. Other people's presence also prevents one to sleep. Based on the work system, shift workers tend to have poorer sleep quality than the ones who do not. Shift workers were found to face 198% higher risks of poor sleep quality compared to non-shift workers (Thach et al., 2020). Although shift work can cause health problems, it is still used in various industries because of the production and service needs that must run for 24 hours. Thus, it is important to think about reducing the effect of the shift work system, which is by identifying the internal clock of the workers.

The individual's internal clock (also known as chronotype) encompasses the peak of physical activities, alertness, and other physiological functions within the span of 24 hours which are related to the Circadian rhythm (Wyatt & Cvengros, 2012). An individual with morning chronotype or also known as Larks tends to go to sleep and wake up early. They are also more active and alert early in the morning (Wyatt & Cvengros, 2012). Individuals who tend to sleep and wake up later then become more active and alert during the nighttime are known to be night chronotype (also called Owl). The two types have endogenic differences in Circadian rhythm and the biological clock (Wyatt & Cvengros, 2012). Results from a study by Juda et al. (2013) showed that night chronotype workers who work the morning shift will experience more significant sleep disorder, social jet lag, shorter sleeping duration, and lower sleep quality compared to morning chronotype workers who do the night shift. Each individual has internal timing resulting from the biological clock (Roenneberg, 2012). The body's internal time is not always aligned with the social time used in daily life. Thus, the distribution of shift work system based on the person's chronotype to reduce the risks and increase the body's tolerance towards the working system.

This study showed that a higher workload causes poorer sleep quality. This finding is relevant to a study by Ghasemi et al. (2019) about nurses which involved 200 participants. The study obtained a finding that there is a direct negative effect of workload on sleep quality, which means that when the workload increases then the sleep quality deteriorates. Another study done by Heidarimoghdam et al. (2019) to office workers in the health industry who work more than 8 hours a day revealed that sleep quality and fatigue act as mediators in the relationship between mental workload and musculoskeletal disorder. In this case, the mental workload can lower sleep quality and cause fatigue the leads to the development of the musculoskeletal disorder (Heidarimoghdam et al., 2019).

The workload in the context of long work hours is related to a shorter sleeping duration. Sleeping duration is an aspect of sleep quality. Insufficient duration causes the body to be unable to have optimum recuperation and therefore leads to fatigue. The setup of work hours in the mining sector is different than in the other sectors. In the mining industry, the work hour is longer, the location is far from workers' residence which means a longer commute, and it applies a shift work system. This study was done on participants who work around 72 hours per week. According to the Bureau of Labor Statistics (2019), individuals who work more than 40 hours per week or 8 hours per day may experience fatigue. Several past studies showed that physical workload is positively related to work fatigue in employees (Mustofani & Dwiyanti, 2019; Mulia, 2019; Ansori, 2020).

Different from previous studies, the current study revealed that the influence of workload towards fatigue is indirect, and instead of being moderated by sleep quality. This finding is aligned with the study by Azwar et al. (2018) which showed that work-related factors (i.e.: work period, working shift, overtime, material burden, and noise) are not correlated with fatigue. However, non-work-related factors namely sleep quality and commute time contribute to fatigue. The study also found that workers with poor sleep quality are three times more prone to fatigue than the ones with decent sleep. An insignificant relationship between work-related factors and work fatigue is caused by the need for mediating variable. Another study showed that a higher mental workload is related to poor sleep quality (Jansen et al., 2020). This study also stated that an individual with a high mental workload has a 28% higher chance to experience poor sleep quality than someone with a low mental workload. Such results indicate that workload does not directly affect work fatigue, without a mediator.

There is a variance in work fatigue based on age groups. Participants who were 21 to 30 years old showed a higher average of work fatigue compared to other age groups. It is understandable, given that this age group is the most productive, thus the workload is relatively higher. In the productive age, optimization of responsibility becomes the main focus. Besides, there is a higher responsibility to oneself and to manage others, especially in older age groups.

The responsibility to support older workers becomes one of the reasons for additional fatigue load because according to Hsu (2019), older workers experience more obstacles and stressors in the workplace due to limited physical strength and health problems, a discrepancy in the use of new technology, and job involvement. The stress of older mining workers causes job delegation to the younger and more productive workers.

In addition to those reasons, according to Windwood et al. (2006), the youngest age group experiences the highest chronic fatigue level and yet the lowest recuperation level if compared to the older group. Furthermore, Windwood et al. (2006) also explained that the level of fatigue in the younger age group is caused by the adaptation toward shift rotation, including adapting to work during nighttime, so that fatigue in younger workers is higher.

Conclusion

Based on the study results, it appeared that sleep quality has a partial role to mediate the relation between workload and work fatigue in mining workers. Sleep quality was not entirely carried out its function as mediator; sleep quality affects the reduction of physical fatigue as a form of physical rest after experiencing physical workload, as characterized in mining workers.

The findings suggest that sleep quality is necessary to maintain physical, mental, and emotional conditions. Logically, it can be stated that when someone has poor sleep quality, they might experience physical fatigue that could develop into mental and emotional fatigue. It is caused by the disproportionate workload given to the person.

Implication

Future studies should consider inhibitors of work fatigue. Exploration within the topic of sleep quality can be furthered by considering factors i.e., punctuality and criteria of adequate sleep. Also, it is necessary to study the right time to have quality sleep within the work time, especially concerning the difference in shift pattern.

Practically, companies, especially those who employed shift systems, should facilitate their workers to rest and have adequate sleep. Facilities such as a nap room and space to conduct physical and non-physical activities could be provided. They will support workers to have a high-quality sleep.

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Author's contribution

RCH designed the study, conducted data collection, analysed the data, and wrote the manuscript draft. S supervised the research process and revised the manuscript.

Conflict of interest

Authors declare no conflict interest in this study.

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