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Work Shift System And Heavy Equipment Operator Fatigue in Mine

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Abstract. The application of the shift work system has an impact on health, including changes in the hemodynamic system, sleep patterns, and fatigue. The purpose of this study was to analyze differences in the fatigue of heavy mining equipment operators undergoing shift work systems. Quasi-experimental design with pre-test & post-test approach with control group. The population of heavy mining equipment operators is used a sample of 50 people. The instrumens with the Strooop Color and Word Test (SCWT). Analysis using the Wilcoxon test and the Mann-Whitney test. These results showed that there were differences in work fatigue in the shift and non-shift groups in the pre-test (p=0.022) and post-test (p=0.006). Prevention of work fatigue is carried out continuously so as to minimize the risk of work accidents. OSH workers and officers are expected to collaborate regarding health monitoring and the implementation of an orderly OSH culture to maintain safety and health while working.

Keywords: work fatigue, work shift, heavy equipment operator, mining

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Introduction

The implementation of the work shift system has an impact on the workforce. The impact of the work shift system on the health of workers includes changes to the hemodynamic system, especially blood pressure, changes in pattern sleep, and fatigue are frequent and reported cases. Fatigue due to subjective shift work can be in the form of not being able to take a nap, decreased appetite, indigestion, stomach pain (Purnomo, Manuaba, Adiputra, 2007; Manuaba, 2000). Schultz (1982, in James, 2005) argues that the night shift has a more negative effect on labor conditions than the morning shift, because the pattern of human life cycle at night is generally used for rest. However, because you have to work the night shift, your body is forced to follow suit. This tends to result in work errors, accidents and absenteeism.

The same opinion was conveyed by Pulat (1992) , that the impact of the night shift, especially disturbances in body rhythms which cause decreased alertness, physiological and psychological disturbances including lack of concentration, decreased appetite, stress and metabolic diseases can increase the risk of work accidents.

The Lampunut Development Project (LDP) is a project of PT. Maruwai Coal to build several mining facilities, including a coal hauling road. In order to accelerate project completion, several activities are carried out for 24 hours which are divided into 2 work shifts with a morning shift work schedule (05:00-17:00) and a night shift (17:00-05:00). The company operates heavy equipment such as excavators, bulldozers, graders, compactors and dump trucks during the road construction activities.

The application of the work shift system can be an factor in the occurrence of work fatigue, including through the mechanism of factors of intensity and duration of physical and mental work, work environment, physical problems, pain and health conditions, changes in the body's circadian rhythm, nutritional status, and personal characteristics of the workforce. The factor of

changes in the body's circadian rhythm is a factor that is widely discussed in studies of work fatigue, especially workers who undergo a shift work system (Tarwaka, 2014; Suma'mur, 2014).

The research results can provide scientific information about the implementation of the work shift system and its impact on the health of heavy equipment operators in mining companies, especially the risk of work fatigue which can result in work accidents.

Controlling potentials that can cause worker fatigue due to work shift patterns, especially psychological reactions, requires a more thorough study so that various negative impacts can be prevented earlier . From the results of the study it is hoped that a recommendation will be made for workers, the government and companies, especially in improving work shifts.

Method

This study used a quasi-experimental study with a pre-test & post-test approach with a control group. Shift and non-shift work groups. Determination of the sample in each group was carried out randomly and the calculation of the number of samples using the Lemenshow formula obtained 100 heavy equipment operators including 50 operators with working shifts and 50 operators without working shifts. Measurement of work fatigue using the *Strooop Color and Word Test* (SCWT) instrument, which is a test that measures the concentration of labor in measurement by naming 10 colors of writing correctly in a span of 20 seconds . The pretest and posttest measurement periods were carried out after one shift period (2 weeks). Data analysis using Wilcoxon and mann whitney.

Results And Discussion

Data on workforce characteristics include gender, age, length of work, job position or title, supporting health data (systolic and diastolic pressure, heart rate frequency, sleep duration, and subjective fatigue complaints). Data as follows:

Table 1. Frequency Distribution of Labor Characteristics in the Lampunut Development Project

No	General Characteristics	Category	Group shif (n=50)		Group non-shif (n=50)	
			n	%	n	%
1.	Gender	Laki-laki	50	100	50	100
2.	Age (tahun)	<26	8	16	6	12
		26-35	19	38	17	34
		36-45	16	32	18	36
		46-55	7	14	9	18
3.	Length of time worked	<1	12	24	3	6
		1-2	23	46	27	54
		≥3	15	30	20	40
4.	Job Position	Operator DT	9	18	4	8
		Operator ADT	9	18	11	22
		Operator MT	4	8	-	-
		Operator man haul	1	2	-	-
		Operator fuel truck	3	6	-	-
		Operator dozer	7	14	5	10
		Operator excavator	7	14	18	36
		Operator compactor	7	14	6	12

Table 1 shows that all heavy equipment operators in the shift and non-shift groups are male. Work in mining requires good physical and mental endurance to cope with a work environment that is far from residential areas so that most companies require male workers.

The highest age category in the shift group is 26-35 years 38%, in accordance with the requirements for recruiting employees the maximum average age is 25 years while in the non-shift group it is 36-45 years (36%) based on the job position the longer the working period directly proportional to the age of the workforce.

The length of time most operators worked was 1-2 years, 46% in the shift group and 54% in the non-shift group. The types of heavy equipment operators were mostly in the shift group, namely DT operators and ADT operators each 18% and in the non-shift group excavator operators 36%.

Table 2. Blood Pressure Data; Pulse Frequency; Sleep Duration; and Subjective Worker Fatigue Complaints in the Lampunut Development Project

No	General Characteristics	Category	Group shift (n=50)				Group non-shift (n=50)			
			Pre-tes		Pos-tes		Pre-tes		Pos-tes	
			n	%	n	%	n	%	n	%
1.	Blood Presure sistole / diastole	90/60-120/79	36	72	34	68	35	70	32	64
		121/80 - 139/89	10	20	10	20	12	24	14	28
		140/90-159/99	4	8	5	10	3	6	4	8
		≥160/100	-	-	1	2	-	-	-	-
2.	Pulse Frequency (times/minute)	<80	16	32	19	38	16	32	15	30
		80-100	33	66	27	54	33	66	34	68
		>100	1	2	4	8	1	2	1	2
3.	Sleep duration (hour/day)	5-6	38	76	33	66	44	88	44	88
		78	12	24	17	34	6	12	6	12
4.	Subjective Complaints of Fatigue	Tiredness of the whole body	5	10	7	14	4	8	4	8
		Feeling of heaviness in the head/shoulders/back/legs	8	16	9	18	7	14	7	14
		Frequent yawning	2	4	4	8	2	4	2	4
		Feeling of heaviness in the eyes	3	6	3	6	1	2	2	4
		Feeling like lying down	4	8	6	12	4	8	4	8
		Difficulty concentrating	5	10	7	14	-	-	-	-
		Dizziness	4	8	7	14	5	5	7	14
		Decreased appetite	-	-	1	2	-	-	-	-

Table 2 shows that the blood pressure of most heavy equipment operators in the two measurements was at blood pressure 90/60-120/80 mmHg, namely 68% and the percentage of blood pressure was 90/60-120/80 mmHg in the first measurement of the shift group 72% and non-shift 70%, and the percentage in the measurement of the two shift groups is 68% and the non-shift group is 64%. A heavy equipment operator (2%) in the shift group has a blood pressure ≥160/100 mmHg. The task of heavy equipment operators when working is always related to machines that generate noise related to noise and dusty conditions that make the work environment not ergonomic, increase workload and can be a trigger factor for work fatigue. The disease suffered by 4 heavy mining equipment operators undergoing shifts, namely hypertension stage 1, so that the condition of work fatigue tends to increase in relation to the cardiovascular health conditions of these workers

Heavy equipment operators in the shift and non-shift groups had the same percentage (66%) in the first measurement of heart rate frequency, namely 80-100 beats/minute, and in the second measurement the shift group was 54% and the non-shift group was 68%. The pulse frequency in the measurements of the two shift groups was 8% of operators with a heart rate of 100 beats/minute. Fatigue occurs due to an imbalance in the sympathetic and parasympathetic activation systems. Increased activity will be shown by several symptoms from the body's vital organs including cardiovascular through a mechanism for increasing blood flow by increasing heart rate and contractility of heart cells (blood pressure).

The duration of sleep for most of the operators was 5-6 hours per day in the shift group (76%) while in the non-shift group it was 88%, in the second measurement the shift group was 66% and in the non-shift group it was 88%. The normal sleep requirement for adults aged 18-40 years as stated by P2PTM Ministry of Health 2018 is 7-8 hours/day, and ages 40-60 is 7 hours/day, and there is an elderly age (> 60 years) which is 6 hours/day . Sleep duration that is less than standard causes a decrease in sleep quality which has a subjective impact on feelings after waking up, causing fatigue. Operators who have less sleep hours need to get attention because in the long term this habit can affect their health.

Subjective fatigue complaints expressed by heavy equipment operators in the shift and non-shift groups at the end of the measurement were the feeling of heaviness in the head/shoulders/back/legs (18%) and the second complaint was dizziness, while the heavy equipment operators in the non-shift group did not complained of difficulty concentrating and decreased appetite.

Table 3. Cross Tabulation of Shift System and Work Fatigue of Heavy Equipment Operators in the Lampunut Development Project

Periode pengukuran	Kelompok	Kelelahan kerja (SCWT)			Total
		Fit	Kurang fit	Tidak fit	
Pre-tes	1. Sif	45 (90%)	5 (10%)	-	50 (100%)
	2. Non-sif	50 (100%)	-	-	50 (100%)
Pos-tes	1. Sif	43 (86%)	7 (14%)	-	50 (100%)
	2. Non-sif	50 (100%)	-	-	50 (100%)

Table 3 shows that all heavy equipment operators in the non-shift group on two measurements were in a fit condition, while in the shift group there was a decrease in the percentage of fit conditions from 90% to 86%. Heavy equipment operators in the shift group experienced an increase in the percentage of unfit conditions from 10% to 14%, and none of them experienced unfit conditions. Changes in the body cycle of workers who undergo a shift work system cause them to be at greater risk of experiencing work fatigue. For the most part, heavy mining equipment operators stated that when they were doing shift work they had problems getting to sleep/resting in the mornings during the day, but they still tried to be able to meet their sleep needs so they could be refreshed when working in the afternoons. This complaint is in line with the opinion expressed by James (2005) in Occupational Health Clinics for Ontario Worker Inc. that the human body has a biological clock that regulates complex internal functions throughout the day for 24 hours. A number of physiological functions show changes in rhythm (circadian rhythms) over a 24-hour period. Circadian rhythms have been found to be associated with changes in mental and physical performance. The human body is meant to be active during the day, whereas the night hours are meant for sleep which allows it to recover and replace energy. Working at night and sleeping during the day is against the body's biological clock and what the body naturally wants to do. This can make it difficult to sleep, it may also mean that the body is not able to recover as quickly from physical and mental exertion.

Mining heavy equipment operators in the Lampunut Development Project have working hours of 12 hours/day equivalent to 78 hours/week. In a 2-week period they will work 7 days of the morning shift and a 6-day evening shift, with one day off on the last day. According to the International Labour Organization (2019), the work shift system includes fixed shift and rotating shift systems. Certain groups of workers who always work in the same shift get what is called a fixed shift. Meanwhile, the rotating shift will schedule varying working times over time, which lets a worker work from morning to evening shifts, from evening shifts to night shifts, or from night shifts to morning shifts. Health Statistics Profile Data states that there is an increase in health complaints of 3.46 % in workers who work ≥60 working hours per week compared to workers who work 45-59/week. Even though the percentage of mining heavy equipment operators who experience unfit conditions is only a small portion (10% pre-test, 14% post-test) and none are in an unfit condition, because this shift cycle will take place continuously, fatigue conditions This needs to get the attention of all parties, namely the individual workforce and company management so that the long-term impact on health and the risk of work accidents due to work fatigue can be minimized or not occur. The shift system involves various work patterns and schedules where the arrangement must consider several factors, including the duration of the shift or the length of working hours for each shift, the number of team workers , hours of work breaks, rotation period or speed (number of days for changing shifts), and shift time off. . Another thing that needs to be considered in setting up work shifts is the regularity of the shift schedule. Work shift irregularity can affect the quality of sleep of employees which can cause health problems or affect the social life of employees.

Table 4. Differences in Pre-test and Post-test Heavy Equipment Operator Work Fatigue in the Lampunut Development Project

	Fatigue	Mean	SD	p value (wilcoxon)
1.	Fatigue pre-tes	1,050	0,219	0,157
2.	Fatigue pos-tes	1,070	0,256	

The results of the Wilcoxon test showed that the difference in mean/average work fatigue was 0.020; pre-test average 1.050 and post-test average 1.070. The closeness of the data point to the mean (standard deviation or SD) pre-test fatigue value is 0.219, and post-test is 0.256 with a p value of 0.157 so that there is no difference in mining heavy equipment operator fatigue between pre-test and post-test measurements. Human organs are the most adaptive organs.

Organs can adapt to environmental conditions so that there are no changes between pre and post in the shift group or pre and post in the non-shift group. Bad environmental conditions can result in changes in organs that are not in accordance with their functions and can damage human organs.

Table 5. Differences in Work Fatigue for Heavy Equipment Operators in the Shift and Non-shift Groups at the Lampunut Development Project

Fatigue	Mean Rank		P value (mann – whitney)
	Sif (n=50)	Non-sif (n=50)	
1. Fatigue pre-tes	53,00	48,00	0,022
2. Fatigue pos-tes	54,00	47,00	0,006

shift group; pre-test average 53.00 and post-test average 54.00. There was a decrease in the mean rank pre-test and post-test in the non-shift group of 1.00 ; pre-test average 48.00 and post-test average 47.00.

The results of the fatigue test pre-test p value = 0.022 and post-test p value = 0.006; the value of both is smaller than α 0.05 , so there is a difference in the fatigue of heavy mining equipment operators in the shift group and the non-shift group in the pre-test measurement and post-test measurement. Subjective fatigue complaints expressed by shift and non-shift heavy equipment operators at the two most frequent measurements were feelings of heaviness in the head/shoulders/back/legs, and the second complaint was dizziness. Complaints of difficulty concentrating and decreased appetite on two measurements were absent in the non-shift group. Susetyo's study (2012) stated that the average subjective fatigue score for morning shift workers was 3.8 (fatigue level 1, low fatigue classification), while the afternoon shift was higher, namely 6.5 (fatigue level 2, moderate fatigue classification). Subjective complaints due to fatigue in the form of symptoms or feelings related to physical weakness, weakening of motivation, and weakening of activities. The shift group showed symptoms of physical weakness; motivation; and activities, while the non-shift group only showed physical weakness and activities. In general, chemical theory explains that the occurrence of fatigue is due to reduced energy reserves and increased metabolic waste as a cause of loss of muscle efficiency, while changes in electrical currents in muscles and nerves are a secondary cause. Meanwhile, the central nervous theory explains that chemical changes are only supporting processes. The chemical changes that occur result in the transmission of nerve impulses through the sensory nerves to the brain which is recognized as muscle fatigue. This afferent stimulation inhibits brain centers in controlling movement so that the potential frequency of activity in nerve cells decreases. Reduced frequency will reduce the strength and speed of muscle contractions and movements on the will become slower. Work fatigue causes the frequency rate (FR) to increase quite high, namely 31 accidents. The 2018 FR value is 1.14. The highest fatigue is experienced by night shift workers. Refreshment by fulfilling sleeping hours when not working, taking advantage of rest periods or shifts, and short breaks during working hours can also provide refreshment for all workers (Tarwaka, 2014). The process of refreshing work must be carried out outside the pressure (cancel out stress). The application of a work system with a total ergonomics approach is proven not only to reduce musculoskeletal complaints, work fatigue, worker workload, and the risk of injury at work, but also to increase productivity, labor income, and company income (Alii, 2008). and companies to reduce the impact of the work shift system needs to be done. As per regulations in Indonesia, companies are required to have a commitment to implementing SMK3, carry out periodic health checks, and provide treatment if illness occurs. The workforce, in this case the operator, has a personal responsibility to continue to apply personal habits through working with a K3 culture, and maintain other healthy lifestyle behaviors, for example not smoking or consuming alcohol and caffeine; fulfill breaks during shift hours; meet the needs of balanced calories; exercise about 2 times for 60 minutes per week; and

immediately communicate to the company's medical officer if you experience health complaints

Conclusions

Heavy equipment operators in mining who undergo shift work significantly show the incidence of work fatigue compared to non-shift based on the SCWT assessment and other work fatigue supporting assessments. There is no difference in mining heavy equipment operator fatigue in the two measurements within 2 weeks.

A good operator working mechanism can reduce work fatigue such as hand movement patterns and taking breaks after work.

The management of the company needs to carry out continuous evaluations through job analysis and job descriptions to obtain high levels of productivity and conduciveness as well as to provide incentives.

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