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Reduce workload of security officers using NASA-LTX, SOFI, Heart Rate and Energy Expenditure Method

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Abstract. Ergonomics is one area of science that study on the workload and fatigue of the workers. The industry needs to increase operational time to 24 hours and 7 days, has become a necessity to meet customer satisfaction. The impact of increasing operating time, necessitated employees working at the night shift, one of which is security officer, with main task of maintaining the safety and security of the company and its employees for 24 hours. Working the night shift can lower performance and interfere of health, because it causes drowsiness, fatigue and physical sluggishness. The objectives of this research is to evaluate the workload of the security officers working the night shift. This research using SOFI, NASA-TLX, Heart Rate and Energy Expenditure method. Results of this research prove that methods can used to determine the workload, with light categories. The Security officer experience fatigue after working 5 days consecutive, be marked the emergence of drowsiness. As a recommendation, a good of work shift rotation systems is shorter rotation system, i.e. 2 days of morning shift; 2 days of day shift; 2 days of nights shift, and 2 days off, with this rotation system, security officer will only experience a mild drowsiness.

1. Introduction
As time goes by, the security officer, sued for more professional in terms of both planning, structure organizational, responsibilities, procedures, processes and human resources. Based on the regulation of the Head Police of the State Republic Indonesia No. 24, December 10, 2007, regarding the management system of organization’s security, companies and/or agencies/government agency, in the exercise of his duties, a security officer, who is a professional, obliged to understand basic tasks, functions and role of the security officer. As a limited Police function carrier, the security officer acted as Police assistants, the leadership element of the organization, companies and/or agencies/government agencies in terms of fostering security, order the community, enforcement regulatory legislation as well as awareness and vigilance of the security in the environment or the workplace.

Some examples of services that do security officer, is: thorough patrols around the area of the company, VIP escort, service by using the system of alarm response, physical protection (the building, employees), security of events or exhibitions, education and training about security and consulting other types security, which usually coordinate with specific institutions. The ability of the security
officer is very useful for the company; given the security officer is ‘first liner’ or people who have always been at the forefront over 24 hours/7 days continuously in a State of secure nor emergency. To add insight and field its work, security officer is also equipped with sophisticated equipment to carry out its duty such as; CCTV, the shock gun; VTS (Vehicle Tracking System) namely tool to monitor the whereabouts of the vehicle in the area of operations, and so on.

The decline in the quantity and quality of sleep and the extension of the duration of wakefulness will result in the occurrence of sleep debt and boost homeostatic to sleep [9]. Meanwhile, [2] identifies the length of work shift schedule will affecting fatigue. [3] Stated another important factor that can increase fatigue is work shift [10]. Some studies report a decline in performance associated work night shift and shift rotation [3]. The low of value of the physiological parameters, such as heart rate and blood pressure, on a work night shift [3]. According to [3], energy expenditure during night shift higher than day shift. In [3] there is a significant relationship between shift work and fatigue, and a period of rest between shifts day and night shift are short. The problem of this research is how the level of the workload experienced by the security officer during working the night shift. The objectives to be achieve in this research is evaluate the level of workload received security officer during working the night shift. This research focus at the level of the workload experienced by the security officer during working the night shift.

2. Methods

2.1. Research participants

Participants in these research amount eight-security officers, work three shifts and 4 working groups, where each group consists of 2 employees. Genders are male, with ages of 22-51 years.

2.2. Methods and procedure

This research using methods qualitative and quantitative. Methods Qualitative using SOFI and NASA-TLX questionnaires, and quantitative using measurement of heart rate and energy expenditure.

NASA-TLX is a subjective assessment tool, which used to determine the level of workload, with a multi-dimensional rating procedure. The end results are overall value of workload based on six sub-scale, namely mental workload, physical workload, time pressure, job satisfaction, level of effort and level of stress.

The Swedish occupational fatigue inventory (SOFI) is an ordinal scale questionnaire used to measure the fatigue level based on perception of the individual. SOFI consists of five dimensions, namely sleepiness, physical discomfort, lack of motivation, lack of energy, and physical exertion. Perception of fatigue in SOFI are divide into perception against the physical and mental work. Perception of the physical work is visible from lack of energy, physical exertion and physical discomfort, mental work is visible from of lack of energy, lack of motivation and sleepiness; and perception towards the work shift that is sleepiness, lack of energy and lack of motivation.

Questionnaire SOFI, consisting of two types, called SOFI-A, used before work and SOFI-B used after work. This is to reduce the effect of learning filling in the questionnaire. Respondents asked to fill out this questionnaire before work and after work, in which respondents choose the value provided in the questionnaire. Assessment using Likert scale, i.e., the value of 0 to 6, a value of 0 stated that the respondents did not feel at all, whereas a value of six States what the respondent felt after doing his job.

The measurement of the heart rate using the special tool for measuring the pulse of branded Omron. Measurement of energy expenditure uses a model of the prediction of oxygen consumption [New].

\[ \text{VO2} = 0.029 \times \text{Weight} + 0.028 \times \text{heart rate} - 3.606 \]

Conversion: 1 l/min of oxygen consumption = 4.8 kcal/min

3. Results

In carrying out its duties, professionals security officer, mandatory understand of basic tasks, functions and role of the guards. Where in the end a security officer must be able to exercise its task properly
and able to assist the enforcement of regulations. Security officers carry out the task of maintaining security in this plastic packaging company. Another task is to hand over the job when the work shift shifts, receives guests or contractors, and receives letters or documents, records items, vehicles, employees who enter or leave. In addition, he also checked the baggage of the vehicle, raised and lowered the flag, turned on and turned off the lights in the area outside the building. Then controlling garbage loading, recording electricity and water usage, managing traffic, opening and locking office doors, patrolling all areas outside the company, supervising contractors when leaving the company area. Reporting in the event of abnormal events, cleaning security posts, conducting regular monthly meetings, evaluating the performance of security personnel and coordinating with company safety officers.

All security officers consists of 8 people, to enhance the security and safety of the company's assets for 24 hours/7 days, security officer is divided into 4 group with 3 shift work, 8 hours of work per shift, 5 working days per week (40 hours per week) and 2 days off. Rotation used is the morning into the afternoon into the night.

| Table 1. Operational hours |
|-----------------------------|
|                            |
| **Descriptions**            |
|                            |
| **Shift 1** (Morning Shift) |
| Start time                  |
| 07.00                       |
| Break time                  |
| 12.00 – 12.30               |
| Finish time                 |
| 15.00                       |
| Over time                   |
| 15.00 – 19.00               |
|                            |
| **Shift 2** (Day Shift)     |
| Start time                  |
| 15.00                       |
| Break time                  |
| 18.00 – 18.30               |
| Finish time                 |
| 23.00                       |
| Over time                   |
| 23.00 – 03.00               |
|                            |
| **Shift 3** (Night Shift)   |
| Start time                  |
| 23.00                       |
| Break time                  |
| 02.00 – 02.30               |
| Finish time                 |
| 06.00                       |
| Over time                   |
| 07.00 – 11.00               |
|                            |
| **Office**                  |
| 08.00                       |

The results of the data processing for NASA-TLX indicate after working the night shift for five consecutive days, the workload experiencing an increase of the value, from day 1 to 5, i.e. of 56.6, 57.8, 64.0, 64.1 and 68.8. The average workload of the all security officer was 10.4 in the category of moderate level.

The workload, which include heavy category experienced by all security officer, was found on the level of effort of 13.0 and job satisfaction of 12.1. While mental workload, physical workload, and time pressure, belongs to the category of level moderate, with each value 10.6, 9.2, and 10.5. As for the workload in light categories contained on the levels of stress (Frustration) of 7.0.

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**Figure 1.** The NASA-TLX workload

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In the calculation SOFI, average of workload experienced by the all security officer in the light categories namely 0.68. The biggest workload of five dimensions experienced by the all security officer is drowsiness of 0.84, as seen in Figure 3.

Evaluation of physiological workload experienced by a worker can also by measuring the heart rate. Measuring physical work a person, the more heavy of physical work, then, the more weight the heart work anyway, which is indicate by the increase in heart rate. Heart rate average all security officer are light level, as seen in Figure 4.
4. Discussion

4.1. Level of workload

Research using NASA-TLX questionnaire proved to be able to determine the value of the workload. The research found that the phenomenon of workload received when the security officer of working at night shift for five consecutive days, have an increased workload from the day the 3rd to 5th. The workload experienced by security officers is light workload of one person, moderate workload of five people and heavy workload of two people. The difference of this workload is affect by factor of the number hours sleep by the security officer.

Based on interviews with security officers who experienced heavy workloads. Known that security officers-3 have lacked hours of sleep because he was caring for his children aged 5 years and 8 years. He did not sleep well when his wife works from 8 am to 5 pm. While the security officer-5 experienced less hours of sleep because of the distance of the house with an office of around 80 km. He took about 2 hours using a motorcycle or it also when he returned to his house.

4.2. Characteristics of the workload

The Workload-Level of Effort-Category Heavy

An average workload of the whole security of 10.4 in the category of level moderate. The results of research using the NASA-TLX questionnaire found that workload experienced by the all security officer at the mental workload, physical workload, and the pressure of time in the category of moderate. As for the workload in light categories contained on the level of stress.

The NASA-TLX questionnaire analysis also found that the workload in the heavy category is the level of effort of 13.0 and job satisfaction of 12.1. These results indicate that the all security officer issue the high effort physically and mentally to achieve good performance. The level of this venture will lead to physical and mental exhaustion for all security officer.

Level of effort is high workload, because the task given to security officer, to conduct patrol to all area of company, every hour and make reports the results of the patrol. In performing patrol, security officer must use Amano to record the time of execution of the patrol. With an area company of about 10,000 m², then a roving patrol activity take about 15 minutes. A security officer work area conditions are outside the building greatly affects the workload of security officer. The time of the evening, the temperature of the environment in the area outside the building sometimes reach 20 °C, will be even more and smaller/cold again when rain falls. This condition makes the workload high physically and mentally to achieve good performance.

4.3. Workload is more dominant Drowsiness

Research using SOFI has proven to be able to determine the level of workload of security officers. This study shows that the biggest workload experienced by all security officers is 0.87 sleepiness. This is because the nature of the work performed by security officers during the night shift is more dominantly waiting, causing boredom and drowsiness. Boredom and sleepiness accumulate every day for 5 days while working the night shift. Company patrol activities carried out for 15 minutes on every

![Figure 5. Energy expenditure all security officers.](image-url)
hour cannot eliminate the drowsiness experienced by security officers. When compared to the activities of security officers on day shift, security officer on the night shift more dominant sitting and waiting at the security post. During the day shift, security officers sometimes receive and check the arrival of guests, contractors and truck deliveries, when the night shift does not exist.

4.4. Physiological workload of lighter categories
Measurement using heart rate and energy expenditure measurements can proved to determine the workload experienced by the all security officer. Based on the results of measuring the heart rate of security officers when 5 days worked on the night shift, the average heart rate was 79.6 pulse / minute, and included a light workload. The average measurement of energy expenditure for all security personnel is 4.1 kcal / minute, including light workload. Physiological workload is light, because on night shift the security officer only checks the condition company area for about 15 minutes and then sits and waits.

4.5. Implications for Industry
Based on the opinions of experts on workload, it known that fatigue working on the night shift is greater than the day shift. The results of this research found that rotation system of shift work 5-2, which is currently done, is potentially huge raises the boredom and monotony for security officers working the night shift. This research assesses the work 5 days consecutive on the night shift are not appropriate for activities more dominant sit and wait. Based on the ILO (1983), change a normal shift is 8 hours/shift. Work shift changes that are carrier out 24 hours including Sunday or national holidays require four work teams. This squad known as a constant work team (3x8). The United Kingdom uses a 2-2-2 system; this system known as a short rotation system with each shift duration of two days then gets two days off. Based on the opinions of experts and the INTERNATIONAL LABOUR ORGANIZATION (1983), this research make changes to system rotation of shift work, from the system 5-2 to system 2-2-2 (short rotation). Changes to the 2-2-2 rotation system of work were starting in October 2016. As for the results of this work rotation system changes is as follows:

4.5.1. Workload Rate Dropped 3%.
Based on the analysis method of the NASA-TLX, changes to the system rotation of shift work, successfully lower the workload of a 3% rate from 13.0 to become 12.1, as seen in Figure 6, this is due to experience security officers working the night shift just 2 today only.

4.5.2. Workload Drowsiness Down 47%.
According to the calculation SOFI methods, work shift rotation system from 5-2 become 2-2-2 proven can decrease the burden of drowsiness from 0.87 be 0.46 or dropped by 47%, as seen in Figure 7. This is due to security officer working of night shift experience just 2 days, while the system of rotation of the previous are 5 days.

| Mental Workload | Physical Workload | Time Pressure | Job Satisfaction | Level of Effort | Level of Stress |
|-----------------|------------------|--------------|------------------|----------------|----------------|
| Average         | 10.4             | 9.9          | 10.6             | 11.8           | 12.1           | 7.0            |
| Percentage      | 52.0%            | 49.6%        | 53.0%            | 58.8%          | 60.6%          | 34.9%          |

**Figure 6.** Workload-NASA-TLX after the change of rotation shift work
In addition to the reduced drowsiness workload, based on the SOFI calculation method, after changing shift work, all security personnel experienced a decrease in workload from 0.69 to 0.51 or decreased by 26% as shown in table 2.

Table 2. Workload security officer after the change of rotation shift work

| Workload        | SO-1 | SO-2 | SO-3 | SO-4 | SO-5 | SO-6 | SO-7 | SO-8 | Average | Category |
|-----------------|------|------|------|------|------|------|------|------|---------|----------|
| Physical Exertion | 1.57 | 1.20 | 0.22 | 0.78 | 0.28 | 0.52 | 0.78 | 0.75 | 0.76    | Light    |
| Lack of Motivation | 0.73 | 0.87 | 0.00 | 0.05 | 0.00 | 0.17 | 0.02 | 0.12 | 0.24    | Light    |
| Lack of Energy   | 1.42 | 1.08 | 0.37 | 0.32 | 0.20 | 0.72 | 0.10 | 0.52 | 0.59    | Light    |
| Physical Discomfort | 1.47 | 0.83 | 0.10 | 0.57 | 0.00 | 0.32 | 0.10 | 0.50 | 0.49    | Light    |
| Sleepiness       | 1.27 | 0.85 | 0.07 | 0.35 | 0.18 | 0.33 | 0.03 | 0.60 | 0.46    | Light    |
| Total            | 1.29 | 0.97 | 0.15 | 0.41 | 0.13 | 0.41 | 0.21 | 0.50 | 0.51    | Light    |
| Category         | Light | Light | Light | Light | Light | Light | Light | Light | Light    | Light    |

4.5.3. Physiological workload according to heart rate increase 4.6%.

Based on Table 2, the average value of heart rate changes after rotation of shift work increase of 4.6% i.e. from 79.6 pulse/minute be 83.3 pulse/minute but still in the category of a light workload. This increase was cause by changes in the working day cycle from 5 working days to 2 working days and then a holiday. Although the overall average heart rate increase 4.6%, but changes the rotation of shift work managed to lower the average score heartbeat of security officer on the night shift, days 5th and 6th of 1.1% , 79.6/ minutes be 78.8 pulse/minute, as shown in Figure 8.

Figure 8. The heart rate changes after the shift rotation changes.

4.5.4. Workload Physiology according to Energy Expenditure rose 13%.

The value of energy expenditure throughout the security officer after a change in the rotation of shift work increase 13% from 4.10 kcal/min into 4.62 kcal/min but still in the category of a light workload. Although the overall value of the expenditure experienced the increase amounted to 13% but changes the rotation shift work managed to decrease the workload on the night shift when the days of the 5th and 6th of 2% from 4.10 kcal/min into 4.01 kcal/min as seen in Figure 9.
5. Conclusion

This research was to evaluate workload of security officer while working on night shift, using NASA-T LX and SOFI questionnaire, the measurement of heart rate and energy expenditure. Based on the research conducted, the workload associated with the night shift work security officer concluded several things, including:

1. The level of the workload experienced by the security officer is included in the category of light, is evident from the analysis questionnaires SOFI, heart rate and energy expenditure.
2. The type of work performed by the security officer has a workload for physical and mental work, which is almost balanced, i.e. amounting to 51% and 53%.
3. Characteristics of the workload experienced by the largest security officer was drowsiness that arise starting day 3 to day 5.
4. Security officer experience fatigue after working five consecutive days marked the emergence of drowsiness.
5. The workload with effect drowsiness are lighter, with system rotation of shift work 2-2-2.

This research still has deficiencies, namely the number of participants is only eight people. The researcher hopes the next researcher will have more participants.

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