The Relationship Analysis between Physical and Mental Workload with Work Fatigue in Extruder Section at PT. ABC

Fanisa Ismi Permatasari and Muchlison Anis
Industrial Engineering Department
Muhammadiyah University of Surakarta
Surakarta, Indonesia
d600170115@student.ums.ac.is, ma228@ums.ac.id

Abstract

Work fatigue can have dire consequences such as decreased productivity and quality, incorrect decision making, and increases risk of work accidents. This study aimed to determine the relationship between physical workload and mental workload with the work fatigue of the extruder section operator at PT ABC. The IFRC questionnaire is used to test worker fatigue, calculate the CVL percentage to determine the physical workload, and NASA TLX to determine the mental workload. This research is a cross-sectional study consisting of two independent variables: physical and mental workload, and one dependent variable, the level of fatigue, is analyzed through simple correlation tests. The sampling method used for this study was total sampling, all 26 operators of the extruder section. The analysis results show from the CVL score indicate that there is no fatigue. Meanwhile, in the NASA-TLX analysis, three operators get very high mental load category, 18 operators in the high category. Then, there are 11 operators into the low category and 15 operators into the medium category for fatigue. The Pearson and Spearman correlation test with 0.05 showed that there was no relationship between physical workload (sig = 0.77) and mental workload (sig = 0.189) on the level of fatigue.

Keywords
Work Fatigue, Physical Workload, and Mental Workload

1. Introduction

Work fatigue is one of the problems that often occur in the modern era, especially fatigue in manufacturing industry workers (Luckhaupt 2012). Work fatigue can have harmful consequences such as decreased productivity, decreased product quality, incorrect decision making, inaccuracy in doing work, and even increasing the risk of work accidents (Torres-harding and Jason 2005, Atiqoh et al. 2014). Work fatigue can be categorized as one of the causes of unsafe acts. Most work accidents in the industry are caused by workers who are exhausted beyond their tolerance limits. The risks caused by work fatigue threaten individual workers and co-workers, and the system (Gabriel et al. 2018, Yazdi and Sadeghniiat-Haghighi 2015). According to data from the International Labor Organization (ILO), in 2013, two million workers experienced work accidents due to fatigue. The study explained that from 58,115 samples, 32.8% of them experienced fatigue (Markkanen 2004).

Fatigue in the industry is caused by work overload (Saito 1999). Workload arises from the interaction between task requirements, circumstances on duty, skills, behavior, and operator perceptions (Hart and Staveland 1988). There are two types of workloads, including physical workloads related to energy, muscle, and physical stamina. Then there is the mental workload related to cognitive activities such as seeing, searching, and thinking (Puteri and Sukarna 2017). Work fatigue can be caused by two interrelated aspects, the physical aspect, and the mental aspect. Although these two things are interrelated, there are differences in conditions and symptoms, and it is essential to analyze these two things (Kanarek and Lieberman 2011, Saito 1999).

According to the data from the company, the extruder section at PT ABC is the section with the highest workload among other sections that involve both physical and mental workloads. The work carried out in the extruder that causes physical burdens includes lifting materials using a hand lift which can reach 300 kg, lifting and mixing resin materials which in one shift an operator can lift 3 tons of resin, making adhesives whose raw materials vary from 5 kg up to 15 kg. At the same time, work activities that involve mental workload include making reports every shift, checking raw materials according to order specifications, setting films, checking defects using a computer, or manually using eyes.

Through the workload in the extruder section, operators can feel various complaints, including sore feet, sore hands, and headaches. The complaint is also felt to be reasonable, apart from the high work activity, because the working environment is quite noisy with the sound of the extruder engine and the heat of the room temperature. Several work accidents have occurred in the extruder section, including a fire accident, being stuck in a machine, being caught in a roll, and being exposed to plastic material with a heat of 300 degrees. The work accident was allegedly caused by human error due to perceived work fatigue.

From the above problems, this research focuses on analyzing the relationship between physical workload and mental workload individually on the level of operator fatigue in the extruder section. This cross-sectional research examines three variables to find their relationship quantitatively. The results of this study are expected to be an evaluation reference for the work process of the extruder section at PT ABC to produce a system and work environment that is safer, more comfortable, and more productive.

1.1 Objectives
Research objectives are to calculate and classify PT ABC extruder operator fatigue level using the IFRC questionnaire, calculate and classify PT ABC extruder operator's physical and mental workload according to the calculation of cardiovascular load percentage and NASA-TLX, and to find the relationship between physical and mental workload with fatigue level using a simple correlation test.

2. Literature Review
2.1 Fatigue
Fatigue is any physical or psychological phenomenon defined by a weakened condition, reluctance to continue activities, decreased alertness, decreased physical and emotional capacity, and decreased ability to do a job (Abd-Elfattah et al. 2015, Thiffault and Bergeron 2003). According to (Yogisutanti 2013) work fatigue occurs when alertness and reaction speed and the ability to display high occupational health and safety (K3) begin to decrease or disappear.

Fatigue is classified into two types, namely muscle fatigue and general fatigue (Budiono et al. 2003). Muscle fatigue is a tremor in the muscles or a feeling of pain in the muscles. General fatigue is usually characterized by the reduced willingness to work caused by monotony, intensity and duration of physical work, environmental conditions, mental causes, health status and nutritional conditions (Tarwaka and Bakri 2016).

Fatigue measurement methods are divided into two, objectively and subjectively. Objective measurements can be done using a reaction timer, while subjective measurements can use a fatigue indicator questionnaire. The method of measuring the level of fatigue used is the Industrial Fatigue Research Committee (IFRC) which is a questionnaire consisting of 30 statements consisting of ten statements regarding the weakening of activities, ten statements regarding the weakening of motivation, and ten statements regarding physical fatigue (Rizkita and Arvianto 2015, Adiatmika 2009, Yoshitake 1971). The test has four fatigue level scales ranging from low, medium, high, and very high (Putri 2008). Table 1 shows IFRC classification of fatigue.

Table 1. IFRC classification of fatigue

Fatigue Scale	Total Individual Score	Classification	Corrective Action
0	30-52	Low	No corrective action needed
1	53-75	Medium	Later action may be required
2	76-98	High	Immediate action needed
3	99-120	Very High	Comprehensive action is needed as soon as possible

2.2 Cardiovascular Load (CVL)

Cardiovascular Load (CVL) is a method of measuring physical workload to determine the classification of workload based on an increase in the working pulse rate compared to the maximum pulse rate due to cardiovascular load. Measuring pulse can use tools such as electrocardiogram and pulse meter, but it can also be done manually using a stopwatch (Tarwaka and Bakri 2016).

Pulse measurement is used to collect data needed in measuring physical workload using the Cardiovascular Load (CVL) calculation method. Pulse measurement process lasted for three working days for each subject to avoid bias in the work pulse. The data will be calculated based on the average results. Pulse data retrieve using a pulse meter. According to Tarwaka (2015), the maximum pulse rate calculation is (220-age) for men, while for women, it is (200-age). Below is the calculation formula for cardiovascular load in percentage.

$$\%CVL = \frac{(Work\ pulse - Resting\ pulse)}{(Max\ pulse - Resting\ pulse)} \times 100\%$$

From the calculation of the CVL percentage, the results will be compared with the classification determined according to (Tarwaka 2015) as follows:

<30%	= No fatigue occur
30% - <60%	= Corrective action needed
60% - 80%	= Work in a short time
80% - 100%	= Immediate action required
>100%	= Not allowed to do activities

2.3 NASA-TLX

NASA-TLX, or National Aeronautics and Space Administration Task Load Index, is a method to subjectively measuring mental workload (Cao et al. 2009). To assess mental workload more accurately, NASA-TLX divided into six dimensions. Table 2 shows the NASA-TLX dimensions according to (Rubio et al. 2004).

Table 2. NASA-TLX dimensions

Dimension	Details
Mental Demand (MD)	How much mental and perceptual activity is required to see, remember, and search. Whether the job was done is easy or complicated, complex or straightforward, loose or tight.
Physical Demand (PD)	Amount of physical activity required (e.g., pushing, pulling, controlling spin)
Temporal Demand (TD)	The amount of time-related stress felt during the immediate work element
Performance (P)	How successful is a person in his work, and how satisfied with the results of his work
Effort (EF)	How hard mental and physical work is required to complete the job
Frustation Level (FR)	How insecure, hopeless, offended, disturbed, compared to perceived feelings of security, satisfaction, comfort, and self-satisfaction.

The steps for measuring mental workload using NASA-TLX, according to (Hart and Staveland 1988), are as follows:

a. Giving a rating, respondents give a rating of the six dimensions of mental workload provided.

b. Weighting, respondents compare between two different dimensions with the pairwise comparison method. The whole pairwise comparisons are 15 pairs where the number of pairs is the total tally which will be the weight of the dimensions.

Calculate the NASA-TLX score from the questionnaire data using the following formula:

$$\text{NASA-TLX Score} = \sum \frac{(Weight\ x\ Rating)}{15}$$

From the results of the workload calculation using NASA-TLX, then the calculated results will be compared with the classification of mental workload scale values according to (Susetyo et al. 2012), as written in Table 3.

Table 3. NASA-TLX mental workload classification

Category	Scale
Low	10-33
Medium	34-56
High	57-79
Very High	80-100

2.4 Hypothesis Testing

Hypothesis testing is an initial statement or assumption that must be verified through a statistical approach (Connelly 2015, Abdurrahman and Muhidin 2011, Borg and Gall 1989). The hypothesis can be a statement that shows the relationship between two or more variables (Mourougan and Sethuraman 2017). The hypothesis is a statement formulated according to the problem formulation at the beginning of the study used to answer the problem (Kabir 2016). There are two types of hypotheses, namely research hypotheses and statistical hypotheses.

The research hypothesis is an initial statement in the form of a narrative or a statement of the results of the formulation of the researcher's thinking. In contrast, the statistical hypothesis is a hypothesis made using statistical symbols such as the null hypothesis or the initial hypothesis (H0) and the alternative hypothesis (H1). The null hypothesis describes the absence of a relationship between the variables tested, while the alternative hypothesis describes the expected results of the researcher. The conclusion of the hypothesis is the acceptance or rejection of the initial hypothesis (Mourougan and Sethuraman 2017, Anupama 2018). The hypothesis does not always get the correct results. The purpose of the hypothesis is to make predictions in research according to the researcher's expectations.

The criterion for rejecting the null hypothesis is when the p-value is less than 5% (p 0.05), while the null hypothesis is accepted when the p-value is more than 5% ($p > 0.05$). The decision to accept or reject the null hypothesis is also known as significance. When the null hypothesis is accepted, the hypothesis is declared to reach significance (Privitera 2019).

3. Method

This study is a cross-sectional study consisting of two independent variables, namely mental workload and physical workload, and one dependent variable, namely the level of fatigue. The analysis of the relationship method used was the Pearson correlation test, and Spearman ranks using SPSS software and Microsoft Excel. The sampling method of this study used a total sampling involving 26 operators or the total population of the extruder section of PT ABC.

Data collection methods were carried out by observation, conducting interviews, fatigue level questionnaire using IFRC, NASA-TLX questionnaire, as well as pulse measurement using a pulse meter for operators before doing work, and while doing work. Observation and interviews used to determine the sequence of the work processes carried out, complaints related to fatigue, workload, the consequences of these complaints, and the overall sequence of work carried out in the extruder section. The personal data obtained through the questionnaire included the operator's name, gender, age, years of service, weight, height, and duration of work each day. The personal data was collected as a supporting factor for the analysis process.

Various methods can measure mental load, including primary and secondary task measures, subjective rating measures, and physiological. In this study, the researcher's focus is to determine whether specific jobs affect mental load based on what the operator feels in various ways. Therefore, the NASA-TLX method was chosen as a multidimensional test with many measurement dimensions so that the research results can be seen more broadly.

The data collection process lasted for three weeks for the three operator teams. Measuring pulse data lasts for three consecutive days to avoid data bias on one of the days. The data used for processing is the average result data. Data from the IFRC and NASA-TLX questionnaire are according to what the operator felt during the last three months of work. After all the variables needed in the test have been calculated, hypothesis testing using the correlation test will be carried out.

4. Data Collection

4.1 Respondent Characteristic

The respondents of this study were the total population of PT ABC's extruder section with the characteristics as shown in Table 4.

Table 4. Respondent characteristic

Characteristics	n	%
Age		
20-25	5	19
26-30	12	46
31-35	3	12
36-40	4	15
41-45	1	4
46-50	1	4

Characteristics	n	%
Working Period		
<4	4	15
5-6	17	65
>6	5	19

Characteristics	n	%
Nutritional Status		
Underweight	2	8
Normal Range	15	58
Overweight	7	27
Obese	2	8

4.2 IFRC Result

The results of the data analysis using the IFRC questionnaire obtained are as shown in Table 5.

Table 5. IFRC result

Fatigue Scale	Category	n	Percentage (%)
0	Low	11	42
1	Medium	15	58

4.3 Physical Workload

Primary data collected to perform physical workload processing is pulse data before doing the work and while working for three days. Table 6 shows the pulse measurement time for three days.

Table 6. Pulse measurement time

Period	Time
Before Working 1	07:45-08:15
During Working 1	10:45-11:30
Before Working 2	13:00-14:00
During Working 2	14:50-15:35

4.4 Mental Workload

Figure 1 below shows the distribution of NASA-TLX scores.

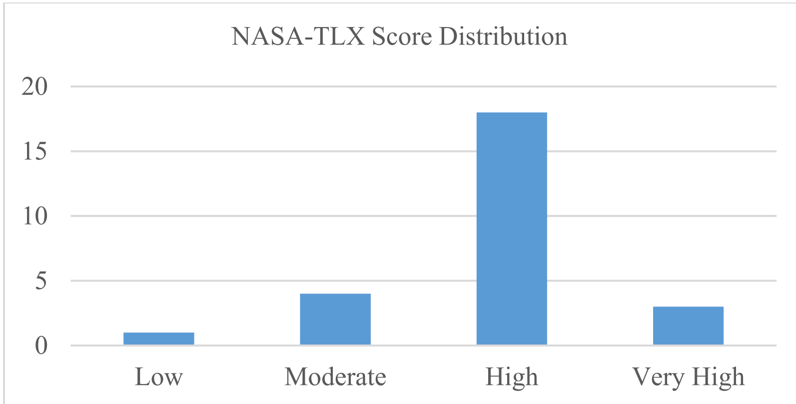

Figure 1. NASA-TLX score distribution

The Table 7 below shows the NASA-TLX dimensions with the most significant values.

Table 7. Most significant NASA-TLX dimension

Dimension	**WWL**
EF	7295
PD	5945
TD	4050
MD	4005
P	3639
FR	1815

4.5 Correlation
Table 8 shows p-value and correlation coefficient for fatigue with physical workload.

Table 8. Work fatigue with physical workload correlation

Work fatigue with physical workload	
p-value	0.77
Coefficient	-0.6

Table 9 shows p-value and correlation coefficient for fatigue with mental workload.

Table 9. Work fatigue with mental workload

Work fatigue with mental workload	
p-value	0.189
Coefficient	0.266

5. Result and Discussion
From the total of 26 respondents, the description of the age distribution of respondents shows the highest number of ages is in the range of 26-30 years by 46% and the lowest number of ages is in the range of 41-45 and 46-50 by 4%. The most working service distribution description is 5-6 years (65%) and a small proportion with less than four years of service (15%). Then the description for the nutritional status of the majority is ideal as 15 people (58%) with a minority of underweight and obese as two operators (8%). All respondent is male. In processing the fatigue level

questionnaire data, 11 of the total 26 operators experienced fatigue level 0 or into the low category. Meanwhile, 15 other operators are included in the medium category. It can be concluded that overall, later action may be required.

The first pre-work pulse measurement is carried out alternately to all operators in shifts. The first measurement of the pulse while working was carried out for 45 minutes at the time listed in Table 5. The measurement of pulse data before the second working session is taken according to the operator's rest hours. The operator's rest duration is an hour at 12:00-13:00 and 13:00-14:00. Break hours are made in rotation so that production continues and the machine is always under supervision. The results of the measurement of the data are averaged, and the CVL percentage is calculated. The average CVL percentage obtained from 26 operators is 15% which is included in the category of no fatigue, the highest CVL percentage value is 26%, and the lowest is 8%. It can be concluded that there is no excessive physical workload in the extruder section of PT ABC.

Based on the results of the NASA-TLX score calculation, it can be seen that 18 operators (69%) experienced a mental workload in the high category, four operators (15%) were in the medium category, three operators (12%) in the very high category, and one operator (4%) fall into the low category. The dimension with the highest weighted workload value is the level of effort. It shows that most operators experience a high mental workload which means that urgent repairs are needed. According to the results of the interview, it can be concluded that a high mental burden is usually felt by the operator when a production problem is found, which requires troubleshooting that involves the decision-making process and makes a detailed report at the end of each shift.

Apart from cognitive activities, the mental workload can also be caused by working environment conditions. The average noise in the extruder working environment is above 80 dB with temperatures that can reach 40 degrees Celsius, according to Indonesian Labor Government Regulations Num.13/X/2011. The permissible level of noise exposure for 85 decibels in a day is 8 hours. Prolonged noise exposure can cause discomfort, create confusion, reduce readiness, interfere with communication and productivity. Meanwhile, too long in a hot workroom can lead to feelings of fatigue, decreased work concentration, and increased errors.

Based on the results of statistical tests using the Spearman correlation with a significance level of 0.05, it was found that the p-value of fatigue and physical workload is 0.77 where the p-value is more than the significant level so that H0 is accepted and there is no relationship between fatigue and physical workload. Then based on the correlation coefficient, the relationship between fatigue and physical workload has a value of -0.6 which means it is negatively correlated and there is no relationship.

There is no relationship between fatigue and physical workload, this can be caused by unstable changes in workload every day. For example, when there is no problem found throughout the production process, the operator's work only focused on the control section and preparing raw materials. According to the operator, under normal conditions, lifting raw materials is no longer a physical burden as the working period progresses. By the description in Table 3, the average extruder operator has a working period of 5-6 years, making their muscles and organs, durability and energy accustomed to the daily physical loads carried out. However, when there are problems in the production process, the operator's physical workload tends to increase because they have to control the machine quickly and cause the operator to tend to go back and forth between machines. The usual pattern is that on Mondays, the production process tends to be quite problematic because the machine was utterly turned off the previous day so that on Monday, it took time to warm up the machine and carry out careful control before starting the production process. The following pattern is that when the production volume increases, the tendency for problematic processes will also increase.

Based on the results of statistical tests using Pearson correlation with a significance level of 0.05, it was found that the p-value of fatigue and the mental workload was 0.189 where the p-value was more than the significant level so that H0 was accepted, so there was no relationship between fatigue and mental workload. Then based on the correlation coefficient, the relationship between fatigue and physical workload has a value of 0.266 which means it is positively correlated and has a weak relationship.

It can be seen in the previous mental load table that most operators, namely 69% are in the category of high mental load; even 12% are included in the very high category. This is because the operator is doing his job must concentrate so that the product produces specifications according to the specifications of the order, the operator must be ready when faced with problems in production that require problem-solving, and when the production volume increases, to meet the capacity of the operator can do long shifts for 12 hours of work. The operator's fatigue level calculation results are in the medium category 58% and low 42%, which shows a difference with the calculation results of mental workload, which is included in the high category, and fatigue in the medium category.

5.1 Proposed Improvement

Based on the results of calculations and analysis related to physical workload, mental workload, and fatigue level. Therefore, some suggestions for improvement can be formulated as follows:

a. Provision of earplugs for operators at work.
b. Increase air circulation with an additional fan or air conditioner.
c. Provides reminder or signage on staying hydrated during work.
d. Although there are recommendations always to do stretching or warm-up before work, in practice, it is often found that operators do not do it, so it would be better if warm-up before doing any activity always be reminded.
e. For further research on fatigue levels, it is recommended to use test equipment for more objective results, such as a reaction timer.

6. Conclusion

In carrying out their duties, the extruder section operator performs various activities involving physical and cognitive activities—starting from lifting various things, controlling, troubleshooting, and decision-making. These activities cause a workload that results in work fatigue. The analysis of operator fatigue is 58% of the total operator experiencing a medium level of fatigue and the rest low level of fatigue. Calculation of the physical workload score with CVL shows that there is no excessive physical burden on all operators, while in mental workload, 69% of operators experience a high level of mental burden and 12% experience a very high mental load. Based on these results, the burden that is felt by the operator and needs improvement is related to things that affect the operator's mental load, such as cognitive load and the environment. Based on the Pearson correlation test for mental workload and Spearman for the physical workload on fatigue levels, it can be concluded that there is no relationship between variables.

References

Abd-Elfattah, H. M., Abdelazeim, F. H., and Elshennawy, S., Physical and cognitive consequences of fatigue: a review, *Journal of Advanced Research,* vol. 6, no. 3, pp. 351–358, 2015.

Abdurrahman, M., and Muhidin, S. A., *Panduan Praktis Memahami Penelitian (Bidang Sosial-Administrasi-Pendidikan)*, CV Pustaka Setia, Bandung, 2011.

Adiatmika, I. P. G., Total ergonomic approach in decreasing quality of fatigue of metal crafters, *Indonesian Psychological Journal*, vol. *25,* no. 1, pp. 71–78, 2009.

Anupama, K., Hypothesis types and research, *International Journal of Nursing Science Practice and Research*, vol. *4,* no. 2, pp. 78-80, 2018.

Atiqoh, J., Wahyuni, I., and Lestantyo, D, Faktor-faktor yang berhubungan dengan kelelahan kerja pada pekerja konveksi bagian penjahitan di Cv. Aneka Garment Gunungpati Semarang, *Jurnal Kesehatan Masyarakat Universitas Diponegoro*, vol. 2, no. 2, pp. 119–126, 2014.

Borg, W. R., and Gall, M. D, *Educational Research: An Introduction,* 5th Edition, Longman, New York, 1989.

Budiono, A. M. S., Jusuf, R. M. S., and Pusparini, A., *Bunga Rampai Hiperkes dan Kesehatan Kerja*, Badan Penerbit Universitas Diponergoro, Semarang, 2003.

Cao, A., Chintamani, K. K., Pandya, A. K., and Ellis, R. D., NASA TLX: software for assessing subjective mental workload, *Behavior Research Methods*, vol. 41, no. 1, pp. 113–117, 2009.

Connelly, L. M.,. Research questions and hypotheses, *MedSurg Nursing*, vol. 24, no. 6, pp. 435–436, 2015.

Gabriel, J., Peretemode, Otaroghene, and Dinges, D., Industrial fatigue: a workman's great enemy, *Journal of Business and Management*, vol. 20 , no. 10, pp. 9–14, 2018.

Hart, S. G., and Staveland, L. E., Development of NASA-TLX (Task Load Index): results of empirical and theoretical research, *Advances in Psychology*, vol. 52, pp. 139-183, 1988.

Kabir, S. M. S., *Basic Guidelines for Research: An Introductory Approach for All Disciplines*, 1st Edition, Book Zone Publication, Bangladesh, pp. 103–122, 2016.

Kanarek, R. B., and Lieberman, H. R., *Diet, Brain, Behavior*, 1st Edition, CRC Press, Boca Raton, 2011.

Luckhaupt, S., Short sleep duration among workers — United States, 2010, *Morbidity and Mortality Weekly Report*, vol. 61, no. 16, pp. 281–285, 2012.

Markkanen, P. K., *Keselamatan dan Kesehatan Kerja di Indonesia*, International Labour Organization, 2004.

Mourougan, S., and Sethuraman, D. K., Hypothesis development and testing. *IOSR Journal of Business and*

Management, vol. 19, no. 5, pp. 34–40, 2017.

Privitera, G. J., *Statistics for the Behavorial Sciences*, 1st Edition, SAGE Publishing, California, 2018.

Puteri, R. A. M., and Sukarna, Z. N. K., Analisis beban kerja dengan menggunakan metode CVL dan NASA-TLX di PT. Abc. *Spektrum Industri*, vol. 15, no. 2, pp. 211-221, 2017.

Putri, D. P., Hubungan faktor internal dan eksternal terhadap terjadinya kelelahan pada operator alat besar di PT. Indonesia Power Unit Bisnis Pembangkitan Suralaya periode tahun 2008, *Skripsi Universitas Indonesia*, Jakarta, 2008.

Rizkita, S. S., and Arvianto, A., Evaluasi kelelahan kerja dan pemberian waktu istirahat di bagian jahit lini 11 PT. Star Fashion Ungaran, *Industrial Engineering Online Journal*, vol. 4, no. 3, 2015.

Rubio, S., Díaz, E., Martín, J., and Puente, J. M., Evaluation of subjective mental workload: a comparison of SWAT, NASA-TLX, and Workload Profile Methods, *Applied Psychology*, vol. 53, no. 1, pp. 61-86, 2004.

Saito, K., Measurement of fatigue in industries, *Industrial Health,* vol. 37, pp. 134-142, 1999.

Susetyo, J., Simanjuntak, R. A., and Wibisono, R. C., Pengaruh beban kerja mental dengan menggunakan metode Nasa-Task Load Index (TLX) terhadap stres kerja, *Prosiding Seminar Nasional Aplikasi Sains & Teknologi (SNAST) Periode III,* Yogyakarta, Indonesia, November 3, 2012, pp. 75–82.

Tarwaka, *Industrial Ergonomics, Knowledge Basics and Applications at Work*, 2nd Edition, Harapan Press, Surakarta 2015.

Tarwaka, and Bakri, S. H. A., *Ergonomi untuk Keselamatan, Kesehatan Kerja dan Produktivitas*, UNIBA Press, Surakarta, 2016.

Thiffault, P., and Bergeron, J., Fatigue and individual differences in monotonous simulated driving, *Personality and Individual Differences*, vol. 34, no. 1, pp. 159-176, 2003.

Torres-harding, S., and Jason, L. A., What is fatigue? history and epidemiology, *In Fatigue as a Window to the Brain*, *May*, pp. 3-17, 2005.

Yazdi, Z., and Sadeghniiat-Haghighi, K., Fatigue management in the workplace, *Industrial Psychiatry Journal*, vol. 24, no. 1, pp. 12, 2015.

Yogisutanti, G., Kebiasaan makan pagi, lama tidur dan kelelahan kerja (fatigue) pada dosen, *KESMAS : Jurnal Kesehatan Masyarakat*, vol. 9, no. 1, pp. 53-57, 2013.

Yoshitake, H., Relations between the symptoms and the feeling of fatigue. *Ergonomics*, vol. 14, no. 1, pp. 175-186, 1971.

Biographies

Fanisa Ismi Permatasari is an Industrial Engineering final year student at Muhammadiyah University of Surakarta. She is an industrial engineering laboratory assistant who focuses on statistics, ergonomics, and work system design. She has facilitated the end-to-end practicum, a total of 13 practicum sessions for the last two years, with more than 250 students. Responsible for material research, practicum systems, and modules. She had an internship at an Indonesian BUMN for three months with a human capital position and analyzed the human capital information system. She is one of 150 students who received leadership scholarships from PT XL Axiata selected from more than 17000 students nationwide with the XL Axiata Future Leaders program, which provides soft skills training for two years to face the world of careers professionally.

Muchlison Anis is a lecturer at Industrial Engineering, Muhammadiyah University of Surakarta. During his career, he served as chairman of the Muhammadiyah University of Surakarta Industrial Engineering Department, chairman of the center for industrial logistics and optimization studies, and editor of industrial engineering scientific journals. His subjects include ergonomics, occupational health, and safety, work system design. His research interests include safety, health and environment, work system design, and ergonomics.